The Impact of Radio Frequency Identification (RFID) Technology on Retail Supply Chain Performance

A Thesis Submitted in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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DECLARATION

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research programme; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and ethics procedures and guidelines have been followed. This thesis was editing by Elite Editing and editorial intervention was restricted to Standards D and E of the Australian Standards for Editing Practice.

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PUBLICATIONS FROM THESIS-RELATED RESEARCH

Journal Articles

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LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
ACMA	Australian Communications and Media Authority
ADC	Automatic Data Capture
AHP	Analytical Hierarchy Process
AIDC	Automatic Identification and Data Capture
Auto-ID	Automatic Identification
AVE	Average Variance Extracted
B2B	Business-to-Business
B2C	Business-to-Consumer
CASPIAN	Consumers Against Supermarket Privacy Invasion and Numbering
CB-SEM	Covariance Based Structural Equation Modelling
CI	Consistency Index
CIO	Chief Information Officer
CPFR	Collaborative Planning, Forecasting and Replenishment
CR	Consistency Ratio
CRP	Continuous Replenishment Programs
DoD	Department of Defence
EAN	European Article Numbering
EAS	Electronic Article Surveillance
EDI	Electronic Data Interchange
EPC	Electronic Product Code
EPC-IS	Electronic Product Code Information System
ERP	Enterprise Resource Planning
FMCG	Fast Moving Consumer Goods
GPS	Global Positioning System
HTML	HyperText Markup Language
ICT	Information and Communication Technology
IOS	Inter-Organisational Information System
ISO	International Standards Organization
IT	Information Technology
JAN	Japanese Article Numbering
KPI	Key Performance Indicator
NDP	National Demonstrator Project

NFC	Near Field Communication
OCR	Optical Character Recognition
OLS	Ordinary Least Squares
ONS	Object Naming Service
OOS	Out Of Stock
3PL	Third Party Logistics
PLS-SEM	Partial Least Squares Structural Equation Modelling
PML	Physical Markup Language
RFDC	Radio Frequency Data Communication
RI	Random Consistency Index
RF	Radio Frequency
RFID	Radio Frequency Identification
ROI	Return On Investment
SCOR	Supply Chain Operations Reference Model
SEM	Structural Equation Modelling
SME	Small-to-Medium Enterprise
UHF	Ultra-High Frequency
UPC	Universal Product Code
UK	United Kingdom
US	United States
VMI	Vendor-Managed Inventory

ABSTRACT

This research investigates the impact of Radio Frequency Identification Technology (RFID) on supply chain performance within the Australian retail sector. This study examines how the factors associated with RFID influence adoption intentions, taking into account organisational readiness, and consequently, the impact on supply chain performance.

Managers continuously investigate emerging information technologies in an attempt to identify innovations that will provide a competitive advantage, and RFID is the latest technology being examined. Focus on RFID became more intense after Wal-Mart's announcement in 2004 that they would be implementing RFID throughout their supply chains (Sullivan 2004). A literature review reveals many benefits, such as increased visibility throughout the supply chain, enhanced track-and-trace capabilities and increased inventory availability, enabling significant improvement in supply chain performance (Sarac et al. 2010). Equally, the literature identifies a range of challenges that have prevented the widespread adoption of RFID. These include standards, reliability issues, security issues and high costs (Ngai & Gunasekaran 2009), and as a consequence, the capability of RFID is being questioned. This research investigates these challenges under the banner of technological, organisational, external environmental and economic context factors. There is compelling evidence reasoning that these challenges will be eliminated with future advances in technology and that organisations will then implement RFID (Poirier & McCollum 2006). However, organisations need to be prepared for this event. Organisational readiness is central to this research and consists of an awareness of the factors that influence intentions to adopt such as needs fit, required skills, financial resource levels, knowledge about emerging information technologies, current Information Technology (IT) use, previous involvement in similar IT projects, demonstrated collaborative efforts with supply chain partners, and the ability to embrace change (Asif & Mandviwalla 2004; Lekakos 2007; Mehrtens et al. 2001; Wu 2004).

There is a lack of research examining RFID in a retail supply chain setting, and very few include organisational readiness. This largely unexplored area of research highlights a gap in existing knowledge. This research adopts an exploratory approach to assess the impact of a number of factors. Two different methods were adopted to investigate RFID factors, Analytical Hierarchy Process (AHP) and Partial Least Squares Structural Equation Modelling (PLS-SEM).

Initially, managers known to be aware of RFID and operating within retail supply chain organisations were interviewed to gain an understanding and a feel for the RFID environment. Following this, an expanded pilot study using AHP enabled a rigorous approach to assess the importance of RFID factors. Respondents consisted of senior managers within two large retailers, five suppliers and five technology provider organisations.

In this study, AHP facilitated the ranking of RFID factors based on their perceived importance. The results at the first level of the hierarchy indicated that technological factors were most important, particularly for the retailers, and economic factors were also important with respect to organisational readiness. Organisational and external environmental factors were less important. At the second level, within the technological context, standards were the most important factor, and in the economic category, tag costs were also important.

Based on the information obtained from the AHP analysis and the literature review a survey was constructed and data collected from a sample of the membership of Global Standards 1 (GS1). GS1 manage the standards related to identification systems, such as barcodes and RFID (GS1 Australia 2009). PLS-SEM, a highly regarded quantitative modelling tool, was used to analyse the data obtained from 116 respondents and ascertain predictive relationships. The results indicated a positive relationship between supply chain performance and intentions to adopt RFID. There was also a positive relationship between organisational readiness and intention to adopt. A number of factors were found to be important. These included one technological factor, (compatibility), an external environmental factor, (security), and an organisational factor, (IT investment), all of which collectively explain 60.3 per cent of the variance in organisational readiness. However, investment in IT was identified as the major factor contributing to organisational readiness.

The implications of this research highlight the need for organisations to become aware of the factors and prepare for the likely event of RFID challenges being overcome. Managers need to reflect on these results and compare them with their current processes. In addition, managers need to concentrate on IT investment as part of this strategy.

Future research may resolve the limitations of this study. For instance, this research was cross-sectional and as such, perspectives may alter over time. Future longitudinal studies may eliminate this issue. Second, a single participant was contacted in each organisation, which may not truly represent the perspectives of the organisation. To overcome this limitation, future research studies should involve multiple participants.

CHAPTER 1: INTRODUCTION

1.1 Background to the Research

This chapter provides an introduction to the research and begins in this section with background information. A description of the Australian retail supply chain is provided in Section 1.2. Section 1.3 briefly outlines how performance is measured in the retail sector. Radio Frequency Identification Technology, also known as RFID, has been acknowledged as an Inter-Organisational Information System (IOS) (Wamba et al. 2008b), and to appreciate RFID in this setting Section 1.4 provides an appraisal of existing IOSs. These include Electronic Data Interchange (EDI) and the Internet, as well as RFID. This study considers RFID in the context of an IOS because of the importance of sharing information between supply chain partners. Sections 1.5 to 1.8 provide an account of the research problem, research framework, research questions and the scope of this study. Section 1.9 then provides a brief overview of the methodology adopted in this study, followed by Section 1.10, where the importance of this research is highlighted. This chapter concludes with Section 1.11, which outlines the subsequent chapters.

The purpose of this research is to examine organisational readiness factors that influence intentions to adopt RFID and therefore its effect on Australian retail supply chain performance. RFID became prominent after Wal-Mart's announcement of their intention to implement RFID throughout their supply chains in 2004 (Sullivan 2004). A review of the literature reveals many benefits from implementing RFID, such as increased visibility throughout the supply chain, enhanced track-and-trace capabilities and increased inventory availability, enabling significant improvement in supply chain performance (Sarac et al. 2010). Equally, the literature identifies a range of challenges that have prevented the widespread adoption of RFID. These include standards, reliability issues, security issues and high costs (Ngai & Gunasekaran 2009). These challenges have resulted in the capability of RFID being questioned. This research investigates these challenges under the banner of technological, organisational, external environmental and economic context factors. There is evidence suggesting that the challenges facing RFID will be eliminated with future advances in technology (Poirier & McCollum 2006).

Organisations today have an extensive range of Information and Communication Technologies (ICT) to apply in running their business. Enterprise Resource Planning (ERP) systems and Internet models are two examples that are well entrenched throughout most industries (Ghani et al. 2009; Hadaya 2009). Industry leaders continually examine the potential of emerging information technologies to assist in supply chain management. RFID is the latest Information Technology (IT) attracting attention; however, RFID is not new, with well-known commercial tollway applications dating back to the 1980s (Attaran 2007). Recent advances in technology and substantial cost reductions have created new opportunities (Curtin et al. 2007). Furthermore, Wal-Mart, purported to be the world's largest retailer, issued mandates to suppliers to adopt RFID as part of their improvement effort (Deitz et al. 2009; Mehrjerdi 2011). Consequently, the retail industry is now leading the way in examining RFID's potential to improve the way products move through domestic and global supply chains (Sellitto et al. 2007).

1.2 The Australian Retail Industry

The summary of the Australian retail trade given in Table 1.1 indicates that the total turnover for Australian retailers was $270.9 billion in the year ending in April 2012, with food retailing accounting for 40.6 per cent (ABS 2012) (Table 1.1). This research study focuses on retail supply chains for several reasons. First, the retail sector is an important contributor to the Australian economy. Second, the retail environment has considerable previous experience in, and commitment to, investigating innovative technologies (Pramatari 2007). Finally, there are examples of information technologies, particularly when combined with other initiatives, which have provided the catalyst for improvement in retail performance and subsequent competitive advantages (Wightman 1990).

Table 1.1: The Australian Retail Trade

Industry	ABS Code	Turnover ($ billion)	Percentage of turnover
Food retailing			
Supermarket and grocery stores and non-petrol sales (convenience stores) of selected fuel retailing			
Supermarket and grocery stores	4110		
Convenience stores of selected fuel retailing	4000	110	40.6
Liquor retailing	4123		
Other specialised food retailing			
Fresh meat, fish and poultry retailing	4121		
Fruit and vegetable retailing	4122		
Other specialised food retailing	4129		
Household goods retailing			
Furniture, floor coverings, homewares and textile goods retailing			
Furniture retailing	4211		
Floor coverings retailing	4212		
Homewares retailing	4213		
Manchester and other textile goods retailing	4214		
Electrical and electronic goods retailing		46.6	17.2
Electrical, electronic and gas appliance retailing	4221		
Computer and computer peripheral retailing	4222		
Other electrical and electronic goods retailing	4229		
Hardware, building and garden supplies retailing			
Hardware and building supplies retailing	4231		
Garden supplies retailing	4232		
Clothing, footwear and personal accessories retailing			
Clothing retailing			
Clothing retailing	4251		
Footwear and other personal accessory retailing		20.3	7.5
Footwear retailing	4252		
Watch and jewellery retailing	4253		
Other personal accessory retailing	4259		
Department stores	4260		
Department stores		19.6	7.2
Department stores	4260		
Cafes and restaurants and takeaway food services			
Cafes and restaurants	4511		
Catering services	4513	38.9	14.4
Takeaway food services			
Takeaway food services	4512		
Other retailing			
Newspaper and book retailing			
Newspaper and book retailing	4244		
Other recreational goods retailing			
Sport and camping equipment retailing	4241		
Entertainment media retailing	4242		
Toy and game retailing	4243		
Pharmaceutical, cosmetic and toiletry goods retailing		35.5	13.1
Pharmaceutical, cosmetic and toiletry goods retailing	4271		
Other retailing n.e.c			
Stationery goods retailing	4272		
Antique and used goods retailing	4273		
Flower retailing	4274		
Other store-based retailing n.e.c	4279		
Non-store retailing	4310		
Retail commission-based buying and/or selling	4320		
Total		**270.9**	**100**

(Source: ABS 2012)

The Australian retail industry also contributes 4.1 per cent of gross domestic product and employs 10.7 per cent of the total working population (Productivity Commission 2011). Two retailers, Woolworths Limited and Wesfarmers Coles Limited, dominate the food sector in Australia. Both organisations have enjoyed a significant increase in their combined national share of the market, from 40 per cent in 1975 to 70 per cent in 2012 (Jacenko & Gunasekera 2005; McGregor 2012).

Australia is recognised as having one of the most concentrated retail food sectors in the world (Jacenko & Gunasekera 2005). This sector has recently come under intense competitive pressure from overseas retail organisations newly entering the market. Aldi, a German retailer, has opened more than 200 stores and intends to open another 500 to successfully compete with Woolworths and Coles (Thomson 2009). Costco, a new bulk retail outlet has also recently open stores in both Melbourne and Sydney, and plans to open six new stores over the next three years (Avenell 2010). Such competition forces organisations to investigate ways to improve. Other retail sectors, such as household goods, clothing, footwear and personal accessories have a similar desire to improve their operations.

Leading retail organisations have been at the forefront of trialling and adopting emerging information technology (IT). Retail supply chains have become more efficient through the implementation of IT, including barcoding and inventory management processes (Jacenko & Gunasekera 2005). United States (US) retailers spend $30 billion a year on IT that automates transactions, tracks inventory and assists in decision-making (Raman et al. 2001). The success and competitiveness of Wal-Mart and similar global retailing establishments has been attributed to their willingness to invest in IT to support their supply chains (Tong & Tong 2006). Australian retailers, including Woolworths and Coles, have also made significant investments in IT. Woolworths has reportedly spent $450 million in IT improvements to their supply chain over a five-year period (O’Brian 2012).

Recently, many well-known retail organisations have begun the process of investigating how RFID might be used to improve their supply chain operations. Marks and Spencer, Tesco and Metro have all embarked on RFID trials (Narsing 2005). Wal-Mart’s RFID adoption efforts throughout their supply chains are well known (Attaran 2007; Bednarz 2004; Corsten & Gruen 2003; Hardgrave et al. 2008; Sullivan 2004). Woolworths has also taken a keen interest in RFID, having hosted an Australian RFID forum (GS1 Australia 2007b). The clothing sector in Australia is also examining ways to adopt RFID (GS1 Australia 2012). One example is the use of RFID to begin a music playlist when customers enter the change rooms in fashion stores (Fibre2fashion 2012). The next section explains the basis underpinning retail performance.

1.3 Retail Supply Chain Performance

There are a number of ways that performance is measured with both quantitative and qualitative techniques being adopted in retail supply chains. Examples of quantitative measures are cost, inventory level, fill rate, lead time, inventory turnover, speed and flexibility (Coyle et al. 2008; Fawcett et al. 2007). Qualitative measures comprise customer service feedback, innovation (Fawcett et al. 2007), quick responses to queries, superior service levels compared to competitors and customers' perception of service (Gunasekaran et al. 2004). Supply chain performance measures have evolved from individual measures to process measures, such as delivery in full on time, the perfect order, cash-to-cash cycle and customer inquiry response time (Fawcett et al. 2007).

Apart from the above measures, the retail sector also focuses on product availability, out-of-stock (OOS) and shrinkage (Fleisch & Tellkamp 2005). There are considerable incentives to increase the level of inventory accuracy and reduce shrinkage throughout retail supply chains. Collaboration is one method used to achieve this improvement between supply chain partners (Pramatari & Miliotis 2008). Japan's keiretsu is a historical example of organisational networking and sharing information. Keiretsu are deeply embedded networks of Japanese buyer and supplier organisations that enjoy the benefits of risk reduction by mutually assisting each other in business. Such business forms were known to provide a degree of insulation from market pressure (McGuire & Dow 2009). Organisations have found that sharing information with supply chain partners provides inventory visibility, improved decision-making, and in turn, improved operational performance (Barrat & Adegoke 2007). The efficient and effective movement of products and related information is fundamental to defining supply chains (Coyle et al. 2008).

1.4 Retail Supply Chain Information Systems

One well-known group of technologies designed to facilitating sharing information in supply chains are the Inter-Organisational Information Systems (IOSs). In the following sections, IOSs are discussed in the context of retail environments. Four major systems are examined including EDI, the Internet, multi-faceted IOS, and the latest entry, RFID.

1.4.1 Inter-Organisational Information Systems

IOS facilitate the exchange and storage of information between organisations (Cash & Konsynski 1985). In the early 1990s IOS were identified and recognised as valuable contributors to organisational networks with the potential to provide a competitive edge (Bakos 1991). Research found that higher levels of integration facilitated by IOSs resulted in higher levels of collaboration (Goodhue et al. 1992). Furthermore, higher levels of collaboration produced higher levels of supply chain performance (Lee et al. 1997). Organisations wanting to improve their performance through collaborative efforts searched for suitable technologies. Two technologies, EDI and more recently the Internet, have both featured prominently in the IOS literature (Hansen & Hill 1989; Kumar & Christiaanse 1999).

1.4.1.1 Electronic Data Interchange

EDI is an early IOS that became well entrenched within a number industries from the 1970s onwards. EDI is defined as the computer-to-computer transfer of information between organisations in a structured format (Hansen & Hill 1989). Data is moved from the sender's computer to the receiver's computer without any re-keying process. EDI is best known for transmitting business documents such as purchase orders and invoices (Hoogeweegen et al. 1998). The primary drivers for implementing EDI were operational gains, competitiveness, and improvements in inter-organisational relationships (Cox & Ghoneim 1996). Benefits were cited as quick response through access to information, improved control of information, improved customer service, faster inventory turnover, consistent flow of information, standardisation of procedures and improvement of relationships (Ngai et al. 2005). These benefits have encouraged organisations to evaluate the strategic implications of adopting EDI to support long term collaborative relationships (Cunningham & Tynan 1993). However, despite considerable media hype, widespread adoption throughout industries did not eventuate. Apart from the Fortune 1000 firms, only 2 per cent of organisations in the US have implemented EDI (Densmore 1998). The reasons for these lower than expected adoption rates included the high costs associated with implementing EDI (Soliman & Janz 2004), the complexity of the technology (Haugen & Behling 1995) and difficulty in obtaining cooperation from all partners (Premkumar et al. 1994). The arrival of the Internet created a possible alternative IOS capability for industry.

1.4.1.2 The Internet

A wide range of Internet models are identified as IOSs. Examples include extranet applications (Min & Galle 2003), e-business (Ranganathan et al. 2004; Xu et al. 2004), Business-to-Consumer (B2C) applications (Debreceny et al. 2002) and Business-to-Business (B2B) applications (Ranganathan et al. 2004). Not all Internet configurations are considered to be IOS. E-commerce, comprising exchange capabilities between suppliers and customers via central hubs is not considered an IOS (Cash & Konsynski 1985). Similarly, virtual markets where buyers and sellers search for products are not IOS. Rather, an IOS exists when organisations conduct electronic business in a ‘dyadic’ framework (Easton & Araujo 2003).

A prominent example of an IOS is e-business, whereby the Internet is applied to conduct business. E-business enables organisations to share information, collaborate, and in some cases distribute products. Benefits include simplified transactions, reduction in manual paperwork, elimination of errors (Min & Galle 2003), ease of use and cheaper collaboration (Christiaansea et al. 2004). Dell, GE and Cisco have all derived significant benefits from integrating the Internet within their supply chains (Hadaya 2009; Lancioni et al. 2000; Ranganathan et al. 2004). Research also argues that higher usage of the Internet within supply chains will lead to increased levels of organisational performance (Frohlich 2002; Frohlich & Westbrook 2002).

Organisations have recognised greater benefits from adopting these Internet configurations compared to EDI. Relative advantages of the Internet over EDI include ease of maintenance, lower implementation and operating costs, no need for close coordination and minimum need for mutual adjustment (Christiaansea et al. 2004). Another important advantage is the use of a common standard (xml), enabling operations over the open world-wide web, unlike EDI with its proprietary standards (Dai & Kauffman 2002). Similar to EDI, adoption patterns of e-business were driven by competitive actions and pressure, as well as the extent of use within industry (Ranganathan et al. 2004).

1.4.1.3 Multi-Faceted Inter-Organisational Information Systems

So far, the two main IOS have been described. However, the literature also provides examples of the Internet merging with other innovations to form multi-faceted IOS (Leymann et al. 2002; Mireille & Kavan 1999; Sawhney 2000). One example is the fusion of EDI and the Internet. EDI is transmitted and communicated through expensive proprietary-based lines known as value-added networks. The Internet has supported EDI by replacing these networks with cheaper and more open configurations (Mireille & Kavan 1999). The Internet has also formed several models such as trading hubs (Sawhney 2000), business process management systems (Leymann et al. 2002), and automatic identification systems (Auto-ID) (Smith 2006). One well publicised example of an Auto-ID is RFID technology, which is the focus of this study.

1.4.1.4 RFID

RFID is an Auto-ID technology designed to identify objects through the use of radio waves (Wyld 2006). RFID is an established technology used for identifying vehicles on tollways, baggage at airports, animals and for security access to facilities (Asif & Mandviwalla 2004). However, these examples are widely accepted as in-house RFID systems. A recent application, referred to as the Electronic Product Code Global network (EPCGlobal) has attracted considerable attention. EPCGlobal is a vision of GS1, a leading organisation involved in developing identification systems, including barcodes, for industry (GS1EPCGlobal 2008). EPCGlobal is similar in many respects to the barcode system. An RFID tag containing a microprocessor chip is attached to a product. When the product travels within the range of a reader, radio signals enable the transfer of information from the tag to the organisation's ERP. Product and location information then circulate to authorised supply chain members via the Internet. This system has a number of advantages over barcode technologies because the tags do not need line of sight, which theoretically means the ability to identify all the products on a pallet passing a reader. RFID tags will operate in harsh conditions and have the capacity to hold more information than barcodes (Sheffi 2004). These attributes provide the potential for RFID to improve performance in terms of sharing information throughout the supply chain. In addition, RFID has the potential to increase product availability and reduce costs.

Despite these advantages, organisations have been hesitant to adopt the RFID model due to the challenges associated with this technology (Fabian & Günther 2009; Jones et al. 2005; Kumar et al. 2009; Ngai & Gunasekaran 2009; Wu et al. 2006). For example, there are issues with interference from water, metals and environmental settings, causing read rates to be unreliable (Wyld 2006). RFID tags are more costly than barcodes and consequently supply chains have not yet created a positive business case (Smart et al. 2010). These challenges have resulted in high levels of uncertainty about the capabilities of RFID technology (Roh et al. 2009). Both the beneficial and the challenging factors featured prominently in the literature are pivotal to the research problem.

1.5 Research Problem

The major driver for adopting RFID is the anticipated benefits including potential improvements in retail performance (Bhattacharya et al. 2007). However, there are currently a number of challenging factors preventing adoption. Therefore, the central problem is the uncertainty regarding factors affecting RFID capabilities in this context.

Identification of the critical factors and the prediction of the intensity of relationships will increase our level of knowledge of this emerging technology. This research speculates that organisational readiness is an interceding factor between the challenges and the intention to adopt RFID with the aim of leading to performance benefits. Organisational readiness is described in terms of availability of financial and technological resources, cultural preparedness and experience in innovative technological adoption (Chwelos et al. 2001; Wu 2004). Organisational readiness appears to be under-represented in the extant RFID research literature.

1.6 Research Framework

The research framework defines the approach taken by this research to assist in solving the research problem presented in Section 1.5. The following factors form this framework:

1.6.1 Retail Supply Chain Performance

The quest to continuously improve performance in retail supply chains is a driver for adopting emerging technologies like RFID (Bhattacharya et al. 2007). This research regards performance as analogous to benefits. Benefits such as improvements in productivity, greater accuracy, visibility, tracking, reduced costs, better asset management, process optimisation and enhanced inventory availability are discussed in the literature (Fleisch & Tellkamp 2005; Ngai & Gunasekaran 2009; Sweeney 2005; Wamba & Chatfield 2010).

1.6.2 The Adoption Decision

RFID has not been widely implemented and is considered futuristic (Mattern & Floerkemeier 2010; Smart et al. 2010). Nevertheless, supply chain managers all understand the possibility that RFID may be implemented at some point (Lee 2007; Lewis 2004). Many have been proactive in gathering information about RFID, while others have undertaken trials (GS1 Australia 2006). Therefore, the intention to adopt RFID is worthy of consideration.

1.6.3 Organisational Readiness

Organisations need to be prepared for the introduction of emerging technologies. This requires organisations to engage in high-risk technology projects in order to gain an understanding of the issues associated with implementing such technologies. Organisational readiness features in the research framework as an intermediary between intentions to adopt and the challenges associated with the technology.

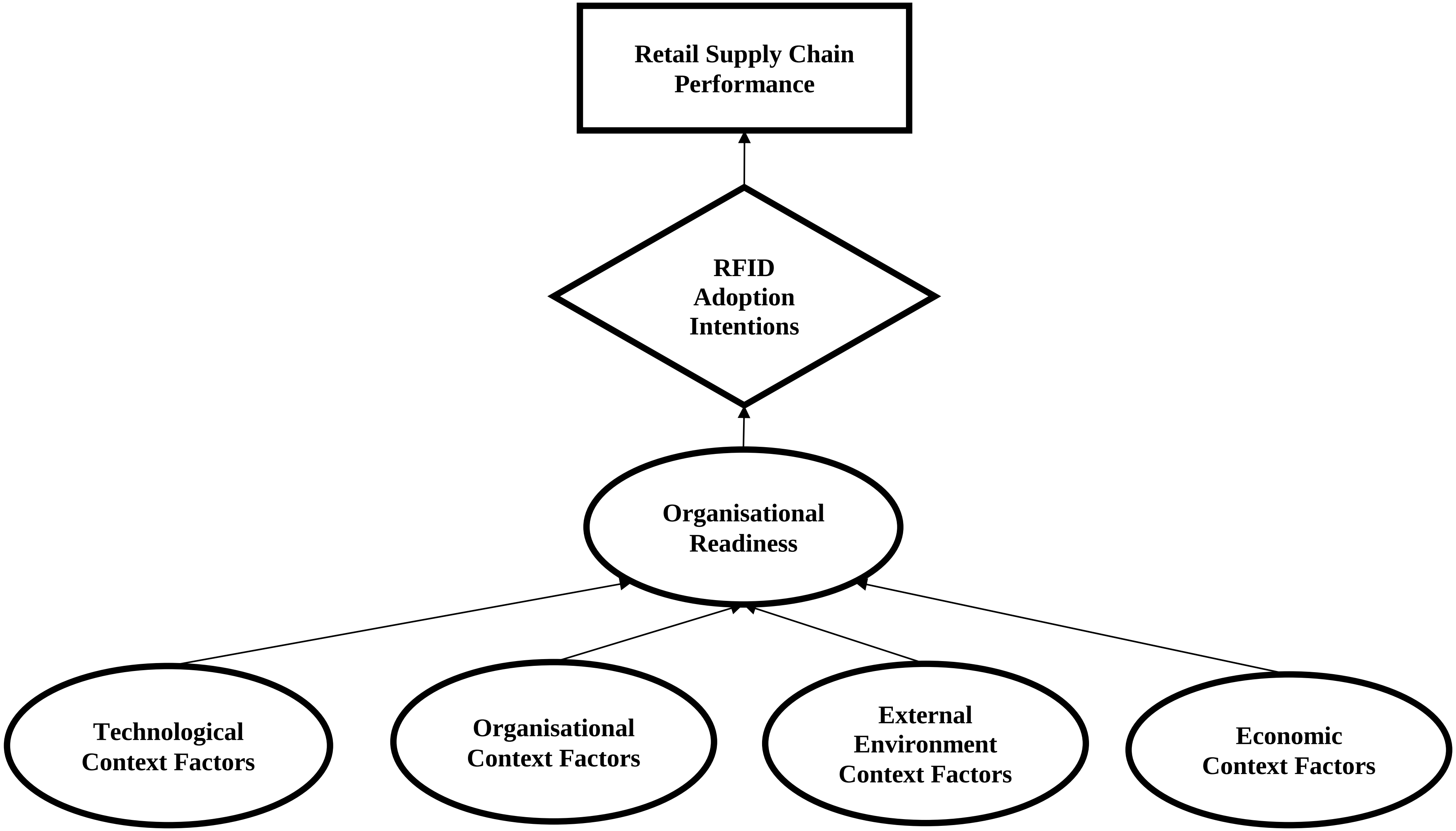
1.6.4 Technological, Organisational, External Environmental and Economic Challenges

The final level of the framework presents the major categories of challenges facing prospective supply chain managers considering adoption. For example, technological factors such as the reliability of the read rate contribute to intentions (Li et al. 2006), together with organisational factors such as a lack of support by top management (Fish & Forrest 2006). Equally, external environmental factors such as security and privacy issues add to the level of uncertainty (Clarke & Flaherty 2008; Shih et al. 2005). Finally, the cost of RFID installation prevents many from considering this technology (Brown & Russell 2007). These categories of challenges are represented by an established technological, organisational, and external environment (TOE) theory (Tornatzky & Fleischer 1990), This theory underpins this research and is explained in more detail in section 2.9.1.

1.6.5 Relationships

This research proposes that the retail supply chain performance is impacted by the intentions to adopt RFID. Furthermore, the intentions to adopt are impacted by the level of organisational readiness. In turn, the challenges associated with organisational readiness, including technological, organisational, external environmental and economic factors, impact on organisational readiness. This framework is presented diagrammatically in Figure 1.1.

Figure 1.1: Theoretical Framework



1.7 Research Questions

The framework developed and explained in the Section 1.6 provides the input for the central research question and sub-questions provided below.

The central research question:

How does RFID impact on retail supply chain performance?

There are a number of related sub-questions:

i. How do technological, organisational, external environmental and economic factors impact on organisational readiness?
ii. How does organisational readiness impact on the intentions to adopt RFID?
iii. How do the intentions to adopt RFID impact on retail supply chain performance?

This research study analyses the perspectives of retailers, suppliers to retailers and RFID technology providers operating in Australia in order to answer these questions. For this study, the retail population is defined as organisations selling tangible products likely to contain an identification label and the suppliers who would subsequently be manufacturing or distributing these products. RFID providers represent those organisations manufacturing or supporting technologies associated with RFID.

1.8 Scope of the Research

The RFID in this research encompasses the EPCGlobal model. EPCGlobal is the term used to express the latest RFID configuration being investigated for potential benefits within the retail supply chain. GS1 is the organisation involved in coordinating RFID-related activities within the retail sector, including the development of the EPCGlobal network (GS1EPCGlobal 2008). This research focuses on the GS1 EPCGlobal model and refers to this RFID configuration throughout. The research considers the adoption of RFID within the Australian retail environment, and the unit of measure is organisational.

1.9 Methodology

The philosophy underpinning this research was positivist. Positivists consider research within a realistic world and adopt an external and objective approach (Easterby-Smith et al. 1991). This research has taken a quantitative and empirical methodology, attempting to explore the impact of RFID on supply chain performance. Included in the methodology was an Analytical Hierarchy Process (AHP) based pilot study designed to gather information about the criticality of factors impacting on the adoption of RFID. Surveys were then developed to gather data for the principal analysis. A mail-out method was adopted with the population selected for this study consisting of organisations registered on the GS1 database. GS1 is a non-profit organisation involved in the management of identification systems such as barcodes and RFID for industry (GS1EPCGlobal 2008), and organisations who require access to these systems and support in the management of item identification are members of GS1. Therefore, GS1 members are aware of EPCGlobal RFID. The data obtained from the mail-out was screened in preparation for analysis, which was performed using Partial Least Squares Structural Equation Modelling (PLS-SEM) with predictive capability.

1.10 Importance of the Research

A preliminary examination of the literature identified the benefits of RFID and the challenges associated with adopting this technology. However, a number of gaps were discovered in the literature. First, there are limited empirical studies researching the RFID EPCGlobal model. Second, no research output appears to include organisational readiness as an intermediary between intentions to adopt and the challenges. Very few RFID installations exist, and so this study focuses on organisational preparedness as an essential element for adoption intentions. Finally, no known empirical research has used this model to study the Australian retail sector. This research aims to address these gaps and contribute to the body of knowledge regarding RFID adoption in retail supply chains. The outcomes will assist the Australian retail industry with an understanding of RFID in terms of the criticality of factors, their relationships and influence on retail supply chain performance. The research will also assist managers by focusing their attention on the significant factors and minimising unnecessary allocation of scarce resources.

The initial media hype regarding the potential of RFID has not manifested into widespread adoption (Keating et al. 2010). Some organisations are moving forward and including RFID in their operations, although these are limited to very large retailers such as Wal-Mart, Tesco, Sainsbury and Metcash. However, widespread adoption of RFID is recognised as a plausible scenario at some point in the future (Roussos 2006; Sheng et al. 2010). New knowledge resulting from this study will assist managers by providing an appreciation of the adoption characteristics of an emerging technology. This research also contributes to scholarly work by explaining the characteristics associated with the early stages of IT adoption.

1.11 Outline of the Chapters

Chapter 2 begins a review of the RFID literature, with a background of the technology and describing the technical characteristics. At this early stage, a distinction is noted between the various RFID models and attention is drawn to the EPCGlobal network configuration. A review of the research related to RFID arrangements within industry, including various supply chain applications, and in particular, retailer supply chains applications, is presented. Discussion then focuses on factors impacting on RFID retail supply chain applications. The benefits of RFID applications is explained. Chapter 2 concludes the review of literature with a discussion of the factors challenging adoption intentions. The significance of the technological, external environmental, organisational and economic contexts are discussed as categories encompassing a range of factors. This chapter then summarises the information from the literature review. Chapter 3 provides the theoretic framework and illustrates the factors identified in literature and the relationships between these factors. The closing section provides the data collection instrument and constructs the survey based on the literature review.

The research design, together with the methodology, are explained in Chapter 4. RFID is recognised as a complex emerging technology and the approach of this study is from a positivist lens. This chapter sets the focus for a research design that enables the researcher to discover, identify, describe and then analyse the potential of RFID. Information regarding ethics is provided, followed by the pilot study. A multi-criteria decision method, analytical hierarchy analysis, was adopted to conduct the pilot study. Pilot studies are normally centred on interviews with respective managers; however, this study adopts a structured format. The operationalisation of this technique enabled an examination of the collection of experts' perspectives into the AHP model. This approach was taken to assist in validating the central survey. A discussion of results from the AHP analysis provides a preliminary understanding of factors and their relationships.

Chapter 5 begins by explaining the survey method and the sampling plan. In addition, the population is defined, data collection process and data screening process defined. This chapter then continues with the results of descriptive statistics obtained from the returned surveys of the GS1 members. The 116 usable responses highlight such information as manager positions, geographic location, IT used and other relevant statistics

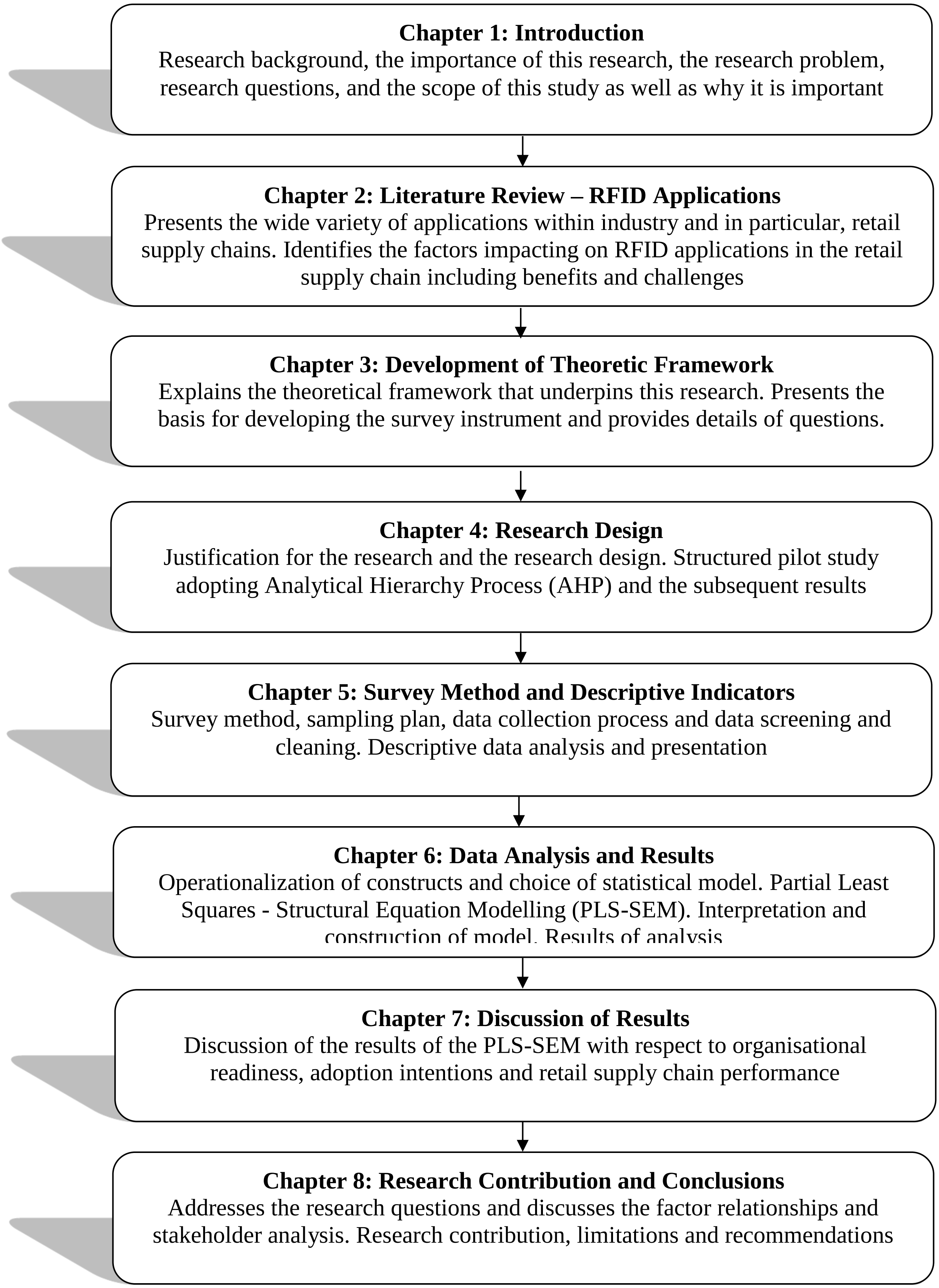
Chapter 6 explains PLS-SEM as the multivariate statistical model used to analyse the data. This chapter justifies the use of this model as an analytical tool and then proceeds to operationalise the technique. Interpretation and discussion of the model parameters are followed by the results of the analysis, including tests of validity.

Chapter 7 presents a discussion of the results based on the analysis presented in Chapter 5. This chapter provides more detail about the PLS-SEM analysis and discusses the measurements and structural components known as the inner and outer models. This chapter also examines the results of PLS-SEM with regards to organisational readiness, intentions to adopt and retail supply chain performance.

Chapter 8 draws the work presented in the preceding chapters to a conclusion. The chapter restates the goal of the research in terms of the research study and subsequent results. Conclusions to the research questions are derived and discussed. The implications of the research are also presented with a view to validating the original worthiness of the research. The chapter also discusses the contribution of the study to academics and practicing managers. The limitations of the research are also presented, as well as the directions future research might take.

Finally, the references and the appendices are presented. A framework illustrating the first eight chapters is included in Figure 1.2.

Figure 1.2: Framework of Chapters



CHAPTER 2: LITERATURE REVIEW – RFID APPLICATIONS

2.1 Introduction

Chapter 2 reviews the RFID literature and provides a foundation for this study's investigation of RFID within Australian retail supply chains. Section 2.2 provides a background on the evolution of RFID and Section 2.3 explains a growing trend in RFID activity, supporting the importance of RFID to industry. The characteristics of RFID are described in Section 2.4., and the discussion narrows in Section 2.5 to explain a specific RFID configuration, known as EPCGlobal, which is the stimulus for the recent increased interest in RFID and is central to this research. In Section 2.6 a number of RFID applications are considered, and the role of RFID in retail supply chains, including the retailer, supplier and technology provider segments, is considered. Factors impacting on RFID are explored in Section 2.7 with Section 2.8 and 2.9 discussing benefits and challenges associated with RFID in the retail sector.

2.2 The Evolution of RFID

RFID has been in existence for many years and a chronological sequence of events that records the evolution of RFID will now be presented. Two early inventions giving rise to RFID were radio waves, discovered by Faraday in 1846, and the Watson-Watts radar in the 1930s (Landt 2001). An historical account presents the major milestones providing the stimulus for the current renewed interest (Chao et al. 2007; Landt 2001). Figure 2.1 provides an overview of RFID history.

RFID began with two important technologies, radio and radar. The literature recognises electromagnetic fields as the fundamental energy source for RFID (Ngai et al. 2005). Faraday discovered this energy source in the early 1800s (Garratt 1994), and Hertz extended the theory, demonstrating radio wave reflection, refraction, polarisation and propagation (Chiesa et al. 2002). Marconi transmitted the first Morse Code signals in 1897, while Alexanderson demonstrated controlled and continuous radio waves in 1906. This represented the beginning of radio wireless communication (Chiesa et al. 2002). Radio wireless transmissions are now well entrenched in modern society, and an important element of many applications.

Figure 2.1: A Brief History of RFID

1846 Faraday: light and radio waves part of electromagnetic energy

1864 Maxwell: equations, the foundation of electrical circuits

1887 Hertz: electromagnetic waves

1896 Marconi: trans-Atlantic radio communication

1906 Alexanderson: continuous waves

1926 Baird: patented radio object detection

1935 Watson-Watt: patented radar

1948 Harry Stockman: communication by means of reflected power

1950's Vernon: application of the microwave homodyne
Harris: patented radio transmission systems with modulatable passive responder

Sensormatic and Checkpoint: electronic article surveillance **1966**

Cardullo: Patented passive RFID **1973**

Los Alamos Scientific Laboratories: RFID research released to public (IDX and Amtex) **1975**

Animal tagging RFID 1**879**

Norway: motor vehicle tollways **1987**

AAR Standard **1991**

All US railcars featured RFID enabled tags **1994**

Massachusetts Institute of Technology uto-ID Centre Freedom **1999**

RFID container tracking in Middle East. EPC system version 1.0 **2003**

Wal-Mart mandate **2004**

Department of Defence mandate **2005**

(Sources: Adapted from Landt 2001 and Chao et al. 2007)

The development of electromagnetic energy also led to the discovery of radar (RAdio Detection And Ranging). Watson-Watt, often described as the father of radar, devised a way to detect aircraft from the ground using radio waves (Buderi 1999). A transmitter sending pulsating signals was turned off momentarily, allowing the same signals to be picked up on their return when they bounced off aircraft. Technicians can calculate aircraft distances and positions because radio waves travel at the speed of light. The 'Chain Home Radar', as it was known, enabled incoming enemy aircraft to be detected during the Battle of Britain (Buderi 1999). An 'identification of friend or foe' innovation used transponders attached to friendly aircraft so that ground crew could differentiate enemy aircraft (Chiesa et al. 2002). The combining of radio and radar technologies formed RFID, and a number of breakthroughs have been recorded during the early development of this technology.

From a scholarly perspective, the journey of RFID is understood to have begun with an article entitled 'Communication by Means of Reflective Power' describing the potential to identify objects from a distance (Stockman 1948). The literature throughout the 1950s also supported an early interest in the potential of radio frequency (Harris 1960; Vernon 1952). There are records of research into radio frequency powered devices during the early 1960s (Shepard 2005). However, the arrival of computers and advancement in integrated circuits, lasers, and digital data networks during the late 1960s precipitated the commercial applications of RFID (Shepard 2005).

Collaborative research began in the 1970s with the formation of several institutes, including Los Alamos Scientific Laboratory in Northwestern University and the Microwave Foundation in Sweden. These organisations concentrated on developing commercial RFID applications (Chiesa et al. 2002). During this period organisations including Raytheon Corporation, RCA, Fairchild Semiconductor, Honeywell and Comsat were established to manufacture and market RFID (Landt 2001; Shepard 2005). Comsat designed an automated toll collection system and patented the first RFID transponder, reader, and interrogation system (Shepard 2005). The Port Authority of New York set up a pilot RFID automatic toll collection system in the early 1970s (Landt 2001) and at about the same time US railways replaced barcodes with RFID transponders on their rail carriages. Readers positioned throughout America tracked all railway stock and provided essential information to optimise rail routing (Twist 2005). During the 1980s, General Motors began to install RFID in their production processes to facilitate work in process tracking during manufacturing (Twist 2005).

However, advancement in RFID began in earnest in the 1990s, with the first RFID-enabled road toll system in Oklahoma enabling automatic collection of tolls from cars travelling on motorways (Twist 2005). Innovative applications such as vehicle tracking, livestock identification, ski passes, anti-theft devices and access entry devices emerged (Shepard 2005). During this period, the commercialisation of RFID applications increased. The formation of the Auto-ID Centre in 1999 was also an important milestone in the history of RFID. The Massachusetts Institute of Technology founded the Auto-ID Centre to coordinate RFID research within five world universities (Angeles 2005; Asif & Mandviwalla 2004).

These events provide an insight into RFID up until the end of the twentieth century. Nowadays, the transponders cited earlier used to identify friendly aircraft during the Second World War have advanced markedly (Lefebvre et al. 2006). Interest in RFID is progressing towards the ambitious vision of an RFID-enabled network using the Internet to create what has been described as the ‘Internet of objects’ (Sweeney 2005). This growing interest in RFID has been recorded in the literature, and the following section captures its recent popularity.

2.3 The Increasing Importance of RFID

The number of publications and patent applications on RFID demonstrate an increasing interest in this technology (Chao et al. 2007; Irani et al. 2010; Taghaboni-Dutta et al. 2009). A review of the literature on RFID between 1991 and 2005 shows a rise in publications, particularly from 2003 (Chao et al. 2007) (see Table 2.1).

The majority of publications were in the context of the US (26.6 per cent), followed by Japan (6.6 per cent), Germany (5.4 per cent), Switzerland (4.7 per cent), South Korea (4.4 per cent) and Canada (3.5 per cent) (Chao et al. 2007).

Table 2.1: RFID Publications between 1991 and 2005

Year	Quantity of publications	Percentage of total
1991	1	0.3
1992	0	0
1993	2	0.6
1994	2	0.6
1995	3	0.9
1996	4	1.3
1997	10	3.2
1998	5	1.6
1999	18	5.7
2000	9	2.8
2001	13	4.1
2002	14	4.4
2003	40	12.7
2004	78	24.7
2005	117	37
TOTAL	**316**	**100**

(Source: Chao et al. 2007)

Another study covered the period between 1984 and 2007 and systematically analyses and synthesises the trends in RFID research output across subject, article titles, locations, document types and publication dates. The results support the contention of a dramatic rise in publications after 2003 (Irani et al. 2010) (Table 2.2). The majority of publications were in the US (25 per cent), followed by Korea (14 per cent). Searches of 834 keywords related to RFID were placed into six categories: reference discipline, 99; external environment, 36; organisational environment, 38; RFID management, 66; RFID technological advancement and development, 489; and RFID applications, 98 (Irani et al. 2010). It is somewhat interesting to note that RFID management, where this research exists, represents only 8 per cent, perhaps suggesting a need for more research in this area. The study included a broad range of literature, covering articles, news, editorial material, letters, reviews and abstracts.

A literature review of RFID within academic journals between 1995 and 2005 also supported the increased interest in RFID and examined the trends in RFID related research (Ngai et al. 2007b).

Table 2.2: RFID Publications between 1984 and 2007

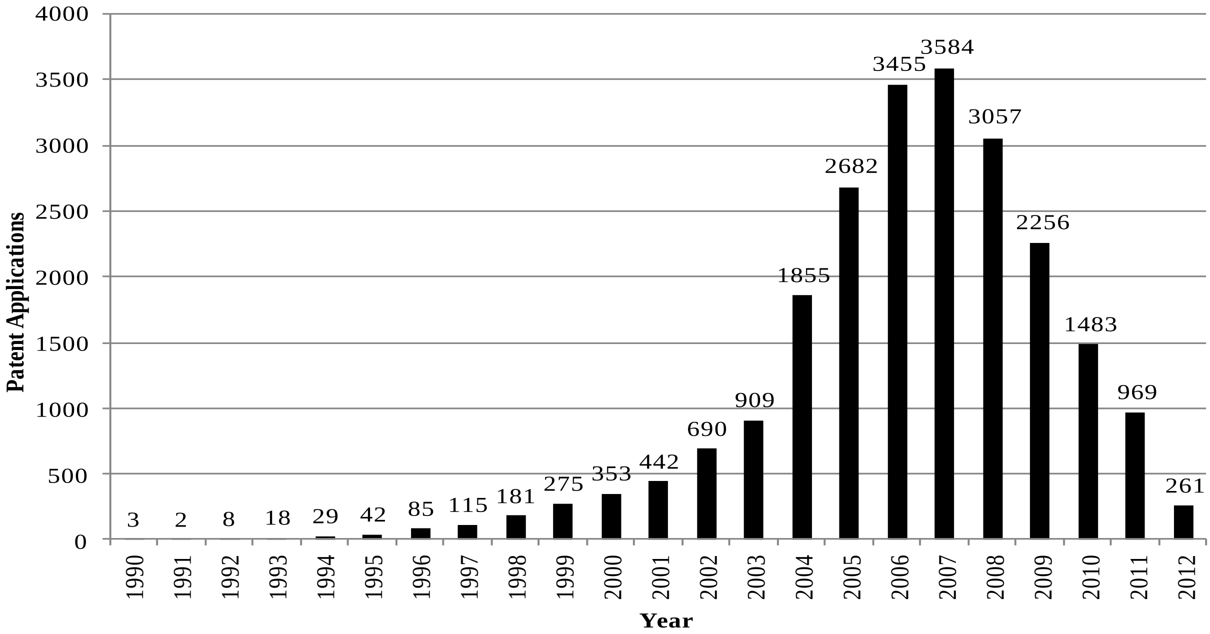
Year	Quantity of publications	Percentage of total
1984	2	0.3
1985	2	0.3
1994	2	0.3
1995	2	0.3
1996	3	0.5
1997	7	1.1
1998	4	0.6
1999	10	1.5
2000	6	0.9
2001	6	0.9
2002	11	1.6
2003	24	3.6
2004	60	9.0
2005	122	18.3
2006	234	35.1
2007	171	25.7
TOTAL	**666**	**100**

(Source: Irani et al. 2010)

This study listed 85 articles from 56 journals. The number of articles per year increased as follows (year, number of articles): 1999, 7; 2001, 3; 2002, 3; 2003, 9; 2004, 22 and 2005, 41). A number of relevant categories for classifying the articles were established. These were technology (36 per cent), application (33 per cent), policy and security issues (13 per cent) and other issues (18 per cent). The majority of application articles were about retailing and library services. These articles discussed the benefits, effects and challenges of RFID, as well as the potential arising from adopting RFID in the retail sector (Ngai et al. 2007b). The small number of articles reflected attention to the quality of the articles chosen. Conference papers, Master's theses, doctoral dissertations, textbooks, news reports and unpublished working papers were excluded and only scholarly articles vetted by the authors ensured a robust RFID orientation (Ngai et al. 2007b).

An analysis of patent applications with the US Patent and Trademark Office (USPTO) related to RFID also supports an increasing level of interest in industry. Figure 2.2 shows the number of patent applications from a search of the USPTO database with the terms RFID or radio frequency technology in the specification/description field. Between 1990 and 2000, there were approximately 76 RFID-related patents per year. Between 2000 and 2007, this number had increased to over 1700 per year. The number of patent applications peaked in 2007 at 3584, and dropped thereafter to 261 in 2012 (UPSTO, 2013).

Figure 2.2: RFID Patent Applications from 1990 to 2012



(Source: UPSTO 2013)

The results of this search may represent the conventional 'technology life cycle', supporting previous studies emphasising the introduction, growth and maturity phases of this cycle (Taghaboni-Dutta et al. 2009). The historical background and current increasing level of interest provides a motivation for examining RFID in more detail. The next sections seek to answer the questions 'What exactly is RFID?' and 'How does it work?'

2.4 Characteristics of RFID

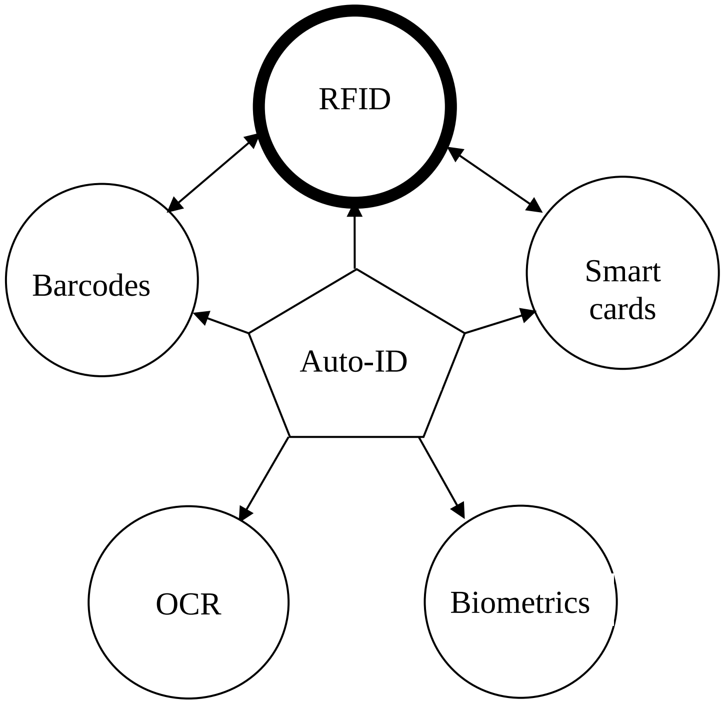
The terminology used in the literature to classify RFID is often broad and ill-defined. For example, Automatic Identification and Data Capture (AIDC), Automatic Data Capture (ADC), and Radio Frequency Data Communication (RFDC) were terms that described the use of radio frequency to capture and communicate data (Furness 2000; Moore 1997; Ross et al. 2009). Near Field Communication (NFC) is a recent term describing the use of radio frequencies to exchange digital content from a variety of devices (Forum 2011). RFID

Electronic Article Surveillance (EAS) is another term describing radio frequency in association with retailing installations used to detect theft (Woyke 2006). Radio Frequency (RF) describes wireless communication installations in factories and warehouses (Kriston 1999). These terms can be confusing, and so Auto-ID is applied to explain RFID characteristics (Finkenzeller 1999).

2.4.1 Automatic Identification

There are a number of unique Auto-ID technologies. These include Optical Character Recognition (OCR), biometrics, smart cards, barcodes and RFID (Figure 2.3) (Finkenzeller 1999, 2003; Rock et al. 2003). Barcodes are closely linked to RFID in the context of this study.

Figure 2.3: Automatic Identification Framework



(Source: Finkenzeller 2003)

2.4.1.1 Barcodes

Barcodes, a well-known Auto-ID technology, are described as a number of bars and spaces printed on a label that can be read by a machine and converted to information (Silvanus 1991). During the 1800s barcodes were invented to overcome problems associated with collecting large amounts of data. For instance, in the US, collecting data on 31.8 million people for the 1880 census took seven years to complete. A search to find better methods resulted in the discovery of a pantograph by Herman Hollerith. This system consisted of a card punched by census-takers on continuous paper and fed onto a drum. The drum's electrified surface registered holes and as a consequence counted the item (Shepard 2005). Shepard (2005) also refers to early commercial barcode applications in the US rail system for tracking freight cars and in General Motors for monitoring production (Shepard 2005). The first item scanned through a supermarket checkout was a packet of chewing gum, in 1973 (Shepard 2005). Barcodes are now widely acknowledged for revolutionising the identification of products (Holmes 2001) and are considered the most accurate and reliable of all the Auto-ID technologies (Cohen 1994). Emerging from its original beginnings at Los Alamos Scientific Laboratories in 1977, barcode technology reportedly took more than 25 years before becoming fully entrenched in industry (Daim & Suntharasaj 2009; Wu et al. 2006).

2.4.2 RFID

A number of texts discuss RFID (Ahson & Ilyas 2008; Bartneck et al. 2009; Brazeal 2009; Finkenzeller 1999, 2003; Glover & Bhatt 2006; Lehpamer 2012; Miles et al. 2008; Ranasinghe et al. 2010; Reyes 2011; Sweeney 2005; Symonds et al. 2009). As an example, Finkenzeller's (2003) second edition 'RFID Handbook' provides comprehensive details of algebraic theories, tag construction, operating and physical principles, electromagnetic theory, frequency theory and system architecture. Since then, several authors have explained the characteristics of RFID (Curty et al, 2007; Schuster 2007). Other literature has provided information on the latest technological advances (Bitkom 2005; Lewis 2004; Wyld 2006). The literature groups the physical technology under the headings of tags, readers, antennae, frequencies and EPCGlobal (Asif & Mandviwalla 2004; Lewis 2004; Swanson 1994; Sweeney 2005). The following sections will explain these factors in detail.

2.4.2.1 Tags, Readers and Antennae

Tags, readers, antennae and associated software form the central components of RFID and all must work in harmony for the entire system to work effectively (Wyld 2006). The tag, or transponder, is attached to a product in order for information to be accessed by a reader (Lewis 2004). Several types of tags have been identified in the literature. Active tags are usually expensive and have a battery powered memory chip, allowing multiple writing to the tag. These tags contain greater information storage capacity and longer read distances. Examples include assets such as shipping containers and similar applications where the value of the product is high (Conneely 2009). Passive tags are cheaper and therefore more appropriate for tracking lower value products. In a passive tag, information written to a memory chip enables radio waves emitted from the reader to wake up the chip and transmit information. Semi-passive tags fall between the active and passive tags, with long readable distances obtained by drawing energy from the reader during communication sessions and only using batteries as a standby (Asif & Mandviwalla 2004; Lewis 2004; Sweeney 2005). Tags have been classified according to their application. For instance, Class 0 tags have information placed on them at the time of manufacture; Class 1 tags allow the user to only write once; Class 2 tags are the most flexible and enable information to be rewritten. Class 3 have sensors capable of monitoring parameters such as temperature or humidity and Class 4 tags have integrated transmitters, enabling communication with other tags (Lewis 2004).

Readers are the interrogators, detecting signals from the tagged products when they pass within range. Reader applications include handheld, mobile or fixed position. Smaller handheld readers and mobile readers are useful for scanning items in a stationary location (Sweeney 2005). Fixed readers installed at appropriate locations, such as dock doorways, enable tagged objects passing through to be automatically identified (Asif & Mandviwalla 2004). The readers ‘interrogate’ multiple tags, without line of sight, as they pass within range. This process is possible due to the development of ‘anti-collision’ algorithms assisting the reader to distinguish between multiple tags (Lewis 2004).

The tag and the reader both have antennae, which enable the transmission of radio waves. These antennae act as aerials to both detect and transmit radio wave signals. The sizes of these antennae range from less than a square centimetre to several square centimetres, and they are described as circular polarised and linear polarised depending on the radio wave direction.

Circular polarised antennae are less sensitive, while the operating range of linear polarised antenna is greater (Asif & Mandviwalla 2004; Lewis 2004; Sweeney 2005).

2.4.2.2 Radio Frequencies

Radio wave frequency is a communication protocol selected for the tag and the reader to exchange information. Because RFID uses radio frequencies, it is subject to regulation by various agencies throughout the world. Radio wave bands have been set aside for use by industry. The industrial, scientific and medical ISM bands are suitable for use by RFID (Finkenzeller 1999; Gerstein & Reisman 1982). These bands are known as ISM-2.4, ranging from 2,400 to 2,483.5 MHz; ISM-5.8, ranging from 5.725 to 5.850 GHz; ISM-900, an ultra-high frequency (UHF) band ranging from 902 to 928 MHz, and microwave, ranging from 2.45 to 5.8 Ghz (Asif & Mandviwalla 2004; Wyld 2006). UHF is suitable for supply chain applications because of the read range (the distance between and tag and a reader), which is typically between 3 to 6 metres. The various frequencies, their characteristics and application areas are summarised in Table 2.3.

Table 2.3: Characteristics and Applications of RFID Frequency Bands

Frequency Band	Characteristics	Applications
Low 100–500 kHz (typically 125–134 KHz world-wide)	Short read range (to 46 centimetres) Low reading speed Relatively inexpensive Can read through liquids Works well near metal	Access control Animal identification Beer keg tracking Inventory control Automobile key/anti-theft systems
High (typically13.56 MHz)	13.56 MHz frequency accepted world-wide Short to medium read range (1–3 mtrs) Medium reading speed Can read through liquids/works well in moist environments. Does not work well near metals. Moderately expensive	Access control Smart cards Electronic article surveillance Library book tracking Pallet/container tracking Airline baggage tracking Apparel/laundry item tracking
Ultra-high 400–1,000 MHz (typically 850–950 MHz)	Long read range (3–10 metres.) High reading speed Reduced likelihood of signal collision Difficulty reading through liquids Does not work well in moist environments. Experiences interference from metals Relatively inexpensive	Item management Supply chain management
Microwave 2.4–6.0 GHz (typically 2.45–5.8 GHz)	Medium read range (3 metres) Similar characteristics to UHF tags, but with faster read rates	Railroad car monitoring Toll collection systems

(Source: Wyld 2006)

The effectiveness of RFID installations depends on harmonising all these components, including the type of tag, the product to which tags are attached, the placement of tags, the tuning of antennae, the brands of components and choice of frequency (Sweeney 2005). Technical issues, together with varying tag costs, have prompted discussion about the capability of tagging at three levels: individual products, cases or pallets. Product-level tagging is considered most technically challenging, complex, costly and difficult to manage at this stage (Sweeney 2005). As a result, individual product-level tagging may not be considered until well into the future (Bottani & Rizzi 2008).

Other factors also define the effectiveness of RFID implementation, including the power source at the reader, the power available at the tag, the size of the reader and tag antennae and environmental conditions and structures (Wyld 2006). The choice of frequency depends on how far the reader and transponder are from each other, what materials exist in and around the area and regulations governing the use of radio waves (Wyld 2006). In addition, the developers and technology providers tend to create proprietary tags, readers, and antennae, causing harmonisation issues. For example, the technology often has to be 'tuned' at each location or risk being ineffective.

2.5 EPCGlobal

EPCGlobal is synonymous with a specific RFID configuration, including an electronic product code (EPC) stored on tags. An EPCGlobal network is being developed to enable information about products to be shared by organisations in a virtual world (GS1EPCGlobal 2008). RFID, in the form of EPCGlobal, is of significant interest to industry and central to this research. EPCGlobal began with the Auto-ID Centre, a European organisation developing technical and commercial RFID applications. EPCGlobal is a joint venture between GS1, originally known as EAN International, and GS1 US, originally the Uniform Code Council. These organisations have vast experience in managing barcode technology systems (Thiesse et al. 2009b). EPCGlobal is a not-for-profit organisation administered by manufacturers, technology providers and retailer members. The organisation's purpose is to manage EPCGlobal products and services, including RFID systems (EPCGlobal 2007).

The EPCGlobal infrastructure used to track products is extensive. Essentially, an RFID tag containing an EPC number is attached to a product. As the product passes by the RFID reader, information is exchanged and processed. The information passes through a SAVANT hierarchy and an Object Naming Service (ONS) tells the computer where information about the product is located. The EPC information system (EPC-IS) then manages events as they take place. A Physical Markup Language (PML) has also been developed to facilitate this environment. A summary of the EPCGlobal characteristics is presented in Table 2.4.

Table 2.4: EPCGlobal Network Characteristics

No.	Classification	Description
i	Identification system	Consists of the EPC tag, readers and antennae used to identify the object
ii	EPC	A unique global numbering system developed for RFID. It is an information numbering system reference administered by GS1
iii	ONS	An index of information sources available used to describe the EPC-numbered tags. Translates the EPC code to an Internet protocol address. The ONS passes on information to the computer system telling it where to find information about that specific EPC number
iv	PML	A language adopted to describe objects, processes and environments. It can be compared to Hypertext Markup Language (HTML), which assists in standardising information on the Internet. PML describes objects for use by both humans and machines, and is a common standard for software applications, data storage and analytic tools for industry and commerce
v	EPC-IS	Acts as a gateway between the user of the information and the organisation's databases. It is a chronological record of tags and their events. These events include quantities, transactions, aggregation and bases. In other words, when, what, where and why
vi	SAVANT	This represents middleware located between the reader and the application system. SAVANT manages very large amounts of information so that the network is not overloaded. The architecture is hierarchical, and lower-level SAVANT processes and filters information to higher levels SAVANT and reduces the load

(Sources: Adapted from Brock 2001; Lee & Kim 2006; Thiesse et al. 2009b; Wamba 2009; Wamba et al. 2008b)

Several studies have explained the tracking capabilities resulting from the implementation of an EPCGlobal infrastructure using the above model (Angeles 2005; Chappell et al. 2002; Twist 2005). For example, a can of soda passes through the field of a fixed reader as it leaves a warehouse. The reader connects to the organisation's enterprise system and automatically reviews the stock, verifies the correct loading destination and notifies the receiver. Global Positioning Systems (GPS) track the shipment as it moves from the warehouse to the retail store. When the truck begins unloading at the distribution centre, readers at the dock door update the stock and identify the cross-dock truck for delivery to the store. When the products reach the store, stock levels and locations are automatically updated as the reader interrogates the tags. Readers positioned on shelves revise the stock when consumers take a can of soda and place it in their trolley. Finally, as the consumer leaves the store, their credit card is automatically updated with the cost of all the items in the trolley via a reader embedded in the door. This vision represents the potential capabilities of RFID (Twist 2005).

With this understanding of the physical characteristics of RFID, an appreciation of the manner in which this technology interacts with the environment will be described in the next sections.

2.6 RFID Applications

2.6.1 RFID Applications in Industry

RFID has advanced considerably from their early tollway applications. For instance, RFID assists libraries, where keeping track of books has always been problematic. Tags attached to books can be switched on when checked in and off when checked out (Coyle 2005). The construction industry is another sector where RFID applications assist in tracking assets. These include tracking pipe spools (Song et al. 2005), tracking tools (Goodrum et al. 2006), concrete processing, labour and equipment scheduling and material control on construction sites (Jaselskis et al. 1995).

There is also increasing evidence of RFID applications in the health sector. RFID assists in keeping track of expensive equipment in hospitals. Hospitals in the US have been recorded as misplacing between 5 and 15 per cent of their equipment each year (Glabman 2004), and studies indicate that RFID has helped reduce this figure (Wicks et al. 2006). Unlike barcodes, which require line of sight and close proximity, RFID enables the remote tracking and location of equipment. Results of research studies suggest that such an application clearly improves preparation activities, maintenance and equipment utilisation (Qu et al. 2010). RFID is also used to track patients in the health sector, where bracelets worn by patients enable hospital staff to monitor their movements (Wicks et al. 2006). This is particularly important for the aged, mentally ill and infants. RFID has provided solutions to many issues such as labour costs, insurance claims, health risks and medication errors (Mehrjerdi 2010).

RFID is also applied in manufacturing facilities for integrating processes, assisting planning and scheduling, indicating equipment status, controlling the actions of robots, managing quality errors and enabling customisation (McFarlane et al. 2003). Automotive manufacturers attach tags to skids carrying auto bodies. These tags enable unique information about the specifications for a particular car to be picked up by readers and passed on to robots for actioning (Shepard 2005). Dell and Boeing have both successfully adopted RFID in their manufacturing environments. Assembly workers at Dell configure computer products based on information obtained from RFID read/write tags (Srivastava 2004). Boeing also attaches RFID tags to spare parts to facilitate global access to details of part numbers, installation dates, life cycle history and manufacturers' information (Asif & Mandviwalla 2004).

This array of applications has provided solutions to problems and ultimately increased productivity and profitability across a range of industry sectors. RFID applications are equally appealing to resolve difficulties in supply chains. The next section introduces RFID applications within supply chains as further testimony for the potential value placed on this technology.

2.6.2 RFID Applications in Supply Chains

The literature provides a number of examples of RFID applications in the supply chain environment. There are several instances of RFID demonstrably improving stocking, storage and product movement operations within warehouse facilities (Albright 2003; Srivastava 2004). For example, RFID was utilised to track paper rolls in a warehouse at a Texas mill. The system coordinated stocking, storage, movement and shipping and provided inventory routing instructions to forklift drivers (Albright 2003). Using a simulation, Ross et al. (2009) were able to compare barcode to RFID in receiving, put-away, order picking and shipping processes in a warehouse environment. The results found that labour costs were three times lower in RFID warehouses, as well as a substantial improvement in the utilisation of administrative activities, compared to non-RFID warehouses. Cross-docking function costs were also found to be 50 per cent lower in the RFID scenario. Choy et al. (2005) studied an RFID-based resource management system within a warehouse environment. Ultra-wide-band readers were positioned throughout the warehouse, passive receivers were attached to forklifts, and tags placed on the dock doors. This enabled information about resources, including material handling equipment and staff, to be captured for analysis. The results indicated improvement in efficiency, reduced costs, increased customer satisfaction and time saving in scheduling activities.

The literature has also provided confirmation of increased commitment to RFID applications within defence force supply chains. The US Department of Defence (DoD) has been attempting to improve inventory management for years. The need to find a more appropriate technology became apparent during the 1991 Desert Storm conflict in Iraq. Army personnel were compelled to open 30,000 containers in the ports of Saudi Arabia to determine their contents and rearrange supplies to troops in the field (Gilligan 2004). This situation became even more critical during the war in Iraq in 2003, with a $1.2 billion discrepancy between goods shipped and goods received (Asif & Mandviwalla 2004). A radically different approach was needed and the DoD began to seriously examine RFID, and in 2004 requested suppliers to tag all products. An extensive global system was developed to track, monitor and manage defence assets (Tegtmeier 2004). The DoD estimated a cost saving of between $1.78 and $70 million per year and payback within three years (Office of the Under Secretary of Defence for Acquisition Technology and Logistics 2005).

The above warehouse and DoD examples are predominantly closed systems. Closed system RFID is only accessible to a single owner or authority (Chiesa et al. 2002; Holmqvist & Stefansson 2006). However, closed systems are not particularly appealing within a supply chain environment. By definition, supply chains require open systems with compatible technologies that enable multiple organisations to share information (Fitchard 2005). Advances in both RFID and Internet technologies have promoted a greater focus on open systems. EPCGlobal networks are being designed around an open system architecture enabling end-to-end exchange of information throughout supply chains (Schuster 2007; Srivastava 2004). Media attention has focused on the potential of RFID applications within the retail supply chain sector. The next section provides details of RFID in the retail supply chain environment.

2.7 Factors Impacting RFID Applications in Supply Chains

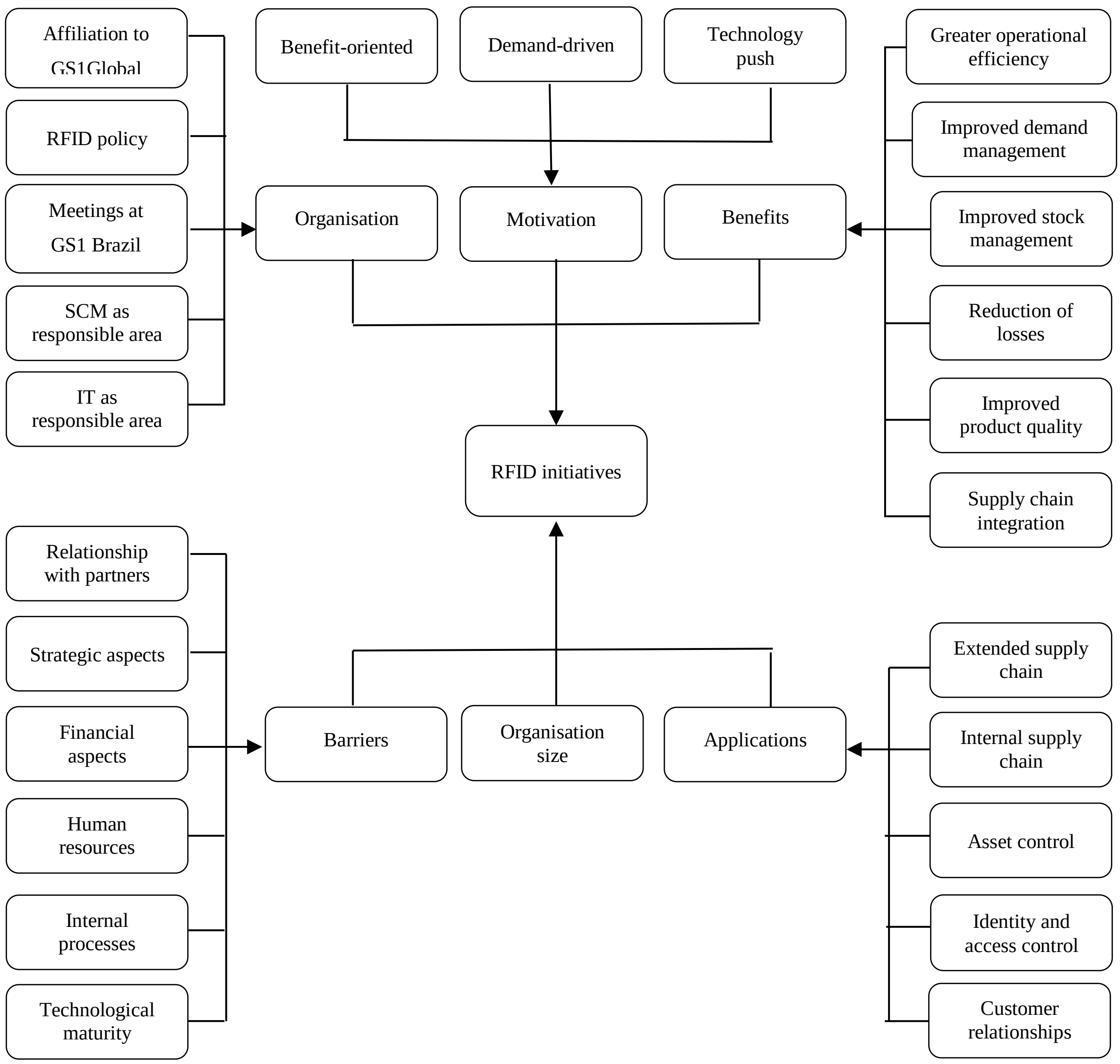
There is a broad range of factors that influence RFID adoption and this is evident within the literature. For example, ‘opportunities and challenges’ (Lai & Hutchinson 2005), ‘benefits’

(Jones et al. 2005; Roh et al. 2009), ‘contributions’ (Azevedo & Carvalho 2012), ‘drivers’ (Pramatari 2007), ‘costs’ (Barut et al. 2006; Hoske 2004), ‘issues’ (Angeles 2005), ‘the quality of information’ (Sellitto et al. 2007) and ‘risks’ (Neumann & Weinstein 2006) are terms used to describe the factors associated with RFID adoption.

Pedroso (2009) provides a valuable insight into RFID applications, expected benefits, barriers and organisational factors (Pedroso et al. 2009). Five different applications of RFID were analysed: extended supply chain, internal supply chain operations, asset management, identification and access control and customer relationship management. The benefits were improvement of inventory management, reduction of losses, greater operational efficiency, better demand management, improvement in product quality, and supply chain integration. The barriers included partner relationships, the strategic impact of RFID on the organisation, financial validation, human resources and culture, alignment to internal processes and technology maturity. The results suggested the motivation for adopting RFID was to improve efficiency through cost reduction as well as to achieve higher levels of customer service. The results also indicated that organisations were more inclined to concentrate on extended supply chain applications (Pedroso et al. 2009). A framework of this study is distinct in Figure 2.4.

A review of articles highlights the term ‘value’ as it relates to RFID adoption and applications (Heim et al. 2009; Lee & Ozer 2007; Microsoft 2006; Tajima 2007; Thiesse et al. 2009a). In trying to determine the value of RFID, Lee and Ozer (2007) discuss a range of models. These authors argued that interpretation depends on what the term ‘value’ means, and offered three methods for interpreting the value of RFID. The first two methods, expert opinions and case studies of pilot implementations, infer that the value is largely based on tests. A third method, deemed to be more useful, was understanding the effect this technology had on the operating characteristics of a system and then examining these new characteristics to determine performance improvements (Lee & Ozer 2007). For instance, RFID has the potential to create visibility, and in turn, advanced knowledge of stock movement and possible disruption (Lee & Ozer 2007).

Figure 2.4: Framework for the Analysis of RFID Initiatives



(Source: Pedroso et al. 2009)

The literature reveals varying levels of value to describe factors associated with RFID adoption. One study of a three-layer supply chain comprising a retailer, manufacturer and supplier offered positive value-oriented results. The findings supported the claim that an RFID EPCGlobal network would improve the shipping, receiving and put-away processes. RFID cancelled, automated, or automatically triggered business processes, positively influencing the sharing of information between supply chain members (Wamba et al. 2008b).

Other studies yielded less than impressive results, with RFID adoption not adding value. Taiwanese retailers in the fashion industry simulated operations of RFID applications in receiving and shipping operations in Small-to-Medium Enterprises (SME). The results showed a 55 per cent labour cost saving in the time it took for an operator to process the receiving and shipping and a 62 per cent labour cost saving for inventory counting (Wen et al. 2010). However, when comparing these savings in labour to the costs of implementing and maintaining RFID, the results indicated that the implementation and maintenance costs far outweighed the benefits from labour savings. This negative result was partially due to the high cost of tags (Wen et al. 2010).

A similar study supported these results and found that RFID was not economically viable. Six manufacturers, five retail distribution centres and four retail stores using an RFID EPGlobal network embarked on an RFID trial. Using a number of economic factors, including discounted cash flow, net present value, and payback period, the results indicated that case-level tagging was uneconomical. Despite positive results at the distribution centres and retail stores, the cost of tags outweighed any benefits. However, the results seemed to be more positive for pallet-level tagging. The manufacturers benefited from reduced safety stock and the retailers benefited from increased efficiency in receiving operations, while the entire supply chain benefited from reduced stock-outs (Bottani & Rizzi 2008).

These limited examples support the view that the adoption of RFID has not taken place in industry because its ‘value’ is not recognised, not understood, or perceived as non-existent (Lee & Ozer 2007). The next sections examine these value elements of RFID in more detail. Firstly, RFID applications in retail supply chains is considered followed by the benefits of RFID application in the retail sector. Finally, the challenges of RFID applications in the retail sector are presented.

2.7.1 RFID Applications in Retail Supply Chains

Retailing involves buying products for selling in stores, operation of the stores to sell these products, and managing the warehouses and trucks for receiving, storing and distributing products to stores (Sen 2007). However while the choice of products to sell is one aspect, a successful retailer is equally focuses on how they sell. In addition, unlike manufacturers, retailers interact directly with the end customer (Sorescu 2011). Retailers are increasingly aware of the trends and recognise that retailing has shifted from transaction based interactions, to enhancing the customer experience (Verhoef 2009). Sorescu (2011) proposes that retailing models include three classifications. Firstly, the structures for organising retail activities into processes described as retailing format. Secondly, retailing activities embracing acquisition, stocking, displaying and exchange of products. Finally, the people involved in retail activities and the mechanisms to motivate their behaviour, namely - governance. These three classifications enable the creation and delivery of a customer's experience (Sorescu 2011).

Based on these three classifications, improvement in retailing, requires changes in terms of value appropriation (operational effectiveness or operational efficiency), or value creation (customer engagement, customer efficiency and customer effectiveness) (Sorescu 2011). Innovative initiatives focusing on operational efficiency often means that changes in one area have a flow on effect into other areas. Zara is one example whereby innovative high turnover of stocking fashion, which was highly visible to customers, required support by less visible upstream supply chain activities. Furthermore, Zara's suppliers also have to reconfigure their own activities to incorporate a supply chain driven by continuously updated forecasting (Sorescu 2011).

Retail supply chains have been at the forefront of supply chain management with retailers recognising the importance of their back end operations for survival. Indeed, a competitive advantage can emanate from effective retails supply chains (Lin & Ho, 2009). Intense competition, significant ongoing change and increasing customer expectations have cumulating in an environment whereby innovations in retail business models is critical for survival (Sorescu 2011).

The power of supply chains historically rested with manufacturers. More recently, however this power has shifted to the retail organisation (Deitz, Hansen and Richey 2009). As a result retail organisations have taken on the role of championing a reliable flow of products across the chain to the retail stores. Internally retail stores needed to balance stock availability at store level against the cost of service. This meant a watchful eye on inventory rationalisation, delivery frequency and transport efficiency (Randall, 2011). Retailers needed to be flexible enough to respond to the variations. For example, during the 2009 economic downturn the focus was on reducing costs. Later, a more balanced approach was needed with a cost/service balance geared towards revenue growth. Agility is identified as one component of effective retail supply chains, in essence, the ability to increase or decrease capacity quickly and with little detrimental impact as possible (Randall 2011). Another important aspect identified is changing the design of the retail supply chain to cover changes in the market place. (Randall 2011).

This flexibility external linkages so that visibility of operations throughout the supply chain is possible. However, the information shared through the linkages and resultant potential visibility leading to improved performance will only be possible if specific resources are present (Barratt 2007). These resources centred predominately on information technology included technology based enablers such as collaborative planning systems, for instance the use of the Internet, as well as people, for example coordinators and managers in customer service (Barratt 2007).

RFID is one technology being considered to assist in the retail environment. The literature has drawn attention to a number of interested parties that are engaged in shaping the future of RFID, such as retailers (Wamba et al. 2008b), manufacturers (Angeles 2005), regulatory authorities (Sweeney 2005), RFID manufacturers (Asif & Mandviwalla 2004), Third Party Logistics (3PL) (Reyes 2007) as well as training and consulting organisations (GS1 Australia 2005). However, retailers are at the forefront of embracing emerging technology and WalMart’s involvement with RFID has been well publicised (Corsten & Gruen 2006; Mehrjerdi 2011; Sullivan 2004). Other larger retailers with the necessary resources and motivation are also positioned to take advantage of such technologies. Marks and Spencer, Tesco, Target, Carrefour and Metro have all have been involved with RFID trials (Angeles 2005; Narsing 2005; Prater et al. 2005; Thiesse et al. 2011).

Equally, several suppliers including Gillette, Proctor & Gamble and Unilever have been closely involved with RFID trials (Angeles 2005; GS1 Australia 2007a). Suppliers recognise the importance of staying close to RFID advancements and monitoring their progress.

In addition, technology providers consisting of organisations that manufacture, market and/or implement RFID to customers are involved in technology developments. Technology providers also consist of service providers such as training, consulting and regulatory organisations (GS1EPCGlobal 2008). These three groups are all involved in determining the potential of RFID as well as examining the challenges restraining its adoption. This study examines all three groups to identify their perspectives about factors influencing RFID adoption and consequently, retail performance.

2.7.1.1 Retailers and their Suppliers

A number of literature sources provide an appreciation and knowledge of RFID applications along the retail supply chain (Harrop 2011; Tsai et al. 2010; Wen et al. 2010). Retailers and their supply chain partners have for many years been involved in collaborative initiatives such as Vendor-Managed Inventory (VMI) (Waller et al. 1999), Continuous Replenishment Programs (CRP) (Vergin & Barr 1999) and Collaborative Planning, Forecasting and Replenishment (CPFR) (Skjoett-Larsen et al. 2003). These practices have been facilitated by IT and a case in point is the Internet, now treated as an IOS (Skjoett-Larsen et al. 2003). Therefore, it is not surprising that retailers have been examining RFID to assist in collaborative efforts to improve their operations (Pramatari et al. 2007).

Wal-Mart is recognised as the largest retailer in the world and a prominent leader in the adoption of cutting edge IT (Mehrjerdi 2011; Sheffi 2004). Wal-Mart’s announcement that it intended to adopt RFID attracted significant media attention. Wal-Mart began examining RFID applications in 2001 and after some encouraging signs decided to adopt RFID in three phases (Angeles 2005).

Phase 1: A limited adoption with one shipment of paper towels on pallets with RFID tags sent to a Wal-Mart distribution centre.
Phase 2: The tracking of cases from multiple first-tier manufacturers (Coca Cola, paper towels, shampoo, razors, cans of deodorant, liquid soap, hygiene products and coffee).
Phase 3: Suppliers tag at item level.

Wal-Mart issued mandates to their suppliers during 2003 (Bednarz 2004; Sullivan 2004; Tong & Tong 2006). Wal-Mart's top 100 suppliers were told they had to install RFID and apply tags to cartons by 2005 (Srivastava 2004). Suppliers were also required to fully implement RFID and connect the network to their own internal enterprise systems. Suppliers, realising the importance of Wal-Mart as a retail customer, began to examine the potential of this technology. However, RFID implementation proved difficult and while some lead suppliers tagged 65 per cent of their products, many were unprepared and tagged less than 3 per cent (Narsing 2005). Problems encountered by suppliers included high costs and inadequate technical support. Suppliers often adopted a 'slap-and-stick' approach whereby tags were simply stuck on cartons with no costly RFID involvement (Narsing 2005). An extension of time was granted to implement RFID. Eventually, eight larger suppliers adopted RFID, complying with Wal-Mart's request (Twist 2005). The eight suppliers were Gillette, Hewlett-Packard, Johnson and Johnson, Kimberly-Clark, Kraft Foods, Nestle Purina Pet Care, Proctor & Gamble and Unilever. However, the impacted products represented only 21 per cent of the estimated 100,000 products found in a superstore (Sullivan 2004).

One Wal-Mart supplier investigated ways that RFID might improve their internal operations. Gillette tracked all cases and pallets of one style of razor during 2003 (Niemeyer et al. 2003). Gillette installed the technology to provide information about the location, delays and due dates for shipping of 'Venus' razors, purchasing 500 million tags and extending this pilot to include United Kingdom (UK) supermarkets. Installation on retail store shelves enabled readers to monitor the removal of tagged razors from these 'smart shelves' and automatically alert a central location of their inventory status (Niemeyer et al. 2003).

Wal-Mart has persisted with RFID installations, although it has acknowledged that it will take some time for RFID to become mature enough to accomplish the objective of improved inventory management (Scott 2006). There are indications that Wal-Mart is still actively pursuing the use of RFID, although it is not progressing to full item-level tagging as originally envisaged (Malone 2012).

Well-known retailers in Europe have also taken part in pilot studies. European retailers Sainsbury, Marks and Spencer, Tesco, Carrefour and the Metro Group have all been examining how RFID might assist their operations (Jones et al. 2005; Thiesse et al. 2011;

Wen et al. 2010). The Metro Group used RFID to track the status of meat, with transponders attached to products so that when stock was taken and reached a certain point, the back room was alerted and replenished with fresh meat. The Metro Group also used RFID to keep track of store promotional merchandise (Metro Group 2009; Ton et al. 2009). However, evidence suggests that the Metro Group's ambitions beyond these examples have not been realised. For instance, a plan by Metro Group to have 250 stores, 10 distribution centres, and 100 suppliers involved by 2005 has not eventuated. As of 2009 there were only 13 stores, 9 distribution centres and 33 suppliers involved (Ton et al. 2009). However, the fact that after four years, the Metro Group is still actively investigating RFID applications is a positive sign.

The literature has also presented the findings of research about RFID in retail supply chains. For instance, one study proposed a distributed network architecture to facilitate RFID-enabled collaboration. The perceptions of retailers and their suppliers were obtained as part of this investigation. The functions examined included back room operations, shelf visibility, OOS responses, remote shelf management, smart pricing, smart recall, in-store promotion and promotion evaluation, demand management and traceability information (Lekakos 2007). The study focused on the relevance of RFID and the importance of collaboration as a prerequisite. Importantly, this study also considered the readiness of organisations in terms of existing collaborative efforts. The results indicated some scenarios were more appealing to retailers than to suppliers. For example, while the value of back room shelf visibility and demand management were equally important to retailers and suppliers, suppliers appeared to place more value on promotion management, while retailers placed more value on smart recall applications (Lekakos 2007). A study by Sari (2010) also examined collaborative efforts with the inclusion of RFID applications. A simulation was undertaken of a four-echelon supply chain operating under different levels of collaboration. The results supported the hypothesis that 'RFID provides significantly greater benefits to a retail supply chain when the level of collaboration between members was more intensive' (Sari 2010, p. 174). A reduction of demand-level uncertainty also resulted from these RFID applications.

RFID applications have also made their way into the retail fashion sector. Fashion exhibits unique issues such as a wide assortment of products, product seasonality, often complex distribution and logistics and the need to react very quickly to trends (Moon & Ngai 2008). A qualitative study involved Kaufhopf, a German department store, and Gerry Weber, a fashion product manufacturer, adopting RFID to track fashion products within their retail supply chain environment. The organisations installed a 13.56 MHz RFID system with reusable tags. The objective was to assess the impact RFID had on workflow in the fashion industry. The study produced positive results, reducing the time for products moving through the fashion supply chain. There were also reductions in labour, improved quality of data and service offerings (Loebbecke 2007). These results supported the reliability of RFID in a 13.56 MHz installation. Throttleman, a Portugal fashion retailer, also examined RFID as an application to overcome the difficulties of manually checking and recording information about products. In addition, there were issues of lead time, inventory accuracy and difficulties in synchronising supply chain information. Throttleman introduced RFID and began a trial attaching tags to garments sourced from Indian manufacturers. Verifying shipments using RFID resulted in increased accuracy and improved item-level tracking and traceability. There was a 60 per cent decrease in stock and a reduction of supply chain inventory from seven days to five days. This example may translate into a fully operational phase, with indications that Throttleman intends to extend RFID into 100 stores (Azevedo & Ferreira 2009).

Several RFID pilot studies have been carried out in Australia. The 2006 EPC Network National Demonstrator Project (NDP) was an EPCGlobal trial conducted in Melbourne involving a consortium of retailers, suppliers, technology providers, transport providers and materials handling organisations. The objectives were to identify where RFID could improve business processes and deliver real benefits to supply chain members. The results were mediocre, with technical and operational difficulties being encountered. However, this trial did prove that a single set of global RFID standards within an EPC network could integrate suppliers and customers (GS1 Australia 2006).

A repeat trial during 2007 capitalised on the lessons learned during the earlier attempt and used more advanced technology. The National Demonstrator Extension Project focused on integrating business processes through tracking and management of pallets. The procedure involved tagging CHEP pallets with RFID labels and placing readers throughout the supply chain to monitor pallet movements. Linfox transported the pallets between a number of retailers and their supplier warehouses in two Australian states. Masterfoods, Proctor & Gamble, ACCO, and Westgate Logistics and CHEP Pallets were also involved in this trial. The objectives were to achieve electronic proof of delivery, paperless delivery, investigate data management and integration requirements, develop commercial pathways and promote interoperability through global standards (GS1 Australia 2007a).

The assessment included three key performance indicators:

KPI 1: Inventory management/delivery accuracy.

KPI 2: Process efficiency gains.

KPI 3: Cost savings calculated by converting the hourly process efficiency gains by the labour rate.

The results from the extension project were positive, with up to 100 per cent read rates as well as productivity gains of between 14 and 22 per cent. Processes were streamlined and CHEP succeeded in eliminating five manual steps within customer receiving, pallet hiring and pallet de-hiring processes. These included pallet quantity checking, signing paperwork, entering information into computer systems and filing. This enabled a 28 per cent reduction in end-to-end processing time for each delivery. Participants were able to access real-time information on pallet movement and location details (Mo et al. 2009).

Notwithstanding these impressive results, the participants acknowledged a number of challenges arising from the trial. Connectivity with participants' existing systems proved difficult, and interference from a number of sources caused an unacceptable number of false reads. Reports of tags not working on wet pallets, readers not compatible with Australian standards, read distances varying, and different readers displayed different results with the same tags creating significant uncertainty. Technology 'tuning' was required before the read rates were acceptable. Despite efforts to eliminate these issues, CHEP conceded that they could not move the RFID model into production (GS1 Australia 2007a). Unlike the earlier NDP project, the extension project did examine cost savings through the conversion of productivity gains. Average savings of $15,000 were calculated per annum, and with an initial investment of $100,000, indicated a 6.70 year payback. The consensus was that 'tangible savings estimated from the pilot study were not sufficient to substantiate the project' (Mo et al. 2009, p. 883).

Difficulties such as those cited above have resulted in most organisations delaying full implementation, or shelving RFID projects altogether, until future advances eliminate these issues. A survey of retail organisations within South Africa possibly sums up retailers' attitudes with the results showing low interest in adopting RFID and a 'wait and see' approach (Brown & Russell 2007).

2.7.1.2 Technology Providers

Technology providers market and distribute RFID and assist organisations in implementing and supporting retail supply chain applications. The advancement of RFID has been due to considerable effort on behalf of technology providers. However, apart from suggestions that RFID is a complex technology and therefore technology providers needed to explain the impact of IT processes and strategies and improve their communication (Leimeister et al. 2009), few literature sources discuss these stakeholders. This research study includes regulatory authorities, consultants and industry associations as part of this category (GS1EPCGlobal 2008).

There have been a considerable number of white papers and reports published by technology providers and consulting organisations. These include an overview of RFID (Lewis 2004), technology systems and applications (Bitkom 2005), supply chain applications and benefits (Maloni & DeWolf 2006), RFID in fashion (Motorola 2012), product protection (Downs et al. 2011) and the value of RFID (Zebra Technologies 2005). These articles often highlight the benefits of RFID and allude to the fact that unless organisations adopt RFID they risk being left behind. However, the challenges associated with RFID have not been solved to industry's satisfaction (Smart et al. 2010).

Furthermore, technology providers have often absorbed the costs associated with development. For instance, RFID manufacturers are highly fragmented, with larger organisations continually offering new products in an attempt to gain an advantage. Some technology provider organisations are newly formed, such as ODIN technologies, OAT Systems, Alien Technology, in addition to existing providers like Symbol Technology and Intermec (Smith 2006). There is a suggestion that newly formed technology providers may not have a vested interest in maintaining the current systems and so will be more likely to succeed in providing cutting edge technology (Spekman & Sweeny 2006).

Technology providers attempt to gain competitive advantages through patent application approvals. This has raised questions about the role of technology providers. For example, Intermec Tec, an organisation that provides hardware, software and services associated with RFID, holds various patents in EPCGlobal's Gen2 technology. Organisations that want to install this technology require a license from Intermec Tec. Zebra, Symbol and SAMSys applied for, and were granted, licenses while other organisations decided not to participate. This situation has prompted some US technology providers to form consortium patent pools (Bovenschulte et al. 2007; Taghaboni-Dutta et al. 2009). Taghaboni-Dutta et al. (2009) provided some insight into the technology providers' environment, which is dominated by fierce competition, and recognised Intermec Tec as a major player. Using information from USPTO, 157 RFID patents and their respective technology providers were analysed between 1995 and 2006. The main providers listed as holder of patents in this field were Intermec Technologies, Symbol Technologies, Sensormatic Electronics Corporation, Avery Dennison Corporation, Applied Wireless Identifications Group, Alien Technology Corporation and Moore Wallace North America Incorporated. Adopting a cluster method, the following groupings of RFID patents were offered:

RFID concepts: Antenna, reader, person, interrogation zone, data storage.
Optical ID: Optical reader, light beam, barcode, reading indicia, barcode symbol.
RFID apparatus: Tag, circuit, communication, identification, transponder.
RFID architecture: Wireless, access, item, protocol, processor, personal digital assistant.
Others: Standard, flexible, metal compensation, circuit enabler.
Table 2.5 presents the patent approval information between 1995 and 2006.

Table 2.5: RFID Patent Approvals between 1995 and 2006

Organisations	RFID concepts	Optical ID	RFID apparatus	RFID architecture	Others	Total	Percent
Intermec Tec	16	5	43	6	5	75	48.0
			RFID Patent Pool				
Symbol Tech	7	16	2	14	5	44	28.0
Sensormatic Electronics	8	7	2	3	0	20	12.5
Avery Dennison	1	0	2	2	3	8	5.0
Applied Wireless ID	4	0	0	0	2	6	4.0
Alien Tech	3	0	0	0	0	3	2.0
Moore Wallace NA	0	0	1	0	0	1	0.5
Total	39	28	50	25	15	157	100

(Source: Taghaboni-Dutta et al. 2009)

The following section considers the factors impacting on the retail sector's intentions to adopt RFID. First, an overview of factors will be provided, followed by the benefits of RFID and then the factors challenging RFID intentions to adopt will be discussed

2.8 Benefits of RFID Application Benefits in the Retail Sector

Benefits are a major reason why organisations are examining the potential of RFID and considering adopting RFID. The literature describes direct benefits, including cost savings and improvements in lead time, and indirect benefits, such as the creation of new business processes (Bhattacharya et al. 2007; Roh et al. 2009).

The primary benefits of RFID are the capability to automate existing processes, leading to lower labour costs, the creation of new processes with higher levels of visibility, production of innovative services and improving the quality of information and thus enabling better decisions (Lekakos 2007; Sellitto et al. 2007). Other benefits include increased accuracy, lower inventory levels, decreased shrinkage and lower levels of OOS (Lee and Ozer 2007). Vijayaraman et al. (2008) identify benefits including meeting customer requirements, closer connection to business partners, improving the ability to track goods and efficiencies on shipping and receiving.

The breadth of the potential benefits arising from the adoption of RFID is evident in the literature, although these benefits are sometimes ambiguous, being described in terms such as ‘improving customer service’ (Harrop 2011) or ‘enhanced inventory management’ (Lacy 2004). Likewise, the benefits of RFID, such as improved forecasts, reduced inventory, reduced stock-outs and increased revenues, are not always supported with evidence of how these benefits might eventuate (Lee & Ozer 2007). To improve the understanding of the benefits associated with RFID adoption some authors adopt categories of benefits (Becker et al. 2010; Visich et al. 2009). A review of literature concentrating on these categories will help in understanding the potential of RFID. For example, Visich et al. (2009) reviewed the literature grounded in empirical studies and adapted Mooney’s model of business processes (Mooney et al. 1996). They identify factors relating to operational and managerial processes and cross-tabulate the results in terms of automational, informational and transformational factors. Within the operational processes, their review of the literature found 55 examples relating to the value of RFID. The vast majority of these sources were identified with automational features (47). The rest were informational (5; e.g., container utilisation, responsiveness and reduced waste), and transformational (3; e.g., process redesign) (Visich et al. 2009). The conclusions of their analysis supported the idea that RFID is an emerging technology with automation being the first phase of this cycle. Within managerial processes, the results were inclined towards informational impacts, such as effective sales, coordination of retail promotions, reconciliation improvement, better quality decisions, better resource usage and production control. The review found no discernible automational or transformational impacts related to managerial processes (Visich et al. 2009). Although limited in terms of secondary sources and perhaps inconsistent in measurement definitions, this study did support the judgement that RFID is a valuable tool.

Another study extended the previous focus by Visich et al. (2009) and incorporated four RFID effects from a process view. Becker and colleagues (2010) discussed the difficulty in measuring the value of technology and introduced a multi-perspective reference model categorising the business value of RFID into different scenarios to assist:

- Process time reduction through automating previously manual jobs. Examples include data entry and data processes automation.
- Error reduction, through RFID correctly collecting data and processing it.

- Reduction in resource consumption and material minimisation. Examples include the elimination of printed commissioning lists, reduction of depreciation for commissioning and the consumption of less fuel.
- Improved process information, leading to more effective and efficient processes. This also included the levels of information granularity and timeliness (Becker et al. 2010).

Becker's (2010) reference model then converts as-is to to-be processes by means of automation, transformation and a combination of the two, defined as joint transition. A case study supported an improvement in operations along the ordering, goods receipt and warehouse assignment. Although there was no empirical data available to support this concept, the results provide a useful way of depicting RFID value.

A similar study investigated the relationship between expected benefits and RFID applications (Roh et al. 2009). First, categories were established comprising internal solo applications, multiple solo applications, internal integrated applications, and multiple integrated applications. These categories were defined according to the number of organisations as well as the level of integration with other technologies. In addition, the levels of scale, scope and impact provided a comprehensive classification framework (Table 2.6).

Table 2.6: Classification of RFID Adoption

Category	**Internal solo application**	**Multiple solo application**	**Internal integrated application**	**Multiple integrated application**
Definition	RFID in one organisation: taking advantage of its tracking accuracy and convenience	RFID in more than two organisations to track and manage inventories or products	RFID with other technologies in one organisation to create new business processes and provide cost savings	RFID with other technologies or systems in more than two organisations, creating new processes
Scale	Low, single organisation	High, multiple organisations	Low, single organisation	High, multiple organisations
Scope	Low, RFID alone	Low, RFID alone	High, integrated with other technologies	High, integrated with other technology
Impact		Economies of scale, supply chain integration	Economies of scope	Economies of scale, economies of scope, supply chain integration

(Source: Roh et al. 2009)

Second, the benefits identified in the literature were categorised according to the following:

- Cost savings from reduced shrinkage and labour reduction.
- Visibility, which relates to the organisation's ability to track products as they move through the supply chain. This reduces bottlenecks, decreases the bullwhip effect and allows better coordination efforts between supply chain members.
- New business creation through new products or processes (Roh et al. 2009).

The final stage considered these three categories of benefits in relation to specific applications. Organisations in multiple integrated and multiple solo categories enjoy higher cost savings. Equally, these organisations also gain greater benefits from visibility. New process creation was more likely to be apparent with organisations in the multiple integrated applications category, where they benefit from strategic application. The study positioned retail cases such as Wal-Mart and the Metro Group in the multiple solo and multiple integrated application cells suggesting that these organisations were at the forefront of applications Table 2.7. (Roh et al. 2009).

Traditional operations management frameworks have also been applied to assist in categorising benefits. A multi-case analysis studying service industries adopted a framework of cost, quality and speed. These factors originated from world-class organisations' attempts to achieve high performance (Ferrer et al. 2010).

Table 2.7: Categories of Benefits and Applications

	Expected benefits			
	Internal solo application	**Multiple solo application**	**Internal integrated application**	**Multiple integrated application**
Cost savings	Low	High	Medium	High
Supply chain visibility	Low	High	Low	High
New process creation	Low	Medium	Medium	High
Examples	Legoland	Wal-Mart, International Air Transport Association	Johnson Controls	Intel, Metro Group

(Source: Roh et al. 2009)

The cases were examined to determine where RFID would impact on these factors and the results recorded. This research found cost benefits in terms of capacity expansion, reduced cycle time, self-service and automation. Quality benefits were defined as spoilage control, greater ability to match a person to a service, security and safety and loss prevention. Finally, speed benefits were attributed to RFID tracking movement. Four RFID attributes were consistent across all cases: tracking movements, automation, reduced cycle time and personal security and safety. The authors concluded that RFID should be adopted in service environments if it can assist in reducing labour, reducing errors, increasing ability to customise or add new features like theft prevention or personal security (Ferrer et al. 2010).

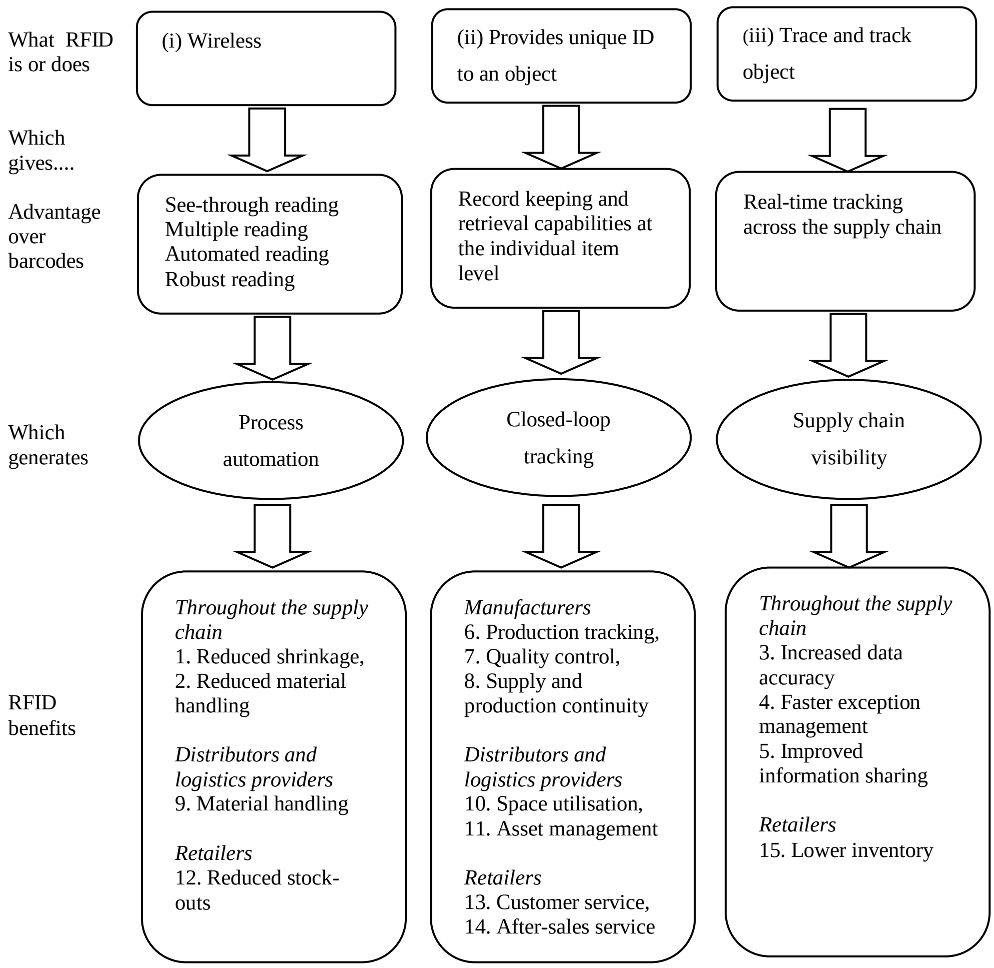
RFID benefits have also been described at points along the supply chain. Tajima (2007) identified 15 benefits at various stages along the supply chain:

- <u>Throughout the supply chain</u>: reduced shrinkage, reduced material handling, increased data accuracy, faster exception management and improved information sharing
- <u>At the suppliers (manufacturers)</u>: production tracking, quality control, supply and production continuity
- <u>At distributors and logistics providers</u>: material handling, space utilisation and asset management
- <u>At retailers</u>: reduced stock-out, improved customer service, after-sales service, and lower inventory (Tajima 2007).

The above benefits were further considered in terms of what RFID is or does, the advantages over barcodes, and how RFID might be applied. What RFID 'is or does' was defined as wireless, providing unique identification and track-and-trace. Advantages over barcodes were defined as see-through reading, multiple reading, automated reading, robust reading, record keeping and retrieval capabilities at the individual item level and real-time tracking across the supply chain. The three uses identified were process automation, closed loop tracking and supply chain visibility.

Although visibility was recognised as one of the primary benefits, Tajima (2007) argued that this benefit would only be realised if and when there was mass rollout, partner collaboration, and the necessary infrastructure. The other two benefits—process automation and closed loop tracking—were judged to be more inclined to provide a competitive advantage. At this stage, Tajima (2007) proposed automation would produce supply chain efficiencies and therefore a motive for investing in RFID in the short term. Closed loop tracking would then realise innovation over a longer term (Tajima 2007). The resultant benefits from each of these and their requisite position in the supply chain are noted in Figure 2.5. However, there may be cause to consider the starkly different technology systems between closed loop and open loop RFID configurations. Closed systems are considered low risk, low cost and low process complexity, while open systems exhibit medium/high risk, medium/high costs and medium/high process complexity, with increasing dependence on external organisations (Fontanella 2005).

Figure 2.5: Alternative Framework of RFID Benefits



(Source: Tajima 2007)

The Supply Chain Operations Reference Model (SCOR) is another useful tool that has been adopted to assist in categorising benefits. A study was undertaken to investigate the impact of

RFID on supply chain activities throughout a single five-layer supply chain including supplier, distribution centre, store, operator, and any recycling (Bendavid et al. 2009). The SCOR model was used in this study and observations of supply chain activities compared to RFID simulations conducted in laboratories. Performance measures were adopted in this study and both horizontal and vertical Key Performance Indicators (KPIs) were established. The horizontal KPIs were the high-level supply chain's collective performance, including reliability, responsiveness, flexibility and asset management efficiency. The proposition was that any weak link throughout the supply chain could have an adverse impact on an organisation's performance.

Vertical KPIs were considered more suitable for individual organisations and examples included days of inventory, inventory carrying costs, capacity utilisation, downtime and number of components reworked. These depended on the specific level of the supply chain, ranging from the supplier, distribution centre, store, operator and finally, recycling. The premise for vertical measures was that individual organisations would attempt to improve their own performance (Bendavid et al. 2009). The results of this research showed performance improvements in several areas. For example, RFID benefits were identified from automating picking and put-away lead times, as well as product identification activities. More importantly, integrating RFID throughout a supply chain improved inventory visibility, enabling suppliers to anticipate demand and thereby optimise production capacity.

Overall, RFID improved 'collective performance' and RFID was an enabler for collaborative integration opportunities (Bendavid et al. 2009).

Several cross-national studies have also been undertaken to determine if there were any differences between countries in their perspectives on the value gained from adopting RFID. A cross-national comparison of 463 German and 157 Italian organisations assessed the perceived potential and strategic importance of RFID. This study was important because it provided evidence that the benefits of RFID, in terms of relative advantage, the organisation's size and the organisation's experience with RFID, all had a positive relationship with the strategic importance of RFID. Likewise, the strategic importance of RFID had a positive relationship with intentions to adopt RFID (Leimeister et al. 2009). There were different views about the value of RFID, with the German Chief Information Officers (CIOs) highlighting increased quality, automation and customer services as well as reduced counterfeiting as benefits. On the other hand, the Italian CIOs identified reduced stock inconsistencies, optimised stock keeping and improved customer service as benefits (Leimeister et al. 2009).

A similar cross-national study of US and South Korean retail and logistics organisations examined the importance of RFID. This study assessed the benefits and risks associated with adopting RFID and the impact on business performance (Park et al. 2009). The major benefits identified were improved inventory management, supply chain efficiency, operational efficiency and an integrated business process. The three major risks were lack of expertise, technical complexity and technical uncertainty. There were no discernible differences between the US and Korea, although South Korean organisations perceived significantly higher levels of RFID impact than their US counterparts (Park et al. 2009). However, the authors did not discuss the potential reasons behind the similarities and differences between these two nations.

The well-publicised Wal-Mart RFID environment has also been examined to determine the value achieved from adopting RFID (Delen et al. 2007; Hardgrave et al. 2008, 2009). Wal-Mart, one of the largest operational RFID EPCGlobal network facilities, anticipated substantial savings from deploying RFID. Wal-Mart intended to achieve these savings through reduction of shrinkage and theft ($575 million), warehouse item tracking cost reduction ($300 million), inventory reduction ($180 million) and labour reduction ($6.7 billion) (Poirier & McCollum 2006). While these intentions did not fully transpire, nevertheless, data from inventory movements between Wal-Mart retail stores and their distribution centres confirmed positive results (Hardgrave et al. 2008). Twelve RFID-enabled Wal-Mart stores and twelve control stores without RFID were examined during normal operations by the University of Arkansas. The trials ran over 29 weeks from February 2005, with 4,554 RFID tagged products. Stores with RFID installed were found to outperform stores without RFID in terms of on-shelf availability. A 21 per cent reduction in OOS products was confirmed and other benefits included replacement of stock three times faster as well as a decrease in manual orders submitted by RFID-enabled stores (Hardgrave et al. 2008). The results of a further study on the impact of RFID on perpetual inventory were also encouraging. Over 23 weeks, the investigators tracked air freshener products in eight RFID-enabled stores and compared the results to eight control stores without RFID. The results confirmed that adopting RFID did make a difference. RFID readers interrogating tagged products entering the stores were configured to automatically adjust understated perpetual inventory level. Consequently, a 13 per cent reduction in understated items was established (Hardgrave et al. 2009).

Wal-Mart's supply chain was also studied to determine if processes improved as a result of this newly captured data (Delen et al. 2007). Adopting a mean time between movement algorithm enabled specific processes to be measured and adjusted. The results suggested product movement from distribution centres to retail stores had noticeably better visibility due to RFID installations. For example, the time stock sits in back rooms triggered changes in the transport system's performance. The key to these benefits was described as the business value obtained from the creative use of the data (Delen et al. 2007).

2.8.1 Inventory Availability

This section reviews the literature addressing how RFID might assist in improving inventory availability. A major issue for the retail sector is making sure that products are available when customers need them. Having products available presents a significant benefit for retail organisations. Retailers attract customers because they have a large variety of goods at the one location, with up to 30,000 products at any one time (Broniarczyk & Hoyer 2006). The extensive range of products often found in retail environments increases the likelihood of products not being available when customers need them. Organisations strive to find a balance between the costs associated with having too much inventory available and having products OOS.

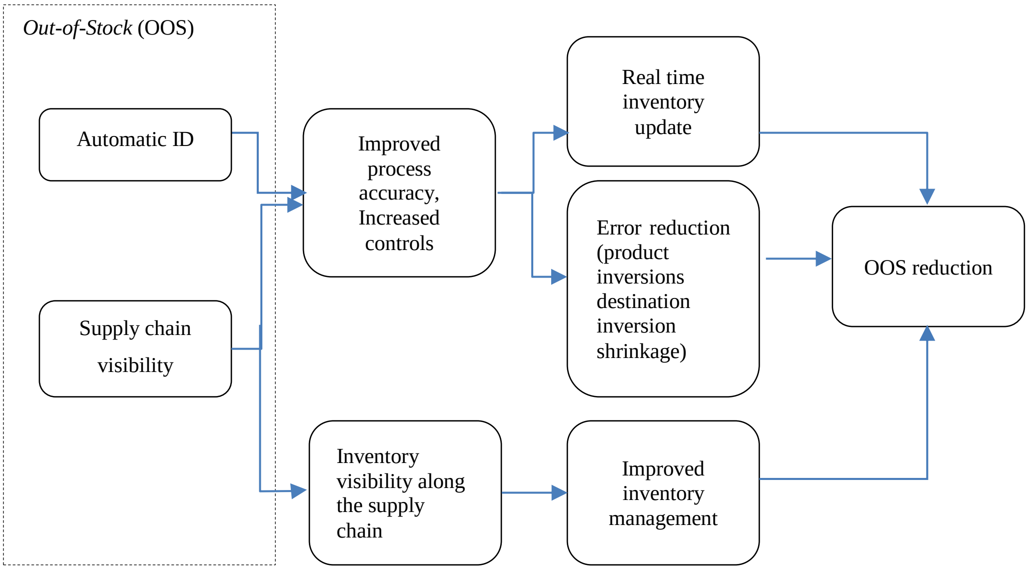
OOS situations occur as a result of store mismanagement, such as failure to order the product, unexpected demand spikes, mistakes within the retail store, ordering too little or too late, misjudging demand, inadequate shelf space and inventory inaccuracy. OOS also occurs as a result of retail back-of-store mismanagement as well as failure of the head office to communicate with the store about initiatives such as discontinued items (Corsten & Gruen 2003; Verhoef & Sloot 2006). The consequences of being out of a product might include customers purchasing a substitute with little negative impact, postponement, switching stores or cancelling purchases. Consequently, OOS is a major concern for retailers and becomes a bottom line measure of performance (Verhoef & Sloot 2006).

Lost sales as a result of products not being available due to OOS costs US stores between $4 billion to $12 billion every year. Retailers are equally concerned about customer dissatisfaction due to not being able to purchase the desired products (Krafft & Mantrala 2006). These figures equate to around 8 per cent of products being unavailable to customers, representing 4.0 per cent of sales (Corsten & Gruen 2003; Hardgrave et al. 2008). The extent of the problem was described by Gillette with an estimated OOS equivalent to USD 30 billion dollars. A one percentage decrease in OOS would increase sales by USD 1 billion (Erickson & Kelly 2007).

The adoption of RFID to improve product availability by reducing OOS and shrinkage has been the subject of several investigations (Rekik et al. 2009; Roh et al. 2009; Ton et al. 2009). RFID has superior tracking capabilities and is able to continuously review on-the-shelf inventory so that replenishment is not compromised (Erickson & Kelly 2007; Szmerekovsky & Zhang 2008). RFID also has the potential to increase visibility and consequently inventory records in the system match the actual inventory position and ultimately lead to more accurate replenishment. Equally, inventory can be monitored so that there are fewer misplaced products and less theft. The overall outcome is performance improvement and increased sales revenue (Lee & Ozer 2007). Finally, enhanced information provided from adopting RFID also enables organisations to reduce the amount of safety stock (Erickson & Kelly 2007).

Miragliotta et al (2009) proposed the adoption of RFID to assist in reducing OOS. Adopting RFID would enable greater levels of supply chain visibility and hence increase the accuracy of inventory information in shipping and receiving processes (Miragliotta et al. 2009). This study, focusing on the warehouse processes in the fast-moving consumer goods (FMCG) sector, found that the quantity and quality of products received at a store was a ‘contentious issue’. In other words, quantities were likely to be incorrect and the quality faulty. RFID would improve process accuracy, increase controls, reduce errors (products and destinations) and increase responsibility at each stage of the supply chain. RFID could be adopted to eliminate these issues (Miragliotta et al. 2009). A simulated profitability assessment model based on a manufacturer and retailer tested two main approaches: pallet units and pallet and case units against a baseline control. The results indicated pallet tagging applications would only assist the manufacturer, while RFID applied to cases and pallet units would benefit retailers. However, the tag costs would be paid by the manufacturer and therefore any conflict would need to be resolved by either lower tag costs or the sharing of costs between the manufacturers and retailers. Item-level tagging was not used in this study (Figure 2.6) (Miragliotta et al. 2009).

Figure 2.6: Assessment of Out of Stock Reduction



(Source: Miragliotta et al. 2009)

Although inventory availability is primarily a retailer issue, retailers and suppliers working together have examined ways to reduce OOS through collaborative techniques such as CPFR and VMI, all facilitated by RFID (Corsten & Gruen 2003; Fleisch & Tellkamp 2005). Much of Wal-Mart's success has been attributed to increasing the level of inventory availability through collaborative methods (Stalk et al. 1992).

A study from Turkey has examined the impact of RFID on logistics processes with a three-tiered supply chain using a simulation model (Ustundag & Tanyas 2009). The receiving, put-away, counting, picking and shipping activities were examined in a pull-based system represented by the manufacturer, distributor and retailer (Ustundag & Tanyas 2009). Collaborative integration brought about by introducing RFID would diminish the difference between system quantity and actual quantity throughout the supply chain. This proposal was tested using simulation to find out how the product value, lead time, and demand uncertainty impacted on the supply chain after RFID was introduced. The independent variable values progressively increased from the manufacturer to the retailer. For example:

i. Manufacturer: value $5, lead time 2 days, uncertainty 10 per cent.
ii. Distributor: value $15, lead time 4 days, uncertainty 30 per cent.
iii. Retailer: value $80, lead time 6 days, uncertainty 50 per cent.

The results indicated that the main drivers of RFID adoption were operational efficiency, accuracy, visibility and security. These would lead to lower inventory, increased product availability and increased sales. These drivers also impacted positively on cost factors including labour costs, inventory costs, ordering costs, lost sales costs and theft costs (Ustundag & Tanyas 2009). A further important contribution of this study was the notion that RFID can play a dual function in terms of identifying and tracking products as they move between locations as well as act as a sensor for detecting theft (Ustundag & Tanyas 2009).

Product availability and OOS positions are closely linked to product shrinkage. Shrinkage is defined as the reduction in available products due to spoilage, obsolescence, record inaccuracy from errors as well as internal and external theft (Evans et al. 1999). The result is a discrepancy between what the computer states should exist in a store and what actually exists (Chapman & Templar 2006; Rekik et al. 2009). Research has estimated the scale of shrinkage in the European FMCG at 2.41 per cent of the sector, with 27 per cent from process errors, 7 per cent deception, 28 per cent internal theft and 38 per cent external theft (Rekik et al. 2009). Once again, RFID is being examined to identify its capacity to reduce shrinkage levels (Fleisch & Tellkamp 2005).

This section has outlined the benefits of implementing RFID. These were found to be wide-ranging, with internal organisational benefits such as improved demand management (Pedroso et al. 2009) through to entire supply chain benefits such as improved information sharing (Tajima 2007) and visibility (Roh et al. 2009). The success of supply chains are identified with respect to these benefits and therefore will be taken as synonymous with performance measures. This research categorises these benefits as performance measures and Table 2.8 presents a summary of these benefits.

Table 2.8: Benefits of Adopting RFID

Measures of Performance	Source
Productivity	Attaran 2007; Becker et al. 2010; Bendavid et al. 2009; Chavadi & Kokatnur 2009; Heinrich 2005; Karkkainen 2003; Lapide 2004; Lekakos 2007; Lewis 2004; Ngai et al. 2005; Park et al. 2009; Pedroso et al. 2009; Sweeney 2005; Vijayaraman et al. 2008; Visich et al. 2009
Increased information accuracy	Angeles 2005; Attaran 2007; Bardaki et al. 2007; Hardgrave et al. 2008; Lee & Ozer 2007; McFarlane 2002; Narsing 2005; Sweeney 2005; Tajima 2007; Twist 2005; Vijayaraman et al. 2008
Increased tracking capability	Angeles 2005; Attaran 2007; Bardaki et al. 2007; Ferrer et al. 2010; Lee & Ozer 2007; McFarlane 2002; Narsing 2005; Sweeney 2005; Tajima 2007; Twist 2005; Vijayaraman et al. 2008
Improved traceability	Bottani 2009; Kelepouris et al. 2007; Lee & Park 2008
Process optimisation	Bartneck et al. 2009; Borthick et al. 2008; Bovenschulte et al. 2007; Lefebvre et al. 2006; Wamba et al. 2010; Wamba & Chatfield 2010; Wamba 2011; Wamba et al. 2008a; Zhou & Piramuthu 2010
Asset management	Bottani & Bertolini 2009; Chang et al. 2010; Conneely 2009; Tajima 2007; Vo et al. 2010
Increased inventory visibility	Attaran 2007; Delen et al. 2007; GS1Germany & WP7Partners 2007; Heinrich 2005; Narsing 2005; Ngai et al. 2005; Roh et al. 2009
Decreased inventory levels	Angeles 2005; Heinrich 2005; Karkkainen 2003; Lee & Ozer 2007; Lewis 2004; Narsing 2005; Penrith 2002; Tajima 2007
Reduced OOS/increased inventory availability	AMR Research 2005; Choy et al. 2005; Erickson & Kelly 2007; Fleisch & Tellkamp 2005; GS1Germany & WP7Partners 2007; Hardgrave et al. 2008; Karkkainen & Holmstrom 2002; Lee & Ozer 2007; Miragliotta et al. 2009; Rekik et al. 2006, 2009; Tajima 2007; Ton et al. 2009; Vijayaraman & Osyk 2006; Visich et al. 2009
Decreased inventory shrinkage	Jones et al. 2005; Srivastava 2004; Tajima 2007; Lewis 2004; Miragliotta et al. 2009; Narsing 2005; Roh et al. 2009
Lower labour costs	GS1Germany & WP7Partners 2007; Heinrich 2005; Jones et al. 2005; Karkkainen 2003; Lewis 2004; McFarlane 2002; Narsing 2005; Ngai et al. 2005; Roh et al. 2009; Twist 2005; Visich et al. 2009
Elimination of bullwhip effect, sharing information	Asif & Mandviwalla 2004; Bharati & Berg 2003; Park et al. 2009; Tajima 2007; Wamba et al. 2008b
Prevention of counterfeiting	Enyinda & Szmerekovsky 2008; Heinrich 2005; Karkkainen 2003; Leimeister et al. 2009; Lewis 2004; Narsing 2005
Improved customer service	Jones et al. 2005; Leimeister et al. 2009; Ngai et al. 2005; Penrith 2002; Tajima 2007

While these cases outline the benefits associated with implementing RFID, sources do not always consider challenging factors that deterred adoption intentions. For example, Wal-Mart, Metro and the earlier studies cited above provide a compelling argument for adopting RFID. However, these particular studies did not discuss the costs or difficulties associated with adopting RFID. Such omissions limit a true representation of RFID 'value'. The next section examines the challenging factors that impact on intentions to adopt RFID.

2.9 Challenges for RFID Applications in the Retail Sector

The literature discusses an extensive list of challenges that impact adversely on RFID adoption intentions. These include high costs, compliance and compatibility issues, unreliability, privacy fears and the difficulty in upgrading existing systems to incorporate RFID. Attaran (2009) discussed the inability to justify a business case, the lack of RFID expert help, the lack of top management support and government regulations (Attaran 2009; Kumar et al. 2009). Other challenges were less conspicuous, such as the inability to access expert RFID technicians and resistance to change, especially since barcode technology has been so successful (Microsoft 2006).

In much the same way that the benefits were grouped in Table 2.8, the literature has also categorised the challenging factors. To illustrate, Wu et al. (2006) have classified challenges into seven groups:

i. Technology challenges, including effects on antenna power patterns, tag antenna orientation affecting radio wave reception and collision caused by simultaneous radio transmission
ii. Standards challenges: lack of a unified RFID standard, lack of a consistent UHF spectrum allocation for RFID.
iii. Patent challenges.
iv. Cost challenges (manufacturing and customisation costs).
v. Infrastructure challenges.
vi. Return on investment challenges.
vii. Barcode to RFID migration challenges (Wu et al. 2006).

Wu et al. (2006) claimed that future initiatives, including advances in technology, would lead to these challenges being overcome.

Lin (2009b) developed an integrated framework based on a literature review and identified five challenging dimensions: cost, technology, infrastructure, standards and specifications and security and privacy, based on literature sources. Twenty-four factors underpinning these dimensions were identified and fuzzy AHP used to weight the importance of factors. The results indicated that at the top level of the hierarchy, the factors were ranked (in order) as cost, infrastructure, technology, standards and specifications and finally, security and privacy. Accordingly, Lin (2009b) argued that the high cost of RFID would lower the return on investment (ROI) and reduce acceptance. At the second level, the most important factors were a willingness of supply chain participants to engage in adoption, technology compatibility, tag readability, superior leadership and systems integration. These were identified as major challenges facing RFID adopters. On the other hand, the least important challenges were identified as privacy invasion, encryption technology, prevention of stealing, reusability of tags and limitation of frequency (Lin 2009b).

A similar study by Wamba et al. (2010) categorised challenges under five headings: strategic decision-making factors, resource issues, technology issues, automation issues and supply chain issues. A survey of industry leaders found the top five challenges to be data accuracy, top management support, inventory management, information visibility and track-and-trace capability. The five least important were privacy threats, security threats, standards ambiguity, data volume and compliance.

2.9.1 Technological, Organisational, and External Environment Context Factors

A popular technique originating from the extant literature that is used to group technology adoption factors is a framework consisting of technological context factors, organisational context factors and environmental context factors (TOE) (Tornatzky & Fleischer 1990). A number of authors have adopted the TOE framework to categorise challenges underpinning RFID adoption (Brown & Russell 2007; Kim & Garrison 2010; Lin & Ho 2009; Wang et al. 2010; Wen et al. 2009). A study of South African retail organisations considered the importance of the TOE factors impacting on intentions to adopt RFID. The relative advantage of RFID over barcodes was an important factor impacting intentions to adopt (Brown & Russell 2007). Lin and Ho (2009) also used the TOE framework. A survey of organisations in

China used multiple regression analysis in the logistics sector to determine the importance of these factors. The independent variables were:

- Technological factors (explicitness of technology and accumulation of technology).
- Organisational factors (organisational encouragement and quality of HR).
- Environmental factors (environmental uncertainty and governmental support).

The dependent variable was a willingness to adopt RFID. The results showed that all factors had a positive influence on RFID adoption intentions; however, the top contenders were explicitness of technology, accumulation of technology, organisational encouragement for innovation, quality of human resources and government support (Lin & Ho 2009).

Wang et al. (2010) found similar results within the manufacturing sector in Taiwan. The factors tested using factor analysis were technology (relative advantage, compatibility, complexity); organisation (top management support, organisational size, technology competence) and environmental (competitive pressure, trading partner pressure and information intensity).

A study of manufacturing organisations in China also adopted the TOE framework to analyse determinants of RFID adoption. However, this study used a technology, organisational and environmental characteristics model. In this instance, product characteristics were an additional category. Using discriminant analysis, the results were positive, with RFID adopters found to be giving greater consideration to these factors than non-adopters. A ranking showed the sequence of importance as organisational, product, technology and environmental (Wen et al. 2009).

Thiesse et al. (2011) also used the TOE framework to identify the determinants of RFID adoption. Employing SEM, the results of this empirical study verified a number of important factors influencing RFID adoption. The factor exhibiting the strongest influence was top management support, an organisational factor. Following, in order, were costs, supply chain forces and the perception of the benefits from adopting RFID. Interestingly, the participants in this study were from organisations that had already decided to implement RFID.

Other authors have taken very similar approaches. Shih and colleagues (2008) arranged RFID barriers:

- Technical barriers, including lack of standards, interoperability, read range and quality, security, integration difficulties and the volume of data.
- Cultural barriers, such as privacy concerns and sharing information between customers and suppliers, environmental constraints, lack of education and high costs.
- Organisational barriers, including redesigning processes and managing scalability, flexibility, storage, routing and monitoring of the data sent from RFID scanners (Thiesse et al. 2011).

These findings were supported by Chang et al. (2008) who identified industry environment, organisation and innovation of technology as the principle components influencing decisions to adopt RFID in the logistics industry.

In summary, research has supported the TOE construct to analyse factors important for RFID adoption intentions. A summary of the technological, organisational and environment categories identified in the literature is provided in Table 2.9.

The next section will examine the literature to determine the impact of these challenging factors on RFID adoption intentions in retail supply chains. Based on the approach outlined above, and similarities with previous studies, the following sections will consider these challenges under the headings of technological factors, organisational factors and external environmental factors. In addition, economic factors, including costs and ROI, will be included, due to the importance of this category in this study.

2.9.2 Technological Factors Affecting RFID Adoption

There has been considerable discussion of a broad range of technological factors affecting the adoption patterns of RFID. Some factors originated from previous innovation literature. For example, Rogers (1995) diffusion of innovations literature labelled compatibility, complexity, relative advantage, trialability and observability as impacting on adoption patterns (Rogers 1995).

Table 2.9: Research Adapting the Technological, Organisational and External Environmental (TOE) Categories to Explain RFID Adoption Challenges

Authors	Technology	Organisational	Environmental	Culture
Brown & Russell 2007	Relative advantage, compatibility, complexity, cost	Top management support, IT expertise, size, organisational readiness	Competitive pressure, external support, change agents	
Lin & Ho 2009	Explicitness of technology, accumulation of technology	Encouragement for innovation, quality of human resources	Government support, environmental uncertainty	
Shih et al. 2008	Lack of standards, interoperability, read range and quality, security, integration difficulties, volume of data	Redesigning processes, managing scalability, flexibility, storage, routing, data monitoring		Privacy concerns, sharing information, environmental constraints, lack of education, high costs
Thiesse et al. 2011	Complexity, compatibility, benefits, costs	Size, top management support, employee fears	Industry forces, external pressure	
Wang et al. 2010	Relative advantage, compatibility, complexity	Top management support, organisational size, technology competence	Competitive pressure, trading partner pressure, information intensity	
Chang et al. 2008	Compatibility, visible profits, visible obstacles, mutual standard	Organisational scale, fundamental establishment of IT, burden of cost, integration of supply chain strategy, support and participation of top executives	Uncertainty of environment, degree of competition in the market, pressure of transaction partners inter-organisational dependency, industry environment of supplier	

The first three are featured in the RFID literature (Thiesse et al. 2011; Tsai et al. 2010; Wang et al. 2010), although observability and trialability do not appear to be considered in this literature. This is possibly due to RFID being readily observable and the known pilot studies and trials. However, there are other technology factors challenging RFID adoption patterns, including standards, the reliability of the technology and interference issues (Soon & Gutierrez 2008). In addition, the literature has identified data volume and integration issues requiring attention (Angeles 2005; Zeier et al. 2009). These technological challenges are discussed in the following sections in relation to RFID adoption.

2.9.2.1 Compatibility

The success of IT adoption has depended to a large extent on its compatibility with existing values, past experiences, the needs of users (Lee 1998), organisations' strategies, existing infrastructure, practices and needs (Premkumar 2003), and with current corporate systems, data quality and the life cycle of the technology (Moon & Ngai 2008). The literature has commented on the issues surrounding RFID compatibility with existing technologies, such as ERP (Davenport & Brooks 2004), warehouse management systems and transport management systems (Twist 2005), as well as with other proprietary RFID applications and technologies such as printers, readers, tags, and middleware (Attaran 2007; Srivastava 2004). Curtin et al. (2007) suggested that RFID would be compatible with other RFID technologies if the protocols, frequencies and voltage levels were able to operate as one application. The results from a South African empirical study suggest that RFID is not compatible with current infrastructure, jobs and skills (Brown & Russell 2007). The current IT architecture was found to be inadequate and therefore unlikely to support RFID in the South African retail sector. Likewise, this developing nation may not have appreciated job losses due to the adoption of some new technology. However, this study did find evidence of positive perceptions of compatibility with strategic fit and organisational intentions to keep up to date with new technology (Brown & Russell 2007).

Technology providers are working on the technical aspects of compatibility. Organisations such as SAP and Oracle have been actively developing RFID capabilities within their software systems to improve future integration between RFID systems and existing ERP systems. SAP was one of the original sponsors of the Auto-ID Centre (Davenport & Brooks 2004). SAP and Oracle have recognised the need to maintain their position selling systems that are compatible with RFID (Oracle 2012; SAP 2012). Microsoft has also introduced an RFID infrastructure, enabling compliance and process transformation (Microsoft 2006). In the future RFID may need to incorporate complementary systems such as GPS and BlueTooth applications (Pick 2004), creating further compatibility issues.

2.9.2.2 Complexity

RFID has been recognised as a complex technology due to its different operating systems, middleware, hardware, languages and architectural structures (Gessner et al. 2007; Porter et al. 2004; Wamba 2011). Understandably, this complexity, defined as perceptions that an innovation is difficult to use or understand (Rogers & Shoemaker 1971), has influenced RFID adoption intentions. The literature has also referred to the complexity surrounding RFID physics (Loebbecke 2007; Spekman & Sweeny 2006). The RFID components described above in Section 2.4.2. need to interact to provide a beneficial outcome. Readers, antennae, and tags must be tuned in different physical spaces, with differing distances and product materials (Loebbecke 2006). The complications associated with implementing RFID, the considerable training required to become competent with the technology, as well as the operational aspects of RFID once installed, have been identified in the literature as significant challenges (Chang et al. 2008). Certainly, the idea of introducing RFID into the computing domain with the necessary infrastructure has raised expectations of a substantial increase in system complexity (Konomi & Roussos 2007).

Complexity was found to influence RFID adoption intentions and a number of concerns were raised. These included customised solutions for RFID, incompatibility with existing IT, the lack of unified standards, high investment and maintenance costs for establishing RFID, poor tracking reliability due to poor reception (radio waves absorbed or distorted by moisture or metals) and low security. Retail stores in Taiwan were surveyed and a proposal that complexity had a significant negative effect on RFID adoption intentions was upheld. This study argued that RFID was not yet considered a mature technology (Tsai et al. 2010). Complexity was also perceived as negatively impacting RFID adoption patterns in the South African retail environment (Brown & Russell 2007).

2.9.2.3 Reliability

Another issue dominating the literature relates to the capacity of RFID to do what it is designed to do: identify objects consistently, accurately and without error. Evidence has suggested that RFID is unreliable, and as a consequence, users are not confident of this technology’s capability (Soon & Gutierrez 2008). Industry has agreed that inaccurate data reading was one of four major reasons why RFID is not being adopted (Chang et al. 2008). A survey by Wamba et al. (2010) supported this stance and placed data accuracy at the top of ten most important factors affecting RFID adoption.

The poor reliability of RFID has been mainly due to the readers being unable to detect information from the tags, or reading the same tag more than once (Angeles 2005). False reads often result from interference, when the radio waves are deflected by liquid or metal with a strong attenuating effect, or by other technologies operating in the same environment (Asif & Mandviwalla 2004; Krishna & Husak 2007; Scharfeld 2001). The ‘noise’ caused by electromagnetic fields, the environment through which the waves travel, or structural issues that distort or reduce the energy range creates an unreliable result (Alu et al. 2006). Electric motors, robots, conveyor belts, fork-lifts, computers and mobile phones all have the capacity to cause RFID interference and false reads (Asif & Mandviwalla 2004; Wyld 2006). False reads may also be due to the distance between the reader and tags being too great, resulting in the reader not detecting the tag (Narsing 2005). A study by Krishna and Husak (2007) found two prominent sources of interference. The first was reader-to-tag, where multiple readers energised a tag at the same time, causing system confusion and misread. The second type was reader-to-reader, where one reader detected another reader’s signal and did not read the tags. A pilot programme involving Auto-ID and Wal-Mart’s experience resulted in a read rate of 80 per cent for pallet and cases (Smith 2005; Twist 2005). Furthermore, case studies of recent trials in Australia by GS1 and other organisations supported these results, with high levels of false reads reported (GS1 Australia 2006).

A considerable amount of tuning the various RFID components is required to avoid misreads (Wyld 2006). This includes a thorough assessment of sites, tuning antennae and readers to minimise interference (Sweeney 2005). One study concentrating on tag selection and reader optimisation achieved a 99.7 per cent accuracy in read rate (Oh et al. 2009). Supporting this result, an investigation of interference mitigation and improvements in read rate carried out at the Auto-ID Centre found power control and graph-based scheduling schemes would improve RFID capability (Saygin et al. 2006). However, given the requirement for read rates to be 100 per cent, the literature indicates that RFID is to a large extent unreliable (Hingley et al. 2007; Srivastava 2007). Therefore a considerable amount of work, including experimental initiatives, needs to be carried out to support the capability of RFID into the future.

2.9.2.4 Standards

Standards describe agreements that provide a foundation and clear understanding for exchanges in industry (GS1 Australia 2010). There are a number of different standards operating concurrently within the RFID environment. The EPCGlobal network, described earlier, is one example of an internationally recognised and established standard adopted for use within RFID-enabled supply chains (Jakkhupan et al. 2010). Additionally, radio frequencies, numbering systems similar to those adopted within barcode technology and radio wave signal strength are all important RFID-related standards. EPCGlobal, the International Standards Organization (ISO) and European Telecommunications Standards Institute are all involved in managing RFID standards (Atzoria et al. 2010; Knospe & Pohl 2004; Lewis 2004). Standards were ranked highest out of 12 issues in one review of the literature (Shih et al. 2008), although it was also believed that standardisation issues would be solved in the short term (Viehland & Wong 2007). Another survey indicated that issues with standards was one of the *least* important factors impacting the intentions to adopt RFID (Wamba et al. 2010). Irrespectively, standards have been recognised as a technological factor impacting on RFID adoption and thus worthy of further discussion.

Standards can be classified according to radio frequency and RFID operates a radio wave system similar to that used in everyday appliances such as radios and mobile phones. Essential services such the police and fire brigades use radio waves to communicate. As a result, government agencies throughout the world restrict the use of radio frequencies (Lewis 2004). The radio frequency band found most appropriate for use within supply chains is UHF, which is central to the RFID EPCGlobal model, even though different designated frequency bands exist throughout the world. For instance, the UHF band nominated for the US is 902–928 MHz; likewise, in Australia it is 918–926 MHz, in Europe 865.6–867.6 MHz and in Japan 952–954 MHz. The world is currently divided into three major regions with unique frequencies: 1) Europe and Africa, 2) the Americas and 3) the Asia Pacific region (Lewis 2004). This means that products moving through these regions will encounter problems reading tags due to the lack of a common standard. To compound the problem, there has been a significant increase in the adoption of several technologies, including mobile telephones, resulting in the UHF frequency sector becoming crowded. Organisations including EPCGlobal have been investigating ways to overcome these frequency issues and one initiative included developing readers capable of reading multiple frequencies (Angeles 2005).

In addition, the product numbering systems are an important standard. Inventory has been identified with the use of barcode technology for many years, although until recently barcode standards were different throughout the world. The Universal Product Code (UPC) was one of the first, developed in 1973 for the US market, followed by the European Article Numbering system (EAN) and the Japanese Article Numbering system (JAN). This resulted in several hundred different barcode numbering standards world-wide (Shepard 2005). However, learning from past lessons, there has been a concerted effort to find a common numbering system for use with RFID. For instance, EPCGlobal has combined the EAN and UPC codes into one specific numbering system known as EPC, specifically for use with RFID (GS1EPCGlobal 2008). However, the Japanese JAN system still operates in isolation (Sweeney 2005). In addition, the ISO has tag and reader standards (ISO 18000) although they are considered compatible with EPCGlobal standards (GS1EPCGlobal 2008).

Finally, the wattage used within the technology is an important standard. The power of RFID is measured as wattage, and regulatory restrictions cause problems in some countries. For example, US regulations allow 4 watts to power RFID, while Australia has only recently been allowed to use 4-watt applications. Trials in Australia investigated the impact 4-watt RFID installations might have on mobile phone installations. Lobbying in Australia by affected parties enabled the increase of allowable power rates and the Australian Communications and Media Authority (ACMA) ruled in December 2008 that RFID equipment with up to 4 watts of power may now be used in Australia in the UHF band (GS1 Australia 2009). However, other countries, including some parts of Europe, operate with lower power. This means that supply chains operating in these regions would likely find suboptimal RFID environments compared to Australia and the US (Sweeney 2005).

2.9.2.5 Relative Advantages

One of the technological factors discussed in literature relating to the adoption of RFID is its relative advantage to current barcode technology (Porter et al. 2004; Sheffi 2004; Thiesse et al. 2011). Relative advantage is described as an innovation’s superiority over the entity it will supersede (Lee 1998). RFID is expected to supersede barcoding technology at some point in the future and referred to as the ‘next generation barcode’ (Porter et al. 2004; Thiesse et al. 2011). Therefore, any decision to transfer from barcodes to RFID will be dependent on the relative advantages RFID has over barcodes. The literature has described these differences as RFID facilitating continuous information, more accurate information, simultaneous reads, read without opening cases, more data stored on a tag and the ability of some RFID systems to record data such as temperature and humidity (Sheffi 2004). Unlike barcodes, some RFID tags have read and write capabilities as well as the ability to be reused (Knospe & Pohl 2004; Li et al. 2004; Shepard 2005). RFID does not require line of sight between the reader and the tag and can operate in harsh conditions (Knospe & Pohl 2004; Shepard 2005; Song et al. 2005). RFID also has the ability to incorporate anti-tampering capability (Sheffi 2004). The literature has also described the limitations of barcode technology in terms of the relatively short read range and the fact it is not effective in harsh environments (Silvanus 1991). In addition, either the product or the reader needed to be manually handled and require line of sight to identify products (Karkkainen 2003). There is also little scope for future advancement, poor tracking capability and limited information on tags that cannot be rewritten (Knospe & Pohl 2004). These limitations fuel the debate about the relative advantage of RFID.

In a study of adoption intentions, the relative advantage of RFID over barcodes positively influenced adoption intentions. However, the advantages result from the manner in which the technology is leveraged (Brown & Russell 2007). Other studies supported this outcome. Tsai et al., (2010) also identified relative advantages impacting positively on the intentions to adopt RFID. However, not all research found positive associations. Wang et al. (2010) studied 133 organisations in Taiwan and found that the relative advantage was not a significant discriminator of adoption intentions in both adopter and non-adopter organisations. The advantages and disadvantages of RFID and barcodes are summarised in Table 2.10.

Table 2.10: RFID Versus Barcode Technology

RFID advantage	Barcode disadvantages
RFID tags can be read or updated without line of sight and can be concealed within an item	Barcodes require line of sight to be read
Multiple RFID tags can be read simultaneously	Barcodes can only be read individually
RFID tags are able to cope with harsh and dirty environments	Barcodes cannot be read if they become dirty or damaged
RFID tags can identify a specific item	Barcodes can only identify the type of item
Information can be overwritten on RFID tags	Barcode information cannot be updated
RFID tags can be automatically tracked, eliminating human error	Barcodes must be manually tracked for item identification, making human error an issue

(Source: Wyld 2006)

2.9.2.6 Data Volume

The literature has suggested that current computer systems would not be able to handle the high volumes of data generated by RFID (Angeles 2005; Lewis 2004; Lin et al. 2007; Srivastava 2004; Twist 2005; Zeier et al. 2009). One estimate of an organisation's tracking of all items from production to point of sale (approximately 3,000–30,000 transactions made every second) resulted in 10 terabyte database to hold a year's worth of data (Angeles 2005). More recent analysis of data volume calculated a substantially lower figure in a retail environment, equating to 3.3 GB per day or 1,042 GB per year (Ilic et al. 2010). However, there is still a need for new ideas on intelligent data aggregation, data filtering and increasing the performance of the applications involved (Zeier et al. 2009). Tests have found that integrating large amounts of data into existing systems was feasible, particularly with filtering mechanisms disposing of unwanted data and a hierarchy or containment relationships and path preserving in-query operations (Lin et al. 2007; Ngai et al. 2005). Software capable of extracting useful and relevant information from large amounts of data is also being investigated (Ilic et al. 2010; Srivastava 2004). This software includes middleware developed by Auto-ID Laboratories called SAVANTs which buffer data between the reader and back-end systems (Lewis 2004). Sharing of this data through IOSs still represented a challenge in real-time processing and software development is needed to cope in the future (Ilic et al. 2010).

This section has described the main applicable technological issues found in the literature, such as compatibility, complexity, reliability, standards, data volume and relative advantage. A summary of these can be found in Table 2.11.

Table 2.11: Technological Challenges

	Technological Challenges	**Sources**
i.	Compatibility (with ERP and other systems)	Attaran 2007; Curtin et al. 2007; Davenport & Brooks 2004; Tsai et al. 2010
ii.	Complexity (technology difficult to use and not well understood)	Loebbecke 2007; Park et al. 2009; Spekman & Sweeny 2006; Wamba 2011
iii.	Reliability (tags are not always read accurately	Angeles 2005; Krishna & Husak 2007; Scharfeld 2001; Soon & Gutierrez 2008; Wamba et al. 2010
iv.	Standards (issues with frequency, numbering, and power standards)	Lewis 2004; Sweeney 2005; Twist 2005; Viehland & Wong 2007
v.	Relative advantage (not acknowledged)	Chang et al. 2008; Ngai et al. 2005; Sheffi 2004; Wamba et al. 2010
vi.	Data volume (the volume of data will be too high for current systems)	Angeles 2005; Lewis 2004; Lin et al. 2007; Srivastava 2004; Twist 2005; Zeier et al. 2009

2.9.2.7 Top Management Support

Top management often acts as a sponsor in organisations contemplating the undertaking of IT projects. They become an agent of change, ensuring that sufficient resources are available to adopt RFID (Ngai et al. 2005). It is difficult to successfully adopt technology without these resources (Sharma et al. 2007). Sweeney (2005) argued that managers need to be deeply involved from the start of discussions on RFID, and active throughout RFID adoption projects. Top management support is an important determinant of the success of RFID adoption (Attaran 2007; Fish & Forrest 2006). Empirical studies indicate an awareness that top management support positively influences RFID adoption (Thiesse et al. 2011; Tsai et al.

2010; Wamba et al. 2010). Conversely, the analysis of data collected from Taiwanese manufacturers found top management support was not a significant factor for determining adoption (Wang et al. 2010). Equally, Brown and Russell (2007) revealed perceptions of negligible top management support for the introduction of RFID; senior managers were only supportive if a business case could be found.

2.9.2.8 IT Investment

IT investment not only describes an organisation’s previous investment in technology, but also the future available financial resources to support the implementation of RFID (Sharma et al. 2007). RFID implementation is an expensive exercise and not all organisations are in a financial position to invest in the technology. Investment in IT is not only an exercise in monetary investment. The ability to provide or access expert assistance to implement RFID also forms part of IT investment. Partnering with competent technology providers is another critical factor influencing RFID adoption (Attaran 2007). This is particularly important when the skills required are in short supply. Experts are needed to assist in installing IT, and IT support was ranked in the top five most important industry dynamics in North American 3PL (Lieb & Bentz 2004). RFID installations require experts with sufficient knowledge to support organisations embarking on RFID projects (Ranganathan & Jha 2005; Sharma et al. 2007).

The lack of experts who understood RFID was found to concern organisations ready to adopt this technology. The fact that the technology was not yet widespread created uncertainty regarding adequate future maintenance and upgrades on RFID installations (Dew & Read 2007). The literature has identified the benefit of outsourcing the actual implementation of RFID to offset a lack of expertise within the organisation (Sweeney 2005), and also suggested an increasing demand on higher education to upgrade the skills of RFID professionals (Viehland & Wong 2007). There is likely to be a shortage of experts as the demand for technical skills increased. A survey by the Computing Technology Industry Association (CompTIA) indicated that 80 per cent of organisations that were examining RFID did not believe that there were sufficient professionals skilled in RFID (O’Connor 2005).

2.9.2.9 Organisational Size

The literature has explicitly recognised the size of organisations involved in implementing RFID. For instance, one survey found a positive relationship between organisational size and RFID investment, with larger organisations having greater financial resources for implementing RFID (Vijayaraman & Osyk 2006). This makes sense, given the earlier discussion of Wal-Mart, Metro, Tesco and Sainsbury's involvement as larger retailers. Manufacturers such as Proctor & Gamble, Gillette and Unilever are large organisations currently involved in RFID trials (Angeles 2005; Jones et al. 2005; Narsing 2005).

Conversely, the literature has also highlighted the importance of SMEs integrating into supply networks (Auramo et al. 2002), and a belief that perhaps 'authorised' SMEs would be allowed to tap into larger organisations' networks (Heinrich 2005). Smaller organisations would be more likely to adopt closed RFID systems so that their internal operations would be improved (Penrith 2002). There were also examples of smaller organisations trialling RFID. For instance, two small Australian organisations, Patties Foods and the Moraitas Group have both conducted trials on RFID (Mills 2005b). However, smaller organisations may be reluctant to adopt RFID due to limited resources (Asif & Mandviwalla 2004). Notwithstanding these issues, SMEs do have a number of important advantages. A qualitative study investigating German SME's adoption of RFID found thought-provoking differences between large organisations and small organisations when assessing the benefits and barriers of RFID (Strüker & Gille 2009). A comparison indicated that in some instances RFID favours smaller organisations. For example SMEs, being smaller, were found to be less likely to suffer from the coordination and cooperation problems associated with the adoption of technologies such as RFID (Strüker & Gille 2009). According to Strüker and Gille (2009) this was due to 'structural inertia theory' whereby as organisations become larger, they are less able to adapt to a changing market and organisational environment. On the other hand, smaller organisations have fewer resources and less cooperation from suppliers and customers (Hall et al. 2004). In terms of benefits, smaller organisations may adopt RFID not just for automation purposes, but also to improve their information quality and enable the re-engineering of business processes (Strüker & Gille 2009). Perhaps more significant was the concept of the supply chain being coordinated and synchronised from end to end. Hamilton et al. (2009) argue that the likelihood of a fully functional supply chain without data capturing tools such as RFID dispersed throughout all organisations in the chain, irrespective of their size, would be less than ideal.

2.9.3 Organisational Readiness

Organisational readiness has been described as an awareness of factors that might influence the decision to adopt technology. For instance, these factors include innovation awareness, innovation needs-fit, technological skills and financial resource readiness (Angeles 2009; Wu 2004). The culture and structure of an organisation, a willingness to embrace change and previous experience in supply chain collaboration are all important for an organisation's preparation for adopting technology (Lekakos 2007). The concept of organisational readiness extends to the formation of IT capabilities enabling exchange of relevant information throughout their supply chains.

Angeles (2009) studied the relationships between IT infrastructure integration (including data consistency and cross-functional application integration), and supply chain integration capabilities (including information flow integration, physical flow integration and financial flow integration) with the RFID deployment outcomes exploration, exploitation, operational efficiency and market knowledge creation. The results partially supported positive associations (Angeles 2009). Although the organisations surveyed had not implemented RFID, their responses included the extent to which they would like to use RFID to meet deployment outcomes including exploration, exploitation, operational efficiency and market knowledge (Angeles 2009).

A number of sources describe organisational readiness in terms of the level of financial resources and technical resources available when adopting technology (Chwelos et al. 2001; Iacovou et al. 1995; Kuan & Chau 2001; Lee & Shim 2007). Financial resources are required to pay for the costs of acquiring IT, while technical resources include the IT capability within the organisations. Financial and technical resources were identified as moderating factors for the speed and willingness to adopt RFID (Lee & Shim 2007) and as variables impacting on RFID evaluation (Kim & Garrison 2010). Interestingly, Lee and Shim's (2007) study found no correlation between the level of financial resources and the intention to adopt RFID. However, the study did conclude that technology knowledge was a motivator when adopting

RFID. On the other hand, Kim and Garrison's (2010) study found both variables had a significant positive impact on RFID evaluation. Tsai et al. (2010) explained organisational readiness in terms of top management support, IT expertise, organisational culture and a championing image—a retail organisation's ability to improve their image as a result of innovation adoption. Their study also supported a positive association between these factors and RFID adoption intentions (Tsai et al. 2010).

Organisational readiness has also been discussed in the literature as a factor influencing RFID adoption. The results of a survey of retail organisations in South Africa suggested that organisations were not financially, operationally or culturally ready to adopt RFID. There was general uncertainty about what was needed to adopt RFID and indications of needing to have cost/benefit data, and adequate ROI and business cases, supporting the view that organisations, at least in this retail environment, were not yet ready for RFID adoption (Brown & Russell 2007). A summary of these organisational challenges is given in Table 2.12.

Table 2.12: Organisational Challenges

	Organisational Challenges	**Sources**
i.	No support from top management	Attaran 2007; Fish & Forrest 2006; Wamba et al. 2010; Wang et al. 2010
ii.	Failure to invest in IT resources	Jeong & Lu 2008; Ranganathan & Jha 2005; Sharma et al. 2007
iii.	Organisational size (larger organisations have more resources)	Hamilton et al. 2009; Jones et al. 2005; Strüker & Gille 2009, 2010
iv.	Organisational readiness	Angeles 2009; Kim & Garrison 2010; Lee & Shim 2007; Lekakos 2007; Tsai et al. 2010; Wu 2004

2.9.4 External Environmental Factors Affecting RFID Adoption

Factors such as pressure from competitors, security concerns and privacy concerns all influenced the adoption of RFID (Brown & Russell 2007; Sharma et al. 2007; Thiesse et al. 2011). This section describes these factors and their impact on the adoption of RFID.

2.9.4.1 Industry Forces

Industry forces have been described as coercive, mimetic and/or normative pressures impacting on an organisation's future intentions (DiMaggio & Powell 1983). Within the RFID literature, these concepts were evident with the extensive media coverage of Wal-Mart's mandates on suppliers to adopt RFID (Bednarz 2004; Murphy 2003; Reyes 2007; Sullivan 2004). Major retailers in Europe were also asking suppliers to adopt RFID (Loebbecke & Huyskens 2006) and the US DoD has 'requested' that suppliers tag cases and pallets (Office of the Under Secretary of Defence for Acquisition Technology and Logistics 2005). There were a number of reactions to these mandates, including suppliers' awareness of the potential to lose business if they did not comply. Industry forces were one of the reasons why organisations trialled RFID (Murphy 2003).

Boeck and Wamba (2008) examined the impact of these mandates on organisations. Their study considered the impact RFID had on buyer-seller relationships in Canada and suggested that IOSs had both positive and negative influences on collaboration, due to disruption and the use of power by larger buying customers. The results indicated a number of important factors:

- Accuracy and shrinkage issues were at the centre of the rationale for use and sharing information throughout the supply chain and integral to RFID.
- Cooperation throughout the supply chain was reliant on sharing the benefits.
- Reduction of shrinkage figures would precipitate a higher level of trust throughout the supply chain. In other words inventory accuracy was crucial.
- Longer term relationships were needed due to the high infrastructure investment, which may not assist with other parties if the existing relationships end.
- Relationships with partners using RFID would increase relative to other partners not using RFID.
- Both suppliers and buyers felt that adopting RFID would provide the other party with more power.
- Pressure by trading partners to adopt RFID further up the supply chain may result in higher influence on manufacturers.
- Potential conflict was evident (Boeck & Wamba 2008).

Sources also drew attention to the asymmetric power balance between weaker suppliers and stronger retailers (Robson & Rawnsley 2001) and the realisation that much of the cost of installing RFID may fall on the supplying manufacturer (Smith 2005). For RFID to be successful, cost and benefit equity between members of the retailer supply chain needs to be resolved (Hingley et al. 2007). Large retailers have led the way in making changes within supply chains for several reasons. First, retailers pressured suppliers to implement technology that provided reduced costs, which would inevitably pass to retailers and consumers. Suppliers were familiar with this behaviour, having encountered similar tactics with the implementation of EDI (Mackay & Rosier 1996). Second, there was constant pressure for suppliers to improve their internal processes so the entire supply chain could benefit (Niemeyer et al. 2003). Finally, there was intense competition with the FMCG and retailers were compelled to maintain a position of power (Heinrich 2005). In reality, only a small number of retailers were considered large enough to have the resources and power to initiate such actions (Niemeyer et al. 2003).

A study also compared organisations affected by mandates with those unaffected by mandates (Soon & Gutierrez 2008). The research adopted Moore's Technology Adoption Life Cycle (Moore 1991) and grouped the effects into three tiers:

i. Immediate impact for organisations initially adopting to comply. This has generally been found to be unsatisfactory, with poor read rates and no benefit.
ii. Attempting to sustain RFID in the organisation to continue complying. Suppliers were often taking a 'slap-and-stick' approach (Narsing 2005) and not using the intelligence available.
iii. Longer run issues of the supply chain environment, including disruptive elements. This involved redesigning warehouses for greater cross-docking and higher levels of collaboration (Soon & Gutierrez 2008).

Soon and Gutierrez (2008) described a 'chasm' or 'gap' (Moore 1991) between the early adopters and early majority, suggesting that in the case of RFID adoption, early adopters were likely to be in a position to define the terms of the future to their advantage, for example, by establishing the standards of the industry (Soon & Gutierrez 2008).

Research also investigated the impact of technology mandates on suppliers' financial positions. This study investigated Wal-Marts suppliers' financial performances after mandates were imposed in 2003. The 'Event Study Method' was adopted to determine the relationships between an unanticipated event and the stock price for 56 top tier Wal-Mart suppliers. Evidence of stock price changes was collected during a 51 day window beginning 25 trading days prior and ending 25 days after the mandate announcement. The results indicated an overall 1 per cent improvement in listed stock returns. Greater returns were evident for organisations with higher levels of cash flow (Deitz et al. 2009). The results suggest that the investing public notices, and endorses, the adoption of technologies such as RFID (Deitz et al. 2009).

2.9.4.2 RFID Security

The adoption of RFID, as an open system network combining several technologies, raised concerns about security. These embraced corporate espionage, trust, inadvertent disclosure of information to competitors, threats to infrastructure (Shih et al. 2005), counterfeiting, cloning, swapping, damaging and disabling (Neumann & Weinstein 2006). RFID systems are vulnerable with unauthorised readers being potentially capable of capturing data, compromising middleware databases, inserting code to enable hacking or malicious software, allowing data to be altered or deleted from tags, as well as worms that may infect systems (Paraschiv & Pricop 2009).

Security has been classified in terms of information confidentiality, integrity and availability, as well as user authentication and anonymity (Fabian & Günther 2009; Juels & Weis 2009; Knospe & Pohl 2004). In terms of confidentiality and integrity the potential for security breaches is an issue. Many of the current systems and tags are unprotected. For instance, the power source is in the receiver, not the tag, and unauthorised access to information is a possibility with longer range readers (Smith 2005). This was of particular concern with read/write tags due to their potential to be rewritten by unscrupulous parties, which could cause major integrity problems. There were also concerns about 'frequency jamming' rendering important information unavailability to the user (Knospe & Pohl 2004). A recent experiment confirmed the possibility of infecting tags with a virus and unintentionally infecting other parts of the system (Oswald 2006). However, user authentication has been supported by cryptography for many years in e-commerce settings and technology providers are adopting this technique to provide confidence in RFID user security (Backhouse 2002).

A number of other initiatives are being examined to alleviate the fears of users with respect to RFID security. For instance, organisations like EPCGlobal are committed to ensuring the network's security with a range of software applications including Web Services Security (WS-Security) (Shih et al. 2005). Pietro and Molva (2011) have also developed a protocol to improve security by ensuring that RFID identification is server-dependent. A unique key is shared by the tag and the server, restricting unauthorised access to the system (Pietro & Molva 2011). Other countermeasures include firewalls, audits, access rights, protected network zones and challenge-response authentication algorithms (Paraschiv & Pricop 2009). Organisations are also considering technology security prevention measures such as tamper-proof tags, surveillance, security procedures and education (Bumbuk 2005).

2.9.4.3 Consumer Privacy

Customers have been concerned about the impact that RFID might have on their privacy (Cazier et al. 2007; Clarke & Flaherty 2008). Consumers are worried about retail organisations accessing information held within tags on the products after they leave the store (Knospe & Pohl 2004). The concern was that a tag could be read by anyone without authority and enable the unwitting consumer to be tracked (Potter 2005). There have also been concerns over the hidden placement of tags and readers, unauthorised access to personally identifiable information and profiling without consumers consent (Clarke & Flaherty 2008). These concerns are not without merit, with reports of tags used without consumers' consent by Wal-Mart in 2003, tracking lipstick and razors by way of hidden tags and readers (Clarke & Flaherty 2008). Customers do not trust organisations to self-regulate with respect to how they handled information deemed private (Clarke & Flaherty 2008). A study of consumers in the US using the Technology Acceptance Model concluded that perceived privacy risk likelihood and harm all have a direct negative impact on consumers' intentions to support RFID (Cazier et al. 2007). This study considered 'residual' RFID tags or tags left on products after purchase by consumers.

An adverse reaction by consumers who objected to being tracked via these tags resulted in the formation of an activist faction 'Consumers Against Supermarket Privacy Invasion and

Numbering' (CASPIAN). CASPIAN members were unhappy with the 'big brother' attitude of retail organisations and were prepared to resist RFID tagging of products. A large proportion of the population are against RFID tagging according to one study (Atkinson 2004). Benetton, a major clothing retailer, abandoned plans to tag all 'Sisley' brand clothes and track them through the supply chain due to boycott actions (Atkinson 2004). The industry has been considering ways to convince such groups that the increased efficiency brought about by RFID adoption will mean lower prices for consumers. Industry continues to improve consumer confidence about privacy. For instance, destroying tags at the retail store checkout in front of the customer was one initiative undertaken (Potter 2005).

Government responses to privacy issues vary throughout the world, with minimal law enacted in the US to regulate the use of data collected by RFID, apart from in California where state law requires the removal of tags before shoppers leave a store. The Federal Trade Commission guide states that organisations intending to use RFID should provide consumers with notice that tags are present, enable an opt-out choice, and take steps to protect against sensitive consumer information (Clarke & Flaherty 2008). In Canada, the Personal Information Protection and Electronic Documents Act is the legislation used to regulate privacy. The terms identify the purposes for which information was collected, ensure consent from consumers, limit collection to intended purpose and limit the use, disclosure and retention of personal information (Angeles 2007).

The approach in Europe is also largely self-regulating, although possibilities of future legislation guided by industry have been recommended to member states for application (Weber 2010). The European Commission has investigated RFID privacy issues and developed legal and self-imposed regulations to assist consumers and industry stakeholders. The Commission identified the need to continuously monitor privacy and the protection of personal data. The legal framework involved a differentiated approach around four areas:

i. the global reach of the processes in question
ii. the vertical reach of RFID applications
iii. the ubiquitous nature of RFID and
iv. the technical complexity of RFID (Weber 2010).

However, not all consumers are unhappy about the use of RFID to identify products, with one survey indicating privacy as the least important factor influencing RFID adoption decisions (Wamba et al. 2010). Shoppers appeared to support this position, indicating they would accept tagged products as long as the organisations comply with the relevant laws (Angeles 2007). Consumers may need to balance the benefits of RFID against the risks associated with the possibility of consumer privacy violations (Eckfeldt 2005), although they also needed to be convinced that their information remains private (Muller-Seitz et al. 2009). A summary of these external environmental factors can be found in Table 2.13.

Table 2.13: External Environmental Challenges

	External Environmental Challenges	**Sources**
i.	Industry forces (competition, mandates, mimetic behaviour)	Bednarz 2004; Boeck & Wamba 2008; Hingley et al. 2007; Loebbecke & Huyskens 2006; Murphy 2003; Reyes 2007; Sullivan 2004
ii.	RFID and security (the Internet is not secure)	Alomaur & Poovendran 2010; Bumbuk 2005; Langheinrich 2009; Oswald 2006; Pietro & Molva 2011; Smith 2005; Spiekermann 2009; vanDeursen & Radomirovic 2009; Weber 2010
iii.	Consumer privacy (consumers not happy with live tags attached to products that leave the store)	Alomaur & Poovendran 2010; Angeles 2007; Langheinrich 2009; Potter 2005; Spiekermann 2009; Weber 2010

2.9.5 Economic Factors Affecting the Adoption of RFID

One of the main drivers for the adoption of RFID is lower costs (Twist 2005) and research indicates that high costs are still restricting RFID adoption plans (Brown & Russell 2007; Chang et al. 2008; Dew & Read 2007; Jones et al. 2005). A survey of packaging manufacturers identified the high costs associated with RFID as a major concern (Vijayaraman et al. 2008). Another study supported this view, citing costs a close second behind standardisation as an important factor influencing the future of RFID (Viehland & Wong 2007).

The application of an existing systematic framework used to identify different types of costs in process innovation adoption was applied to determine the influence of potential costs on

RFID adoption intentions (Smart et al. 2010). This study examined the generation, acceptance and implementation stages of RFID adoption against the influence of different costs. Generational costs related to the costs in the development and initiation phase, including creation of standards. Acceptance costs included switching from barcode technology, the uncertainty surrounding any new technology and the potential reputational risks associated with adoption. Both the direct and indirect costs associated with implementation were considered. Within the implementation cost category the relational and ethical costs were also considered. For instance, costs associated with retailers and suppliers working together and ethical issues concerning privacy aspects of RFID adoption were considered. These categories of costs and their influence are presented in Table 2.14.

Table 2.14: Framework for RFID Adoption Costs

Development costs	These were largely associated with standards creation by ISO and EPC organisations and more inclined to be absorbed by large retailers and manufacturers
Initiation costs	There does not seem to be evidence of these costs being visible in RFID as no organisation had yet begun implementation because RFID was an emerging technology
Switching costs	These include compatibility costs associated with changes in the technology, including less problematic, but still important, backward integration with existing technologies
Capital costs	Technology uncertainty was a major factor and the participants in this qualitative study described RFID as immature, making these costs high. There were also costs associated with the financial, technical, and security risks associated with adoption
Market uncertainty costs	Described in terms of a fragmented technology provider environment and despite many attempts no serious RFID application had yet been produced. There were also competitive and reputational risks and their related costs
Direct costs	The initial purchase of RFID and ongoing costs, including purchase of tags. Respondents described these costs as too high to justify adoption
Indirect costs	Costs associated with change management, training and redesigning the processes in the organisation were also considered too high
Relational costs	Despite mandates, the larger retail organisations and their large suppliers were working together to examine RFID. Therefore relational costs were found to be weak. Additionally, there was no evidence that smaller organisations were being considered in the discussion, and they were unlikely to have the resources
Ethical costs	A new addition to this model and represented the privacy features often discussed in literature. These costs were relevant at the retail store

(Source: Smart et al. 2010).

The results indicated that larger organisations would be funding the generational costs. In terms of acceptance costs, smaller organisations would follow mandates. Initiations costs were future-oriented with few installations currently recorded. RFID tags, readers, infrastructure, software, upgrades, maintenance and training were all considered expensive. The following section discusses these costs in relation to their impact on RFID adoption intentions.

2.9.5.1 Tag Costs

Tag costs were important due to the fact that they were an on-going variable cost (Gaukler et al. 2007). However, advancement in technology and lower costs in the semiconductor industry has prompted increased use of tags and it was thought that increased tag usage would lead to lower costs. The number of RFID tags sold in 2005 was reported to be 700 million, and expected to reach over 28 billion by 2017 (Das & Harrop 2007).

In one study, active tags used for tracking tools cost USD 75 each, making them more expensive than some of the tools (Goodrum et al. 2006). However, the more common and less expensive passive tags suitable for retail EPCGlobal pilot studies were priced at around $1.00 in 2000. The price of these tags reduced to around 20 cents during 2005 (Prater et al. 2005) and prices ranged between 5 cents to 25 cents in 2006 (Attaran 2007). Sources suggest that a target cost of less than 5 cents was needed for mass rollout (Donovan 2003), with a break even cost of between 2 cents and 4 cents calculated in another study (Bottani & Rizzi 2008). Several studies have indicated that the cost of tags was too high and therefore impacted on adoption patterns (Brown & Russell 2007; Wu et al. 2006). Currently, the costs are still considered expensive, with just the inlay without a label costing close to 7 cents (Roberti 2011).

There are also concerns about who would pay for tags and an expectation that the manufacturer would be attaching tags to products and therefore was ultimately responsible for paying. This created considerable resistance from upstream partners to the adoption of RFID (Gaukler et al. 2007). An economic study of tag cost sharing between retailers and manufacturers suggested that if the market leader was the retailer, as is the case in most economies, then it depended on the retailer’s ability to exert power and force the manufacturer to accept a lower profit margin (Gaukler et al. 2007). Conversely, the retailer would need to pay for an increasing number of readers at downstream facilities receiving/despatching in distribution centres, potentially offsetting tag costs at upstream locations (Lewis 2004). Equally, the cost of tags was also found to be associated with the cost of the item to which it was attached. The more expensive the product, the more likely tag cost would not be an issue (Fitzek 2003). A further complication was the tagging of items, cases or pallets, with most organisations initially concentrating on pallet and case tagging (Smith 2005). However, industry was calling for item-level tagging for the full benefits of RFID to be realised.

2.9.5.2 Other Costs

The high cost of infrastructure also influences RFID adoption intentions (Narsing 2005), with one source citing the cost of infrastructure at between USD 2 million and USD 16 million (Chappell et al. 2002). Readers are expensive and cost between USD 1,000 and USD 3,000, depending on the number of installations required (Asif & Mandviwalla 2004). Vijayaraman and Osyk (2006) revealed that the projected initial RFID project investment for small organisations was less than $100,000; for medium companies between $100,000 and $11.5 million and for larger organisations up to $50 million (Vijayaraman & Osyk 2006). There were also suggestions that the training costs, which had to be considered, may be greater than the actual cost of the technology (Walker 2004).

The Australian NDP discussed earlier in Section 2.7.1.1 confirmed that a significant outlay would be required for any meaningful RFID implementation exercise. The costs included network installation, on-site IT equipment, including a server as the EPC-IS, registration and EPC assignment with EPCGlobal, establishment of EPC services at the global EPC-IS administrator, network enhancement of EPC Network to the Internet and training and development of staff (Mo et al. 2009).

2.9.5.3 Return on Investment

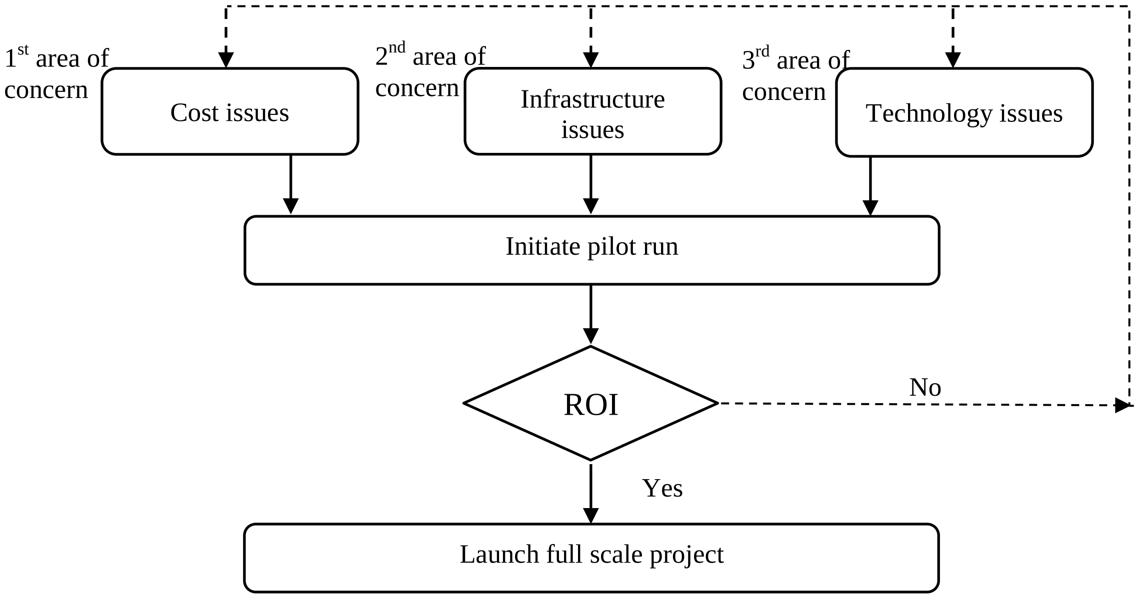
The difficulty of determining the ROI for RFID has been well established in the literature (Bottani et al. 2009a; Lee & Lee 2010; Li et al. 2006; Lin 2009b; Reyes 2007; Reyes & Jaska 2007; Sarac et al. 2010; Veeramani et al. 2008). Sarac et al. (2010) examined the ROI for RFID and developed a formula based on the final monetary yield of the project divided by the investment required by the project and expressed as a percentage. In simple terms, ROI is the difference between the benefits and costs. Costs were acknowledged as hardware, software, system integration, installation labour and changes to business processes. The benefits of RFID were increased revenue and lower operating costs and expenses, as well as an improvement in capital efficiency by reducing property, plant and equipment costs and inventory. Importantly, the results of this review were inconclusive due to the issues surrounding RFID reliability.

Some sources have provided indications of a positive ROI outcome. For instance, an analysis of the business case for introducing RFID in the DoD resulted in expectations of a small but positive ROI in the short term within shipping and receiving activities, and higher ROI in the longer term due to improvements in inventory management (Office of the Under Secretary of Defence for Acquisition Technology and Logistics 2005). Bottani et al. (2008, 2009) also provide examples of empirical studies on the 'economic feasibility' of RFID applications including ROI calculations. A study of the management of returnable containers using RFID within the FMCG sector found a positive 25 per cent ROI (Bottani et al. 2009b; Bottani & Rizzi 2008). Another study of the FMCG industry considered case and pallet tagging and found negative ROI at the manufacturer level and positive ROI for the distributor and retailer when calculating the benefits of adopting RFID (Bottani et al. 2009a; Bottani & Rizzi 2008).

A study of the difference between the ROI for earlier adopters through to laggards revealed that the average ROI would increase within innovator and early adopter groups and decrease within the late majority and laggard groups. While conceptual, this framework applied the diffusion of innovation theory (Rogers 2003) and focused on an analysis of strengths, weaknesses, opportunities, and threats. This study developed an ROI model based on simulation output and the results exposed a negative ROI (minus 48 per cent) in the first year, with a move to positive ROI from the third year within a retail supply chain (Luo et al. 2008).

Irrespective of the financial method adopted, the evaluation of RFID is difficult and normal financial methods are somewhat ineffective (Lee & Lee 2010). A central question is whether RFID can deliver benefit for the cost, and how this might be measured (Lee & Lee 2010). One possible answer for organisations within retail supply chains was the 'Supply Chain RFID Investment Evaluation Model' developed by Lee and Lee (2010). This model considered the way in which ordering efficiency, 'just in time' efficiency, and operating efficiency could be improved and plotted the results against the investment level required to obtain these efficiencies. The evaluation process was underpinned by an extension of the Economic Ordering Quantity, a well-known optimisation model. The demand for products is central to this model and the results showed that organisations with higher levels of demand, as well as organisations enjoying growth, would be more likely to benefit from adopting RFID. This implied that larger organisations would be more inclined to reap the benefits of adopting RFID (Lee & Lee 2010). Lin (2009b) supported the view that it was difficult to identify the ROI based on the limited trials available, and suggested a hierarchical approach to adoption. Based on the respondents' feedback, the weighted values indicated costs were the first issue that needed to be examined, followed by infrastructure and then technology issues. Once these matters were satisfactorily covered, a pilot run would be undertaken. This activity determined the ROI, and if positive, a full scale launch could begin (Lin 2009b) (Figure 2.7).

Figure 2.7: Structural Procedure for the Establishment of an RFID System



(Source: Lin 2009b)

Various sources have presented estimation techniques for ROI, including calculators and assessment models (Miragliotta et al. 2009; Tellkamp 2003; Veeramani et al. 2008). Tellkamp (2003) developed an ROI calculator to estimate the costs and benefits accompanying different

RFID applications. The logic included the supply chain, made up of retailer, distributor and manufacturer, with three levels of units: item, case and pallet. Provided the correct information on a range of variables was entered, an expected ROI could be calculated. However, this calculator was not expected to replace a thorough analysis of the organisation's unique supply chain environment (Tellkamp 2003). This article seemed to be somewhat limited, with a greater focus on the results and little information about how the model actually worked.

A similar study, focusing on the manufacturer and distributor, proposed an RFID ROI assessment tool (Veeramani et al. 2008). Adopting algorithms around the five areas of operating costs, revenue, overheads, capital and lead time enabled ROI to be calculated. The tool was applied to a tier one supplier of Wal-Mart and the results suggested that RFID adoption was justified. This research appeared to concentrate on the benefits and did not include investment costs such as infrastructure, hardware and software, or ongoing tags.

An RFID profitability assessment model has also been developed to calculate ROI with respect to pallet and case level tagging applications. There were a number of difficulties in terms of the costs of tags and supply chain characteristics in terms of efficiency, quality and products. Adapting this model to a simulation of a retailer and manufacturer found contradictory results. Regarding pallet-level tagging, profitability was only apparent if the supply chain was less than moderately inefficient, with efficient supply chains not achieving positive results. In relation to combined case and pallet tagging, where the manufacturer always has negative profitability and, provided the supply chain was average or inefficient, profitability would be high for the retailer and moderate for the distributor (Miragliotta et al. 2009).

In summary, industry appears to perceive the costs as still too high to provide a positive ROI from the adoption of RFID. A survey of manufacturing firms, 3PL, distributors and retailer firms examined RFID implementation intentions and discovered that 56 per cent of manufacturing firms, 3PL, and distributors did not expect cost savings from any RFID adoption. The retailers appeared more optimistic, although a only small sample indicated expectations of a positive ROI (Vijayaraman & Osyk 2006). The economic factors are summarised in Table 2.15.

Table 2.15: Economic Challenges

	Economic Challenges	Sources
i.	High costs (hardware and software, infrastructure, training and tag costs)	Asif & Mandviwalla 2004; Brown & Russell 2007; Smart et al. 2010; Walker 2004
ii.	ROI (not readily confirmed as positive)	Bottani et al. 2009a; Lee & Lee 2010; Li et al. 2006; Lin 2009b; Reyes 2007; Reyes & Jaska 2007; Sarac et al. 2010; Veeramani et al. 2008

The challenges discussed in the preceding sections are creating uncertainty regarding the capabilities of RFID and holding back intentions of adoption (Cannon et al. 2008). Many potential adopters are waiting until there is sufficient proof of successful implementations before proceeding (Mehrjerdi 2008). Furthermore, organisations are not accepting the notion put forward by the popular press that failure to begin the RFID adoption process would cause them to be left behind and at a competitive disadvantage (Wang et al. 2010). On the other hand, there have also been suggestions that if these challenges were overcome, RFID adoption would proceed (Poirier & McCollum 2006).

2.10 Summary of the Literature Review

The literature review began with the evolution of RFID, followed by an outline of the technology's components and characteristics, including a briefing on how the technology actually works and a discussion of the EPCGlobal model in order to understand the current focus. This section of the literature review was followed with an overview of various RFID applications, including the retail supply chain, for which EPCGlobal is well suited. The value, benefits and drivers of RFID EPCGlobal networks were then reviewed in detail. In addition, the challenges associated with adopting RFID were also considered.

Previous research efforts specifically concentrating on the EPCGlobal model are limited, and the major contributors considered throughout this review are now summarised. Thiesse et al. (2009) provided a summary of EPCGlobal and related standards (Thiesse et al. 2009b)), while Schuster (2007) has outlined the value of EPCGlobal across a broad range of applications, including the retail supply chain. Bottani et al. (2007, 2009, 2010) have published a number of articles examining EPCGlobal and a panel of experts provided details for an economic assessment of EPCGlobal highlighting the financial capabilities of this technology (Bottani &

Rizzi 2008). These authors have also used mathematical analysis to address the way in which EPCGlobal has assisted in ensuring that promotional products were available (Bottani et al. 2009b), and EPCGlobal's role in traceability and reducing the bullwhip effect in an Italian supply chain was verified (Bottani et al. 2010). Wamba (2008b, 2009) supported this work and contributed to the research field with an empirical examination of the positive effect of EPCGlobal network on the shipping, receiving and put-away activities in the retail supply chain (Wamba 2009; Wamba et al. 2008b). Wamba (2009) also introduced the proposition that the business value of RFID in an EPC network is mediated by intra- and inter-organisational capabilities, including organisational structure and strategies that enhance information flow between supply chain partners (Wamba 2009). This enhancement has been achieved by automation and allowing the synchronisation of information and product flows, leading to improved visibility in the supply chain (Wamba & Boeck 2008). Finally, this author investigated the benefits and risks of adoption of EPCGlobal technology across a broad range of industries, including the retail sector. The results identified the relative importance of a range of issues and found the most important factors were data accuracy and top management support (Wamba et al. 2010). Other contributions have focused on specific aspects of EPCGlobal, such as security (Fabian & Günther 2009; Shih et al. 2005), counterfeiting (Kwok et al. 2010) and business processes/integration (Jakkhupan et al. 2010; Mo et al. 2009).

The review of the benefits and challenges associated with RFID adoption demonstrated a level of uncertainty regarding RFID capabilities. The literature presents three possible scenarios for the future of RFID: first, that barcodes will continue to be used in retail for many years because the advantages of RFID are not easily offset by the high costs of this technology, particularly the ongoing tag costs (Karkkainen 2002; Sheffi 2004). Second, that RFID will be adopted within specific industry sectors and co-exist with barcodes (Ngai et al. 2005; Zebra Technologies 2005), and finally, there was a view that RFID would eventually replace barcodes, although the timing for this to take place was unknown (Hingley et al. 2007; Michael 2003; Ngai et al. 2007a).

CHAPTER 3: DEVELOPMENT OF THEORETIC FRAMEWORK

3.1 Introduction

Chapter 3 establishes a theoretic framework in section 3.2 including a macro level framework in section 3.2.1. Organisational readiness, central to this study, is discussed in detail in section 3.2.2. In this section, Figure 3.2 encapsulated these details diagrammatically for use throughout this thesis. Following on, Section 3.3 explains the development of the survey instrument and Sections 3.3.1 to 3.3.7 present the proposed questions.

3.2 Theoretical Framework

Attention now focuses on highlighting relevant aspects from the literature review and presenting a framework to encapsulate the major factors found to be influencing the intentions to adopt RFID. To begin, the review of literature revealed gaps:

i. Although many conceptual papers have described RFID, few empirical studies were found, and even fewer investigating the EPCGlobal RFID model.

ii. The benefits and challenges of RFID were widely discussed in literature, with many associated factors within each category examined. Less apparent in literature was the inclusion of organisational readiness, with few studies discussing this factor. No known empirical studies included organisational readiness as an intermediary factor between the benefits and challenges associated with adoption of RFID. The crucial relevance of these factors necessitates further research.

iii. Finally, the relationships between the benefits of RFID, the challenges of RFID and organisational readiness also require further research. No known study has considered the impact of these factors on intentions to adopt RFID, and consequent supply chain performance.

This research intends to bridge these gaps and develop a theoretical framework to provide the motivation for the next phase of the study and justify further analysis and discussion. The research questions posited in the introduction (section 1.7.) provide a point of reference.

This research intends to capture the perspectives of managers within retail supply chains in order to answer to these questions. This research study seeks to understand the relationships between these factors and their impact on RFID on supply chain performance.

Details of the potential benefits associated with the adoption of RFID were documented earlier in Section 2.8, and these are considered to be the motivating factors for retailers to adopt RFID. Retailers recognise the importance of investing in emerging IT in order to improve the performance of their organisations. The adoption of appropriate IT within the logistics environment is known to generate a competitive advantage (Bourlakis & Bourlakis 2006). The main categories of benefits, as described earlier in this literature review, were summarised in Table 2.7. Challenges associated with adopting RFID were equally well recognised and well documented in the literature. A summary of these factors has been presented in Tables 2.11, 2.12, 2.13 and 2.15.

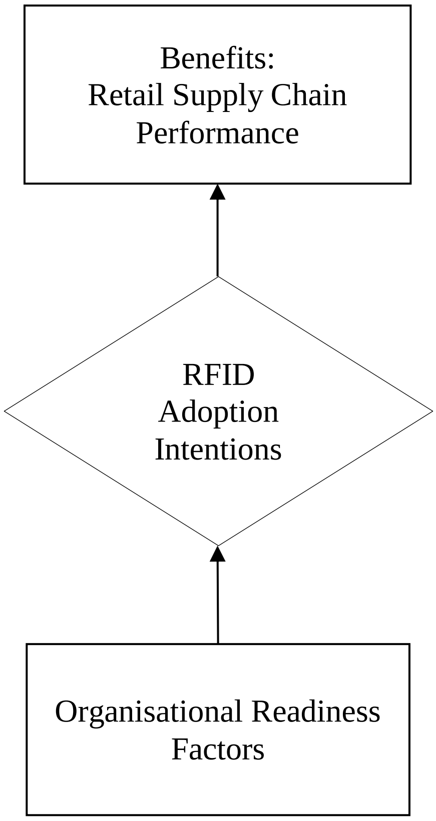
The level of interest in the potential of RFID has precipitated a variety of responses. While some organisations have not yet accessed information about RFID, others have spoken informally about this technology. Organisations more aware of this technology have formally gathered information and examined RFID opportunities. Proactive organisations have extended these investigations with pilot studies and trials (Brown & Russell 2007). However, very few have then taken the final stage and implemented RFID.

3.2.1 Macro Level Framework

Literature sources provide the background and framework for this investigation into RFID and its impact on retail supply chain performance. This research reveals three areas identified in the literature. First, benefits were recognised as the main drivers for adopting RFID within the retail sector, and possess the potential to improve retail supply chain performance (Bhattacharya et al. 2007; Brown & Russell 2007). Second, challenging factors were currently delaying the decision to adopt RFID (Lin et al. 2006; Wu et al. 2006). Third, the intention to adopt RFID was influenced by beneficial factors leading to potential improvement in retail supply chain performance, while the challenges negatively influenced this decision (Asif & Mandviwalla 2004).

This research sets out to examine the challenges faced by organisations intending to adopt RFID. The literature argues that successful treatment of these factors has the potential to improve retail supply chain performance (Poirier & McCollum 2006). Specifically, this research considers the criticality of factors, their relationships and their impact on retail supply chain performance. A macro level diagram illustrates these relationships in Figure 3.1.

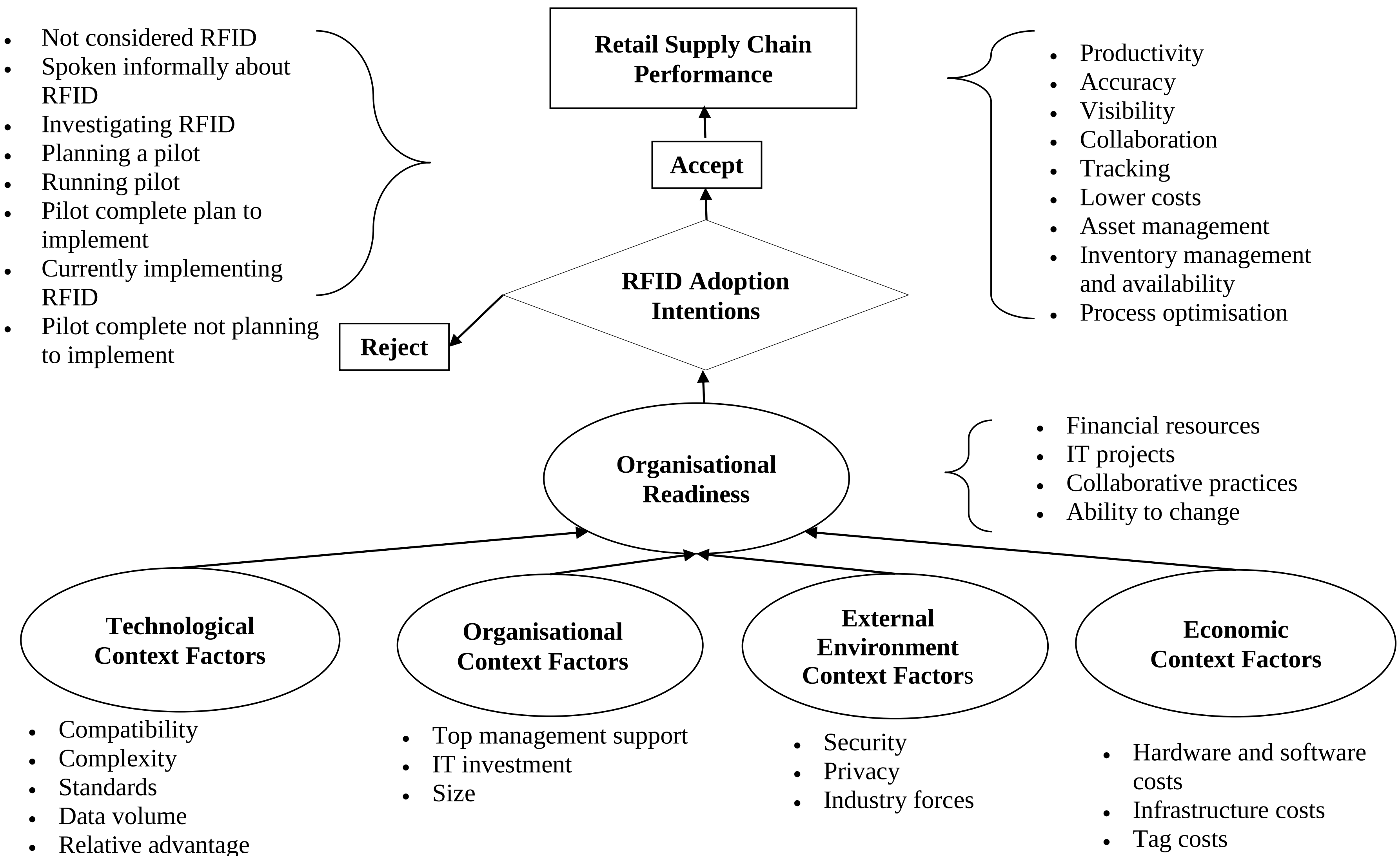
Figure 3.1: RFID Research Macro Level Framework



3.2.2 Organisational Readiness

The research framework above shows a link between the three areas including benefits, intentions to adopt and organisational readiness. This research proposes that organisational readiness |intercedes between the decision to adopt RFID and the underlying challenges. Previously, it was established that organisational readiness was inadequately represented in current RFID research. This gap in the research literature forms an integral part of this study. Organisational readiness was previously described in terms of awareness of factors that influence intentions to adopt, such as needs-fit, skills required and financial resource levels (Wu 2004). Readiness also included knowledge about emerging IT, current IT use (Mehrtens et al. 2001), previous involvement in similar IT projects (Asif & Mandviwalla 2004) and demonstrated collaborative efforts with supply chain partners (Lekakos 2007). The ability to embrace change was also considered important (Asif & Mandviwalla 2004). A more comprehensive theoretic basis for this study is diagrammatically presented in Figure 3.2.

Figure 3.2: Theoretical Framework



3.3 The Development of the Survey Instrument

This section operationalises the theoretical framework outlined in Figure 3.2 and constructs a survey instrument. The majority of questions were acquired from surveys used in previous empirical studies identified in the literature, validating their use in this study.

3.3.1 Questions Related to Performance Measurement

Retail supply chain performance is at the apex of the framework. The literature has acknowledged many benefits associated with the adoption of RFID that are translated into measures such as productivity, inventory accuracy and inventory visibility. In addition, tracking and tracing capabilities are important considerations when moving products throughout the world. Lower costs, asset management are equally likely to be influenced by the adoption of RFID. Inventory management and the availability of products were also mentioned and are an important consideration, especially within the retail sector. Finally, the ability to improve and optimise processes in the supply chain is fundamental to effective management. Research questions related to these measures have been adapted from a similar RFID study in Taiwan titled ‘An Empirical Study of Factors Affecting RFID Adoption in Taiwan’ by Shih et al. (2008). Table 3.1 presents these factors together with a brief description, and the associated research question: How do RFID adoption intentions impact on retail supply chain performance?

Table 3.1: Research Questions Related to Retail Supply Chain Performance Factors

Research question	Factors	Definition
How do RFID adoption intentions impact on retail supply chain performance?	Productivity	The ability to process orders faster (Attaran 2007; Heinrich 2005; Karkkainen 2003; Lapide 2004; Lekakos 2007; Lewis 2004; Ngai et al. 2005; Sweeney 2005)
	Accuracy	Defined as more accurate transaction due to transaction automation or less human intervention. The timeliness, accuracy, accessibility, currency, relevance and completeness of information. Sharing information and reduced bullwhip effect also improve accuracy (Asif & Mandviwalla 2004; Bardaki et al. 2007; Bharati & Berg 2003; Sellitto et al. 2007; Tajima 2007)

	Visibility	Visibility is described as the ability to view products as they make their way through the supply chain (Attaran 2007; Heinrich 2005; Narsing 2005; Ngai et al. 2005).
	Tracking and tracing	Tracking is defined as the ability to follow the product as it moves through the supply chain. Tracing reflects the history and associated information\ (Angeles 2005; Attaran 2007; Bardaki et al. 2007; Bottani 2009; McFarlane 2002; Narsing 2005; Sweeney 2005; Twist 2005)
	Lower costs	Costs are described as inventory, labour, transport and storage (Heinrich 2005; Jones et al. 2005; Karkkainen 2003; Lewis 2004; McFarlane 2002; Narsing 2005; Ngai et al. 2005; Twist 2005)
	Asset management	Defined as better usage of assets such as returnable containers or materials handling equipment (Bottani et al. 2009a; Bottani & Rizzi 2008; Tajima 2007)
	Inventory management and availability	Inventory availability describes products that are on the shelf when required by consumers. Often described in metric terms of OOS percentage. Inventory availability is also a function of reduced shrinkage (AMR Research 2005; Choy et al. 2005; Fleisch & Tellkamp 2005; Karkkainen & Holmstrom 2002; Rekik et al. 2006; Vijayaraman & Osyk 2006)
	Processing optimisation	Process optimisation considers the trade-off elements in the practices employed to add value to products (Jakkhupan et al. 2010; Vo et al. 2010; Wamba & Chatfield 2010) Questions for this section were adapted from Shih et al. (2008)

3.3.2 Questions Related to Intentions to Adopt RFID

This study proposes a relationship between the above performance measures and adoption of RFID. To date, there are very few RFID installations in the EPCGlobal framework throughout the world (Chiesa et al. 2002; Smart et al. 2010). Therefore, 'intentions to adopt' enables an understanding of the current retail industry landscape, particularly when considering the Australian retail sector. The level of intention is classified according to an organisation's position with regards to adopting RFID. Some organisations within the retail supply chain are yet to consider RFID; others are currently examining the technology, while some are embarking on pilot studies. This study postulates that higher levels of intentions to adopt will have a positive relationship to supply chain performance. Research questions related to intentions to adopt are adapted from a similar RFID study in South Africa titled 'Radio

Frequency Identification Technology: An Exploratory Study on Adoption in the South African Retail Sector' (Brown & Russell 2007). Table 3.2 presents these factors together with a brief description, and the associated research question: What are organisations' intentions with respect to adopting RFID?

Table 3.2: Intention to Adopt RFID

Research question	Factors	Definition
What are the organisation's intentions to adopt RFID?	Level of intention	Have not considered RFID yet Have spoken informally about RFID Formally investigated RFID Planning to launch a RFID pilot Currently running a RFID pilot Have completed a pilot and will not be implementing RFID Have completed a pilot and are planning to implement RFID Currently implementing RFID Questions for this section were adapted from Brown and Russell (2007)

3.3.3 Questions Related to Organisational Readiness

This research is differentiated from other studies of RFID by the proposal that complex emerging technologies such as RFID require a high level of organisational readiness. RFID technologies are not 'plug-and-play' (Lewis 2004). Organisations contemplating adoption must engage in learning about RFID and the processes that must be followed to successfully implement this technology. Change management, learning curves, knowledge transfer and financial resources are examples of concerns that need to be addressed. For instance, an organisation that has not previously been involved in major projects involving technology is unlikely to understand the requirements or have an internal culture capable of withstanding the dramatic changes associated with adoption.

This study postulates that higher levels of organisational readiness will have a positive influence on intentions to adopt RFID. Research questions related to these measures are also adapted from Brown and Russell's (2007) South African study. Table 3.3 presents these factors together with a brief description, and the associated research question: How does organisational readiness impact on RFID adoption intentions?

Table 3.3: Research Questions Related to Organisational Readiness

Research question	**Factors**	**Definition**
How does organisational readiness impact on RFID adoption intentions?	Organisational readiness	Organisational readiness relates to organisations that are prepared for significant change. These include organisations actively involved in similar IT projects, involved in collaborative practices with their supply chain partners and with access to information about emerging technologies. Sources also describe organisational readiness in terms of the level of available financial and technical resources (Asif & Mandviwalla 2004; Chwelos et al. 2001; Iacovou et al. 1995; Kuan & Chau 2001; Lee & Shim 2007; Lekakos 2007; Mehrtens et al. 2001). Question for this section were adapted from Brown and Russell (2007)

Organisational readiness implies that organisations have learned not only about the benefits of a technology which will improve their performance, but are equally well informed regarding the challenges associated with adoption of the technology. Challenges, grouped under technological, organisational, external environmental and economic categories are presented in Figure 3.2 and operationalised in the following sections.

3.3.4 Questions Relating to Technological Context Factors

Any form of RFID needs to be compatible with other RFID technologies, as well as any technologies with which it interacts, and organisations must also understand the complexities associated with RFID. RFID is part of the Auto-ID group of technologies discussed earlier and so requires standardisation to function effectively. These standards include numbering, power (wattage) and radio frequencies. In addition, data volume is considered to be an issue that needs to be resolved. Finally, the relative advantages of RFID over existing technologies such as barcodes needs to be fully understood.

This study argues that higher levels of understanding of these technological factors will have a positive influence on organisational readiness. The research questions relating to compatibility, complexity, standards, data volume and relative advantage are primarily adapted from similar RFID studies. The surveys from both Brown and Russell (2007) and

Shih et al. (2008) were used, and in addition, appropriate question were found in other comparable non-RFID studies. For example:

- Using Enterprise Architecture Standards in Managing IT (Boh & Yellin 2006)
- Success Factors for Domestic and International EDI Implementation for US Firms (Angeles et al. 2001)
- An Empirically Derived Model for the Adoption of Customer-Based IOS (Grover 1993)
- A Meta-Analysis of Research on IT Implementation in Small Business (Premkumar 2003)
- Determinants and Outcomes of EDI Diffusion (Ramamurthy & Premkumar 1995)
- Assimilation and Diffusion of Web Technologies in Supply Chain Management: An Examination of Key Drivers and Performance Impacts (Ranganathan et al. 2004)
- Predicting Intention to Adopt Inter-Organisational Linkages: An Institutional Perspective (Teo et al. 2003)
- Adoption of Information Technologies in Rural Small Business (Premkumar & Roberts 1997)
- An Exploratory Study to Identify the Critical Factors Affecting the Decision to Establish Internet-Based Inter-Organisational Information Systems (Soliman & Janz 2004)
- Key Obstacles to EDI Success: From the US Small Manufacturing Companies' Perspective (Jun & Cai 2003)

In addition, questions related to standards were drawn from 'Standards and the Market Acceptance of IT: An Exploration of Relationships' by Morell (1994). This author developed a model to understand the link between standards and the success of IT. This model included an examination the impact of standards on the acceptance of technology and so questions obtained from its theoretical framework were considered suitable for this study.

Table 3.4 presents these factors together with a brief description, and the associated research question: How do technological factors impact on organisational readiness

Table 3.4: Research Questions Related to Technological Context Factors

Research question	Factors	Definition
How do technological factors impact on organisational readiness?	Compatibility	Compatibility refers the perception that an innovation is consistent with existing values, past experiences and the needs of users (Rogers 1995). Compatibility indicators include integrating RFID with existing ERP, other RFID technologies, or existing information systems (Asif & Mandviwalla 2004; Davenport & Brooks 2004; Twist 2005) Question for this section were adapted from Angeles et al. (2001), Brown & Russell (2007), Grover (1993), Premkumar (2003), Ramamurthy & Premkumar (1995), Ranganathan et al. (2004) and Shih et al. (2008)
	Complexity	Complexity refers to the relative difficulty in understanding and using a technology. Complexity also refers to levels of reliability including false read rates(Lie et al. 2006; Rogers & Shoemaker 1971; Spekman & Sweeny 2006). Question for this section were adapted from Brown & Russell (2007), Premkumar & Roberts (1997), Ramamurthy & Premkumar (1995) and Teo et al. (2003)
	Standards	Standards indicators include frequency standards (Angeles 2005; Lewis 2004; Twist 2005), numbering standards (Angeles 2005; GS1EPCGlobal 2008; Lewis 2004; Shepard 2005; Twist 2005) and power standards (GS1EPCGlobal 2009) Question for this section were adapted from Brown & Russell (2007), Jun & Cai (2003), Ramamurthy & Premkumar (1995) and Soliman & Janz (2004)
	Data volume	Data volume is a potential issue requiring attention. When RFID is implemented throughout industry the amount of data could increase significantly (Angeles 2005; Lin et al. 2007; Twist 2005; Zeier et al. 2009)
	Relative advantage	Relative advantage indicators are expressed in terms of comparing RFID with current barcode technology (Hingley et al. 2007; Knospe & Pohl 2004; Shepard 2005; Song et al. 2005) Question for this section were adapted from Angeles et al. (2001), Boh & Yellin (2006) Morell (1994), Shih et al. (2008) and Soliman & Janz (2004)

3.3.5 Questions Relating to Organisational Context Factors

There are a range of organisational factors presented in the literature that impact on the adoption of RFID. The two major organisational influences identified in the literature include top management support and IT investment. Once again the research questions for this study have been derived from some of the above authors, including Brown & Russell (2007), Ranganathan et al. (2004) and Grover (1993). In addition, question were also taken from the following sources:

- Logistics Information Systems: The Strategic Role of Top Management (Bardi et al. 1994)
- IT Investments and Organisational Productivity and Performance: An Empirical Investigation (Mahmoud & Mann 2005)
- Research Report: Empirical Test of an EDI Adoption Model (Chwelos et al. 2001)
- IT Infrastructure Capability's Impact on Firm Financial Performance: An Exploratory Study (Schwager et al. 2000).

Table 3.5 presents these factors together with a brief description, and the associated research question: How do organisational factors impact on organisational readiness?

Table 3.5: Research Questions Related to Organisational Context Factors

Research question	**Factors**	**Definition**
How do organisational factors impact on organisational readiness?	Top management support	Top management support is defined as the willingness for senior management to sign off on risky and uncertain technology projects. Top management support is also associated with RFID adoption (Attaran 2007; Ngai et al. 2005) Question for this section were adapted from Bardi et al. (1994), Brown & Russell (2007), Chwelos et al. (2001), Grover (1993), Premkumar (2003) and Ranganathan et al. (2004)
	IT investment	IT investment describes the organisation's access to resources when embarking on installing RFID (Sharma et al. 2007). IT investment also describes the propensity of an organisation to embrace technology (Ranganathan & Jha 2005; Sharma et al. 2007) Question for this section were adapted from Brown (2007), Mahmoud & Mann (2005) and Schwager et al. (2000)

Questions were also constructed that relate to the size of the organisation. It was proposed that the size of organisations would correlate with the likelihood of adopting RFID, due to the greater availability of resources in larger organisations. These factors, including organisational size and organisational turnover, are presented in Table 3.6.

Table 3.6: Research Questions Related to Organisational Size

Research question	**Factors**	**Definition**
Organisational size	People employed	Employing less than 20 people Employing 20 or more people, but less than 200 Employing 200 or more people, but less than 300 Employing 300 or more people, but less than 400 Employing 400 or more people, but less than 500 Employing more than 500 people
	Organisational turnover	Less than $25K $25K to less than $50K $50K to less than $75K $75K to less than $100K 100K to less than $150K $150K to less than $200K $200K to less than $500K $500K to less than $1M $1M to less than $2M $2M to less than $5M $5M to less than $10M $10M to less than $20M $20M to less than $50M $50M to less than $200M More than $200M Question for this section were adapted from Pink & Jameieson (2000)

3.3.6 Questions Relating to External Environmental Context Factors

Several external environmental factors have been identified in the literature as impacting on the adoption of RFID. The three major external environmental influences identified include security issues, consumer privacy issues and industry forces. The questions related to security issues are derived from Angeles et al. (2001) and Soliman & Janz (2004), already cited above. Questions related to privacy were also derived from Angeles et al. (2001) as well as 'The Impact of Consumer Perceptions of Information Privacy and Security Risks on the Adoption of Residual RFID Technologies' by Cazier et al. (2008). Lastly, industrial forces, including the mandates imposed by customer organisations, are also critical to the success of adoption intentions. Question for this section were obtained from Brown & Russell (2007), Chwelos et al. (2001), Premkumar (2003) and Soliman & Janz (2004).

The major factors discussed above together with a brief description are presented in Table 3.7. These all relate to the research question: How do external environmental factors impact on organisational readiness?

Table 3.7: Research Questions Related to External Environmental Context Factors

Research question	Factors	Definition
How do external environmental factors impact on organisational readiness?	Security issues	Security issues are described as the propensity for unauthorised access to information. These include information confidentiality, integrity, availability, as well as user authentication and anonymity (Shih et al. 2005) Question for this section were adapted from Angeles et al. (2001) and Soliman & Janz (2004)
	Industry forces	Industry forces are explained as the mandate behaviour of powerful retailers and the mimetic behaviour of competitors (Bednarz 2004; Murphy 2003; Reyes 2007; Sullivan 2004) Question for this section were adapted from Brown & Russell (2007), Chwelos et al. (2001), Premkumar (2003) and Soliman & Janz (2004)
	Privacy issues	Privacy issues are described as the willingness of customers to buy products that are RFID tagged and embrace a technology that may compromise their privacy (Angeles 2007; Potter 2005) Question for this section were adapted from Angeles (2007), Cazier et al. (2007) and Shih et al. (2008)

3.3.7 Questions Relating to Economic Context Factors

The final set of factors relate to costs, and the literature has identified the variable and fixed costs impacting on the adoption of RFID. Questions related to cost factors were taken from Brown and Russell (2007), Premkumar (2003) and Ramamurthy & Premkumar (1995). The factors associated with the costs discussed above are presented in Table 3.8. These all relate to the research question: How do economic factors impact on organisational readiness?

Table 3.8: Research Questions Related to Economic Context Factors

Research question	Factors	Definition
How do economic factors impact on organisational readiness?	Economic	Cost indicators include tags (Attaran 2007; Donovan 2003), hardware and software (Asif & Mandviwalla 2004), training and consulting (Walker 2004) and infrastructure (Narsing 2005) Question for this section were adapted from Brown and Russell (2007), Premkumar (2003) and Ramamurthy & Premkumar (1995)

This research argues that the above technological, organisational, external environmental and economic challenges are associated with organisational readiness. Increased levels of understanding of the first three factors will lead to a positive influence on organisational readiness. The conjecture is that there will be a negative influence with regard to costs; in other words, costs will result in a negative influence on organisational readiness. Further, higher levels of readiness will have a positive influence on intentions to adopt and consequently, on retail supply chain performance.

The use of IT is also important and questions related to these technologies were derived from a number of sources including 'Supply Chain Management' by Bowersox et al. (2010) and 'A Field Study of RFID Deployment and Returns Expectations' by, Whitaker et al. (2007) (Table 3.9).

Table 3.9: Research Questions Related to Information Technology Usage

Research question	Factors	Definitions	Definitions
Organisation's use of IT	IT	ERP CRM systems Supply chain planning software Data warehouse Business intelligence tools Web services Content management software Product life cycle management software EDI XML/EDI Advance planning and scheduling system Advanced shipment notification	Barcoding Portal technologies RF communication Voice input interfaces RFID hardware RFID software RFID readers RFID infrastructure RFID tags Extranets Intranets Satellite communication Decision support systems
Question for this section were adapted from Bowersox et al. 2010; Whitaker et al. 2007			

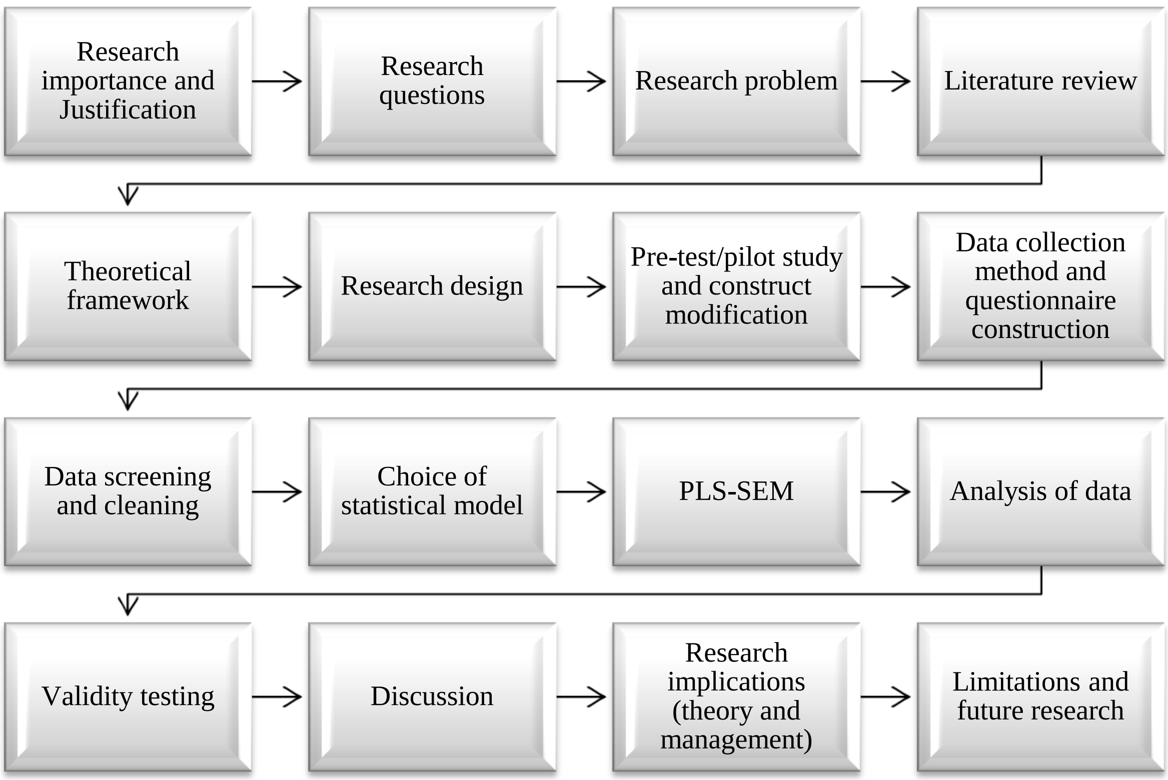
The above sections relate to the operationalisation of the research questions developed in the Section 1.7. The intention is to determine the perspectives of managers within organisations so that these questions may be answered. The next chapter discusses the manner in which this research is designed and the methods employed.

CHAPTER 4: RESEARCH DESIGN

4.1 Introduction

In Chapter 1, the research problem and research framework set out in Sections 1.5 and 1.6 established a starting point and informed the development of the research questions in Section 1.7. Chapter 2 reviewed the literature and chapter 3 presented a theoretical framework as well as establishing and justifying a data collection instrument. This chapter describes the research design, including the philosophy and procedural framework that describes how the research is to be done (Blaxter et al. 2001; Remenyi et al. 2000). Section 4.2 explains the methodology as it relates to this study, while Section 4.3 provides the justification for this research. Section 4.4 presents the details of the research plan, while the ethics approval process is described in Section 4.5. In Section 4.6, a structured pilot study applying AHP provides a preliminary understanding of the factors and relationships outlined in Chapter 2 and validates the survey instrument developed in Section 3.3. Finally, the results of the AHP analysis are discussed in Section 4.7. The methodology flowchart for this research is presented in Figure 4.1.

Figure 4.1: Methodology Flow Chart



4.2 Methodology

Undertaking research requires decisions about the choice of methodology from the possible alternatives; nonetheless, the foundation for the choice of methodology resides in research philosophy. Research philosophy refers to the development and nature of knowledge (Saunders et al. 2007). There are several research philosophies and the two most common, phenomenology and positivism, will be described below as an introduction to the approach taken by this study.

4.2.1 Phenomenology

Phenomenology focuses on describing how things are experienced by those involved (Denscombe 2003). Behaviour is determined by a 'phenomenon of experience'; in other words, a subjective consciousness that has moved past the detailed reality of the situation (Remenyi et al. 2000), so does not reside outside of reality. The process concentrates on subjectivity, descriptiveness and the interpretation of phenomena (Denscombe 2003). This approach is suited to social settings where the experience of those involved is a primary feature.

4.2.2 Positivism

Positivist research is more aligned to the natural sciences and this approach is inclined to use precise quantitative measures (Cavana et al. 2000). Positivism is about observable reality (Saunders et al. 2007). A positivist approach to research is known and understood in the supply chain literature (Kotzab et al. 2005; Mentzer & Kahn 1995), and is suited to researching the influence of factors associated with RFID in retail supply chains. The two main techniques employed in positivist research methods involve quantitative and qualitative approaches.

4.2.3 Qualitative and Quantitative Techniques

Qualitative techniques concentrated on what people do and say and emphasise rich descriptions of situations and processes. Qualitative research exists in everyday life, and there is no judgement, decision or action without some input of a qualitative nature. The focus is on discovering and clarifying the situations, feelings, attitudes, values and experiences of people

(Kumar 2011). Such research involves the use of narrative answers to questions, the contexts of which are then analysed in order to provide further information (Cavana et al. 2000). Qualitative techniques also consider the meanings, definitions or analogies characterising something, whereas quantitative techniques assume a meaning and refer to its measurement (Cooper & Schindler 1998).

In contrast, quantitative research communicates an attribute in numbers and these enable measurement to examine relationships. Many areas of science are stated in numeric terms in order to specify some degree of exactness (Nunnally 1978). Quantitative techniques are highly structured and specific, with prior testing for validity and reliability (Kumar 2011). Research within supply chain management often involves such relationships, and quantitative techniques allow the measurement of causal relationships between the factors involved (Mangan et al. 2004). This research study employed quantitative techniques for the analysis of the data collected. The questions asked in this study elicited responses that were represented numerically, either on an ordinal scale—for example, for the demographic data—or on an interval scale in the form of Likert dimensions. This was to allow the communication of attributes in numerical format to enable further examination of the relationships between these factors. Likert scales are well established in research and the choice between a five point, seven point and nine point scale considered for this research. A seven point Likert scale was chosen as more suitable for this study rather than a five point Likert scale because this provides an appropriate scope for capturing the relevant information (Lee and Lings 2008)

4.3 Justification for the Research

The justification for this research is based upon the following aspects:

4.3.1 The Recent Focus on RFID in the Retail Sector

The literature review in Chapter 2 has addressed this aspect by explaining the increasing level of interest and subsequent examination of RFID within the retail sector. Currently, retail businesses are engaged in investigating this technology in an attempt to determine potential opportunities that might be acquired from its adoption.

4.3.2 Gaps in the Literature

The theoretical framework presented in Section 3.2 has explained the gaps in the literature, thus justifying the position of this research in attempting to address these gaps. For instance, the EPCGlobal network is a recent phenomenon that has attracted limited research attention. While previous research has examined the relationships between individual factors, there is no known research output focusing exclusively on the relationships between these factors, including attempts to identify the importance of factors impacting on intentions to adopt RFID. In addition, there is also no known research predicting organisational readiness, intentions to adopt and supply chain performance. Furthermore, no known research effort has established organisational readiness as an intermediary between the challenges associated with RFID and intentions to adopt this technology. Finally, unlike much of the research focusing on RFID, this research output concentrates on the Australian retail environment.

4.3.3 Contribution of the Research Outcomes

Given the interest in this area and the gaps in the current knowledge presented above, this research contributes to the existing knowledge by extending the understanding of RFID in the retail sector. This research will provide a rich understanding of EPCGlobal in a retail environment through the provision of a sound empirical examination of factors. This study also presents an explanation of how these factors interrelate and the strengths of the relationships between them. Managers will be required to rethink the status of their organisation's preparedness in order to successfully engage with emerging technologies such as RFID.

4.4 Research Plan

This research follows on from Chapter 1 and the research problem presented in Section 1.5, the research framework represented in Section 1.6 and the subsequent research questions given in Section 1.7. The design of this research provides a clear path to enable the interdependence of all elements to be identified and understood. The research plan establishes a rationale for this research (Saunders et al. 2007).

4.4.1 Purpose of the Analysis

The purpose of this research is to analyse the factors affecting the acceptance of RFID, including challenges, organisational readiness, adoption intentions and benefits that improve retail supply chain performance. The analysis is exploratory, descriptive and predictive. An exploratory approach is effective when the area being studied is considered new, with little information available regarding it (Sekaran 2003). RFID in the EPCGlobal model is a recent innovation, and this study explores the phenomena surrounding this model. In addition, this study sets out to describe the characteristics of the major factors involved in the choice to adopt this new technology, as well as the relationships between them. Finally, and importantly, this research endeavours to predict the extent to which each factor influences the other factors by adopting a path-wise structural equation model, PLS-SEM. This approach enables an understanding of the importance of factors being analysed.

4.4.2 Unit of Analysis

The unit of analysis relates to the accumulation of data at the analysis stage and incorporates individuals, dyads, groups, organisations or cultures (Cavana et al. 2000). This research deals with a supply chain environment, and hence the unit of analysis is organisational. The data were collected from managers in organisations who were involved with supply chains and understood the manner in which products are identified using technologies such as barcodes. The respondents' perspectives formed a proxy of their organisation's view of the factors being studied (Cavana et al. 2000).

4.4.3 Type of Investigation

There are several paths of investigation available and these depend to some extent on the purpose of the research. The two main investigative processes centre around the correlational, indicating that two or more variables move simultaneously, or the causal, whereby one variable causes the other variable to move (Cavana et al. 2000). The purpose of this research was to examine the factors associated with intentions to adopt RFID and their relationships. The intention was to identify the manner in which one variable influences another. The approach was therefore causal, and visually defined the direction of influence, size of the impact and the form of the impact in a pathway model.

4.4.4 Extent of Interference and Study Setting

There are varying levels of interference by the researcher depending on the approach. For example, studies adopting simulation have higher levels of interference because changes can be made to the values of the object of interest and different scenarios developed. However, this research took place in a normal setting and analysed the events as they occurred, and therefore exhibited minimal levels of interference.

Research settings can also be contrived, meaning that the variables are manipulated, or not contrived, where interference is minimal. Once again, an example of a contrived setting is in simulation studies where the variables are deliberately manipulated to identify patterns of behaviour. This research study was not contrived, because it took an empirical approach involving a survey of industrial organisations. The setting for this study involved asking relevant managers for their perspectives on the variables required to measure latent or unobserved variables (Saunders et al. 2007).

4.4.5 Time Horizon

Research either studies a phenomenon at one point in time, or carries out studies at two or more points in time. Longitudinal studies consider changes over time, or the changes observed before and after altering a variable. Although it would be helpful to undertake a comparative study of organisational readiness, due to time constraints and the research design, a single cross-sectional event was used in this research.

4.4.6 Data Collection

The data was collected through survey questionnaires. The questionnaires were based on information obtained through a review of literature. A mail-out approach using Australia Post enabled the survey to be distributed to participants. The survey was sent to participants considered likely to be involved in product identification and have some understanding of RFID in a retail supply chain setting.

4.4.7 Measurement

Measurement is the process of assigning numerical values to the characteristics of objects, as determined by a set of rules (Sekaran 2003). In this research, the variables were operationalised to become the dimensions measured. Respondents circled an appropriate number related to the questions to indicate their level of agreement with specific statements. For example, in relation to technological standards, a statement ‘Standards will assure the performance of RFID’, required a response to be given by circling a number between ‘strongly agree’ and ‘strongly disagree’ using a 7-point Likert scale. These indicators enabled the measurement of the relevant factors.

4.4.8 Sampling Design

There are two major types of sampling design; namely, probabilistic and non-probabilistic (Sekaran 2003). A non-probabilistic sampling design is one where the components being studied do not have a known chance of being selected. On the other hand, in probabilistic sampling the components in a given population have some chance of being selected. This research study is probabilistic because the representativeness of the sample relative to the total population enables a generalisation about the population. In this case, the population was all organisations within the Australian retail sector that have been involved to some extent in the identification of products and/or the associated identification systems. In addition, the population also involved technology providers and consultants involved in developing, administering or marketing identification systems, or training those who use these systems.

4.4.9 Data Analysis

The data was analysed using quantitative techniques. This research adopted AHP in the pilot study and a multivariate analysis approach, PLS-SEM, to analyse the data in accordance with the intentions of the investigation. PLS-SEM analyses the way in which variables are linked, and predicts the outcome of these linked variables to identify the manner in which they influence the outcome; in this case, performance in retail supply chains. Table 4.1 provides the framework for this research design and summarises this section.

Table 4.1: Planned Research Approach

Problem Statement	**Purpose of the study**	**Type of investigation**	**Extent of research interference**	**Measurement**	**Data collection**
	Exploratory Descriptive Predictive	Clarification Causal	Minimal: studying events as they normally occur	Operational definition Itemised measurement	Interview and mail-out of survey questionnaires
	Unit of analysis	**Study setting**	**Time horizon**	**Sampling design**	**Data Analysis**
	Organisational	Non-contrived	Cross-sectional	Probabilistic	Quantitative

(Sources: Adapted from Cavana et al. 2000; Saunders et al. 2007; Sekaran 2003).

4.5 Ethics

Ethics is an important aspect of all research, particularly within academic institutes. The ethics approval process involves clarifying what the researcher is intending to undertake in order to protect the interests of both the research institute and the participants. This research has approval to contact business leaders and managers in order to gather information pertinent to the research objective. Approval has been granted by the RMIT Ethics Committee and adheres to set guidelines. Participants were asked to respond to questionnaires, although they were not pressured to do so and confidentiality was ensured. Participants gave informed consent and names and addresses were neither requested nor obtained, and so anonymity has been preserved. Section 10.2 in Appendix B provides a copy of the letter containing the ethics information.

4.6 Pilot Study

A pilot study was conducted to provide a preliminary understanding of the importance of the factors associated with the adoption of RFID, as well as to validate the content and understanding of the main survey questions presented in Section 3.3 of the previous chapter.

At the start of this research study, industry leaders were contacted to arrange short informal interviews. These interviews were designed to gather preliminary information about retail supply chains, as well as perspectives on the retail sectors’ understanding of RFID, and in particular the EPCGlobal network. Interviews prompt respondents and enable more reliable responses about the topic (Rossi et al. 1983). The results of these personal interviews assisted in interpreting the literature and structuring the research. The questions developed in Section 3.3 formed the basis of this pilot study. Normally, pilot studies are undertaken by interviewing business managers. However, in this study, in addition to the interviews, a structured framework was adopted to assess the importance of the factors. AHP was employed to determine the importance of factors and facilitated the construction of the main survey instrument. The aim of this pilot study was to analyse the factors associated with intentions to adopt RFID and subsequent supply chain performance, as set out in the theoretical framework. This process also assisted in validating the questions that were used in the main survey.

4.6.1 Analytical Hierarchy Process

Analytical Hierarchy Process (AHP) is a multi-criteria decision analysis model where the central focus is on optimising or trading off against several alternative solutions to a problem (Köksalan & Sagala 1995). AHP is appropriate in a variety of research situations, including portfolio decisions and subsequent allocation of resources, directions for new product development and evaluating marketing mixes (Wind & Saaty 1980). AHP is also used for examining benchmarking factors, quality management factors, determining public policy, health care and strategic planning (Forman & Gass 1999). AHP has also been applied to solve economic/management problems, political problems, social problems and technological problems (Vaidya & Kumar 2004; Vargas 1990). AHP was adopted in supply chain applications to determine the importance of risk factors (Gaudenzi & Borghesi 2006; Sofyalıoğlu & Kartal 2012), supplier selection (Kaur et al. 2010; Liao & Kao 2010), evaluate IOSs (Sarkis & Srinivas 2004), reverse logistics (Barker & Zabinsky 2011) and to analyse the suitability of RFID for organisations (Chang & Chen 2011; Lin & Lin 2007).

AHP models can be applied in a number of different ways. First, AHP might assist in choosing between alternatives, for example, where the relative merit of one set of alternatives is compared. This differs from having one clear 'winner' by ranking of several alternatives in order; for instance, the relative importance and subsequent ranking of project proposals. Third, AHP can be applied in an allocation exercise to determine the effectiveness of a number of resources when compared to an organisation's goals. An example might be to find the best combination of project alternatives for an organisation. A comprehensive listing of articles presenting the problems, applications and trends associated with AHP is available (Ho et al. 2010; Subramanian & Ramanathan 2012; Vaidya & Kumar 2004; Vargas 1990).

AHP simultaneously integrates qualitative and quantitative information to solve complex problems (Saaty 1980). It relies on judgement and experience in making decisions and integrates this information with values to enable the analysis and ranking capability (Cheng & Heng 2001; Meade & Sarkis 1998; Partovi et al. 1989; Sureshchandar & Leisten 2006). According to Saaty (1982) the decision-making approach should be simple in structure, adaptable to both group and individual decision-making environments, intuitive, encourage consensus and not require inordinate specialisation to master and communicate. Within the AHP framework, problems are reduced into smaller parts so that they can be compared in a pairwise manner and prioritised. This process allowed a researcher to cope with intuitively rational, as well as irrational, multi-criteria decisions (Saaty 1986).

A benefit of AHP analysis is systematising what would otherwise be a subjective decision to facilitate a more accurate answer. Information about the inherent weights is made available and the use of recent computer software enables sensitivity analysis (Narasimhan 1983). Despite limitations, including arbitrary and subjectively nominated values and inconsistency issues, AHP has been widely adopted in academic research because of its robust structure and intuitive modelling characteristics (Eckman 1989; Ishizaka & Labib 2009). AHP represents a trade-off between usability and perfect modelling, particularly when complex decisions need to be made (Ishizaka & Labib 2009).

4.6.1.1 The Analytical Hierarchy Modelling Process

The process of applying AHP involved the following steps:

Step 1: Assessment of factors relevant to the study
Step 2: Structuring the problem as a hierarchy and building the AHP model
Step 3: Collection and compilation of expert opinions and application of the prioritisation procedure
Step 4: Determination of critical factors (Saaty 1982)

The following sections present details of the pilot study in terms of the above steps.

Step 1: Assessment of Factors Relevant to the Study
The first step required the compilation of factors in preparation for determining their importance in relation to RFID adoption intentions. In this instance, factors were derived from the literature review presented in Chapter 2 and 3. The literature identified a number of factors that are important to RFID adoption intentions (Cannon et al. 2008; Roh et al. 2009; Wamba et al. 2010). Specifically, this research concentrates on examining the technological, organisational, external environmental and economic context factors, which are all considered integral to the adoption of RFID. The intermediary factor between these categories and adoption intentions was organisational readiness.

Step 2: Structuring the Problem as a Hierarchy and Building the AHP Model

The second step involved the arrangement of the factors into a hierarchical structure. The hierarchy comprised three levels. The first level, or apex, was defined as the 'goal'. In this analysis the goal was to consider organisational readiness based on the awareness of the critical and challenging factors described in Step 1. The intention was to validate the challenges with respect to organisational readiness. The second level was the basis on which the rankings were made and consisted of the criteria presented within the technological, organisational, external environmental and economic categories. The lowest level in this analysis, Level 3, was populated with a more detailed set of factors aligned to Level 2 requiring assessment. The structure is presented in Table 4.2.

Table 4.2: Problem Structure

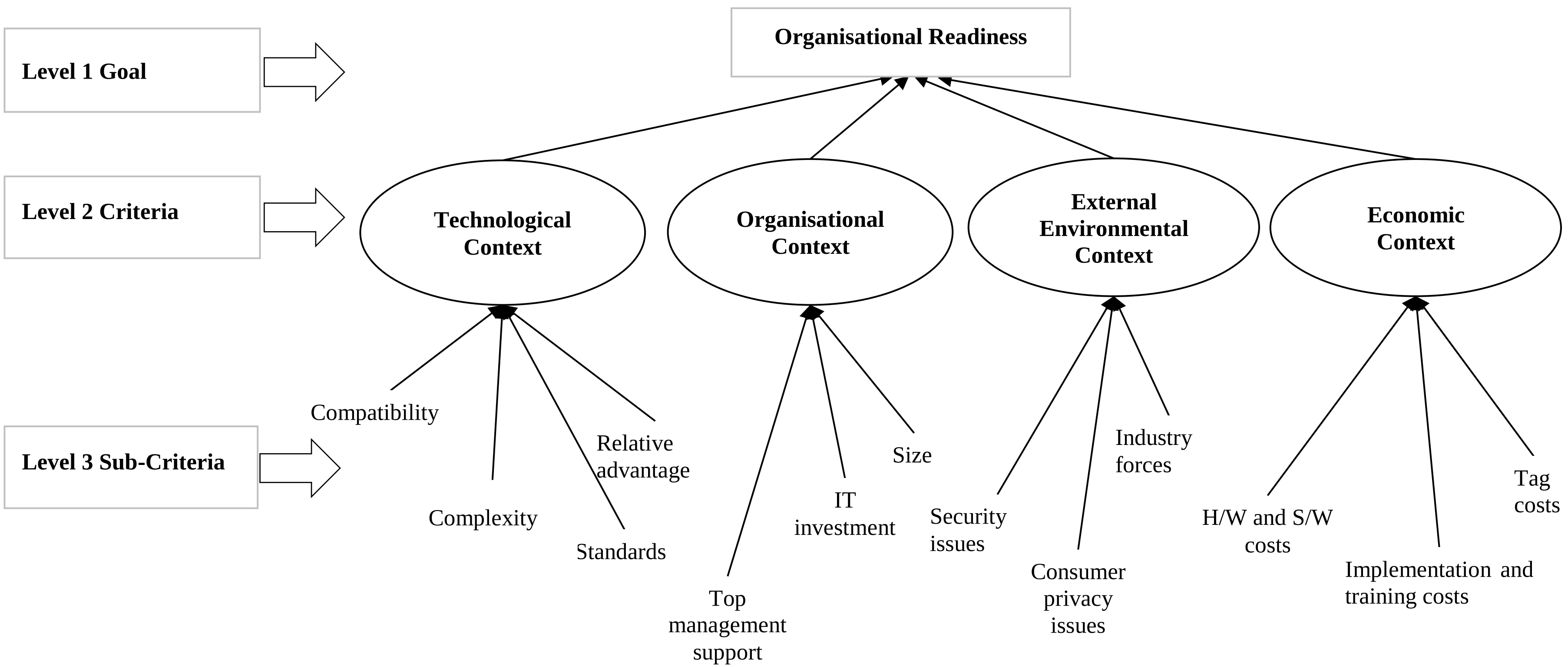
Level No.	**Level description**	**Generic definition**	**RFID study**
1	Goal	The overall objective of the decision-making process and the apex of the hierarchy	The goal is to identify organisational readiness based on awareness of the factors
2	Criteria	The basis on which the rankings are evaluated	Factors such as the technological, organisational, external environmental and economic context
3	Sub-Criteria	The factors	Detailed factors aligned to each of the criteria in Level 2

(Source: Adapted from Saaty, 1982)

The factors within each of these levels embrace the current discussion regarding the challenges organisations encounter when examining RFID, as outlined in Chapter 2. For example, within the technological category, RFID compatibility with ERP systems and other technologies is considered a potential problem (Curtin et al. 2007; Davenport & Brooks 2004). Technological challenges also exist with complexity, standards, and relative advantages. Initial discussion with managers, as well as the literature sources, identified data volume as not a significant issue and thus this challenge was eliminated from further analysis. Factors within the other categories—organisational, external environmental, and economic—also represented challenges. These key factors all influence the decision to adopt RFID. The

Level 1 goal was to identify the 'state of organisational readiness' based on how each of the Level 2 factors were judged in comparison with each other factor in the group. Level 2 was represented by the four categories: technological, economic, organisational and external environmental. Factors within each of these categories (Level 3) required continuous refinement, knowledge and awareness of RFID developments. A comprehensive framework explaining all of these factors is illustrated in Figure 4.2, in preparation for the collection of data.

Figure 4.2: AHP Hierarchical Configuration of Factors



Step 3: Collection and Compilation of Expert Opinions and Application of Ranking

The third step in the AHP involved the collection and compilation of expert opinions and the application of the prioritisation procedure. The initial collection of data comprised a survey mailed to managers involved in making decisions throughout Australian retail supply chains. The managers surveyed for this pilot study belonged to a diverse range of industries including home improvements, electronics, fashion, grocery and soft furnishing products. Suppliers included distributors, wholesalers and manufacturing facilities. The survey was also sent to technology provider organisations involved in marketing, supporting and installing RFID products and services.

The respondents were initially contacted by telephone, with those agreeing to participate being e-mailed the survey details and a return mail envelope. The initial returns from the respondents were found to be inconsistent, and thus a more considered approach to data collection and additional explanation of the AHP process and the criteria and sub-criteria was necessary.

The data collection methods were modified and it was decided to conduct face-to-face interviews with the managers who agreed to be involved. This enabled a more detailed explanation of each factor as well as how AHP, and in particular, pairwise decision-making actually worked. Additionally, during the interviews data was entered directly into Expert Choice software enabling the researcher to determine if the entries exhibited inconsistency (Expert Choice 2010). Managers who participated in the survey were assured that all details of their organisations would remain strictly confidential, in line with ethics approval. Twelve managers agreed to participate and were interviewed. There were a total of two retailer respondents from the retailer sector; a supply chain manager and an IT manager. Both retail facilities were identified as large, with more than 500 staff. The supplier respondents included five managers; three in logistics, distribution, e-business, and two in the manufacturing sector. The size of supplier organisations ranged from quite small, with 20 or fewer employees, to larger organisations represented by more than 500 staff. The turnovers of these organisations were not provided. The technology respondents included five technical and business-oriented managers involved in either selling products or supporting the technology. Two organisations were small, at less than 200 staff, and the other three medium, with 20 and 200 staff. These details are summarised in Table 4.3.

Table 4.3: Pilot Study Respondents

Origin	Respondent	Organisation Size (employment)
Retail	Supply Chain Manager	>500
	IT Manager	>500
Supplier	Logistics Manager	20–200
	Distribution Manager	>500
	Manufacturing Manager	<20
	Manufacturing Manager	20–200
	E-business Manager	>500
Technology Provider	Technical Manager	20–200
	Technical Manager	20–200
	Business Development Manager	20–200
	Business Development Manager	<20
	Business Development Manager	>20

Step 4: Determination of Critical Factors

The fourth and final step involved the determination of the critical factors. The rationale for the calculations involved the respondents choosing one factor over another and weighting this factor accordingly. For example, in ranking second-level technological, organisational, external environmental and economic factors, the respondent had to consider each and compare them all with each other. If the respondent viewed technological factors as extremely preferred in relation to organisational factors, the rating 9 would be given. Based on the hierarchical configuration developed previously in Figure 4.2, a similar process was adopted for all factors. The ranking process was based on a 9-point Likert scale, with 1 representing equally preferred and 9 representing the highest possible order of favouring one activity over another. Reciprocals of the above also needed to be acknowledged. For example, if factor 'A' was judged as moderately preferred over factor B, then factor B must be 1/3 preferred. These preferences and reciprocals are presented in Table 4.4.

Table 4.4: The 9-Point Rating Scale for Analytical Hierarchy Process Analysis

Verbal Judgment	Description	Degree of preference/ (reciprocal)
Equally preferred	Two criteria/alternatives contribute equally to the objective	1 (1)
Moderately preferred	Experience and judgment slightly favour one activity over another	3 (1/3)
Strongly preferred	Experience and judgment strongly favour one activity over another	5 (1/5)
Very strongly preferred	A factor is very strongly favoured over another	7 (1/7)
Extremely preferred	The evidence favouring a factor is of the highest possible order of affirmation	9 (1/9)
Intermediate numbers 2, 4, 6, 8 were also adopted. Reciprocals of the above are in brackets		

(Source: Saaty 1994)

4.6.1.2 Expert Choice Software and Consistency Index Rationale

A number of different software programmes were available to assist in the analysis of the data. These included CGI (CGI 2008), Rational Focal Point (IBM 2011) MakeItRational (MakeItRational 2011) and Expert Choice (Expert Choice 2010). This research adopted Expert Choice as the software tool for the AHP methodology-based analysis. Expert Choice helps the decision-maker throughout the phases of the problem-solving process, including model formulation. This AHP software comprises a structuring module and an evaluation and choice module, enabling a decision-maker to create the AHP model. The respondents' expert assessments were entered into the programme to provide a result, allowing sensitivity analysis to then be performed (Udo 2000).

An important issue is the level of consistency when comparing factors in AHP analysis (Labib & Shah 2001; Saaty 1980). Consistency means that all respondents have made judgements that are intuitively reliable (Labib & Shah 2001). For example, if technological factors were found to be twice as important as organisational factors, and organisational factors twice as important as external environmental factors, then to be totally consistent, technological factors would be four times more important that external environmental factors. The Consistency

Ratio (CR), which shows the amount of inconsistency that would be considered acceptable, has been determined in previous studies (Labib & Shah 2001).

A CR is comprised of two components and enables a researcher to verify the participants' uniformity in choice. The first component, a Consistency Index (CI), reflects the degree of deviation. The following equation represents the eigenvalue λ where n = number of judgements.

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

The second component, the Random Consistency Index (RI), enables randomness to be taken into account. Wind and Saaty (1980) provide the foundation for a fixed CI based on the number of judgements required (n). In this study, in the criteria level, there were four judgements required (technological, organisational, external environmental and economic). There were also four judgements to be made in the technological sub-category level (compatibility, complexity, relative advantage and standards). There were three judgements required for all other sub-criteria. Therefore with n=4, the RI was calculated to be 0.9. Similarly, with n=3, RI=0.58. Table 4.5 provides the random consistency index results (Wind & Saaty 1980).

Table 4.5: Random Consistency Index

n	1	2	3	4	5	6	7	8	9	10
Random Index	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

(Source: Wind & Saaty 1980)

A CR can then calculated by comparing CI as a ratio of RI:

$$CR = \frac{CI}{RI}$$

There will always be some inherent level of inconsistency, and Saaty (1994) adopted simulations to justify an acceptable level of inconsistency. A CR of less than 10 per cent was deemed acceptable (Saaty 1994).

4.6.1.3 Analytical Hierarchy Process Logic

In the first instance, respondents were asked to choose and rank each of the criteria: the technological, organisational, external environmental and economic contexts, in terms of importance with respect to the goal and organisational readiness when adopting RFID. To demonstrate how this works, the responses from one of the suppliers are provided in Section 10.1, Appendix A. These judgements required the respondent to compare the criteria in the left column with the criterion on the top horizontal row. Note that Supplier ‘A’ judged the technological criteria to be between equally preferred and moderately preferred (2) when compared to economic criteria, which were strongly preferred (5) compared to organisational criteria and very strongly preferred (7) compared to external environmental criteria. Similarly, the economic criterion was considered very strongly preferred (7) compared to organisational criteria and extremely preferred (9) relative to external environmental criteria. Finally, organisational criteria were deemed moderately preferred (3) to external environmental criteria.

The respondent was then asked to consider sub-category factors with respect to the above criteria. For instance, for the technological criteria, the respondent was asked to compare each of the factors (complexity, compatibility, relative advantage and standards) against each other. Respondent ‘A’ in this instance judged complexity to be 1/3 preferred to compatibility (Refer to Appendix A). The logic was similar for the rest of the process. The weights from this analysis were then calculated. Supplier ‘A’ judgements enabled the calculation of the cell figure divided by the sum of each column. The average of all weights for the technological criteria relative to the judgement in each cell (including reciprocals) resulted in weights of 0.471 for the technological criteria. These results were then be compared and ranked accordingly.

This ‘forced pairwise comparison’ logic forms the basis of AHP analysis and enables a weighted judgement and subsequent ranking of all factors in terms of their relative importance. A separate evaluation of retailers, suppliers and technology provider responses were calculated. The aggregation of the respondents' input was processed using the geometric mean method (Kallas et al. 2011).

The next sections provide details of the analysis and the subsequent determination of the importance of each factor. Each stakeholder group—retailer, supplier and technology provider—were surveyed and their input analysed. The second-level criteria with respect to organisational readiness were analysed first, followed by each of the third-level sub-criteria factors. Finally, a synthesis of sub-criteria factors in relation to organisational readiness is presented.

4.6.1.4 Criteria Influencing Organisational Readiness

This section provides details of the output for the second level in the AHP hierarchy, as detailed in the problem structure outlined in Table 4.2 and Figure 4.2. The results showed the levels of importance for the technological, organisational, external environmental and economic criteria with respect to the goal, organisational readiness, in Table 4.6. Results showed that technological criteria (0.393) and economic criteria (0.379) were considered significantly more important than external environmental criteria (0.130) or organisational criteria (0.098). Separating and comparing the retailer, supplier and technology provider results showed relative consistency in ranking both organisational criteria and external environmental criteria as less important than the other criteria. However, the retailers ranked the technological criteria higher (0.550) compared to the suppliers (0.300) and the technology providers (0.304). In contrast, suppliers considered the economic criteria more important (0.495) compared to the retailers (0.322) and technology providers (0.284). The CRs were below 10 per cent, and therefore acceptable (Table 4.6). Respondents were also asked to rank between each of the sub-criteria factors with respect to the second-level criterion. The following sections provide details of the results of the AHP analysis with respect to these factors.

Table 4.6: Results of the Analytical Hierarchy Process First-Level Hierarchy: Organisational Readiness

Factor	Retailer Weight	Supplier Weight	Technology Provider Weight	Aggregated Stakeholder Weight
Technological	0.550	0.300	0.304	0.393
Organisational	0.056	0.110	0.130	0.098
External environment	0.072	0.096	0.282	0.130
Economic	0.322	0.495	0.284	0.379
Total	1.000	1.000	1.000	1.000
CR	0.050	0.030	0.040	0.010

4.6.1.5 Sub-Criteria Factors within the Technological Context Category

Respondents were asked to compare and rank the sub-criteria factors complexity, compatibility, relative advantage and standards. Taking each factor and comparing it to all other factors enabled a relative ranking of importance with respect to technological criteria. The aggregate results highlighted standards as most important (0.505), with all other factors ranked considerably lower. However, the results of the individual stakeholder groups—retailers, suppliers and technology providers—indicated a level of disagreement. For example, supplier respondents ranked standards as less important (0.168) than complexity (0.322) and compatibility (0.443) factors. Meanwhile, technology providers considered complexity as least important (0.050). The CRs were below 10 per cent for all categories and acceptable. A summary of the analysis is illustrated in Table 4.7.

Table 4.7: Results of the Analytical Hierarchy Process Second-Level Hierarchy: Technological Context Factors

Factor	Retailer Weights	Supplier Weights	Technology Provider Weights	All Stakeholders Weights
Complexity	0.152	0.443	0.050	0.178
Compatibility	0.145	0.322	0.118	0.217
Relative advantage	0.042	0.067	0.224	0.101
Standards	0.661	0.168	0.608	0.505
Total	1.000	1.000	1.000	1.000
CR	0.100	0.050	0.070	0.015

4.6.1.6 Sub-Criteria Factors within the Organisational Context Category

Again, respondents were asked to compare and rank the sub-criteria factors top management support, IT investment and organisational size. Taking each factor and comparing it to all other factors enabled a relative ranking of importance with respect to organisational criteria. The aggregate results indicated that IT investment was considered most important (0.554), compared to top management (0.348) and organisational size (0.097). However, the individual stakeholder group results were different. Most noticeable was the supplier stakeholder group ranking top management support as most important (0.631) compared to IT investment (0.294) and size (0.075). Retailers, suppliers and technology providers all ranked size as low importance. Once again, the consistency indices were within range. In all cases organisational size was least important (Table 4.8).

Table 4.8: Results of the Analytical Hierarchy Process Second-Level Hierarchy: Organisational Context Factors

Factor	Retailer Weights	Supplier Weights	Technology Provider Weights	All Stakeholders Weights
Top management support	0.221	0.631	0.236	0.348
IT investment	0.707	0.294	0.623	0.554
Size	0.072	0.075	0.141	0.097
Total	1.000	1.000	1.000	1.000
CR	0.060	0.060	0.050	0.010

4.6.1.7 Sub-Criteria Factors within the External Environmental Context Category

Within the external environmental context criteria, respondents were asked to compare and rank the sub-criteria factors privacy, security and industry forces. All stakeholders were consistent in agreeing that security issues were most important (0.620). Industry forces followed (0.265), with privacy issues considered the least important (0.115). There was little deviation in the sub-criteria when comparing stakeholder group results. Once again, the CI of less than 10 per cent was within range. A summary of the analysis is illustrated in Table 4.9.

Table 4.9: Results of the Analytical Hierarchy Second-Level Hierarchy: External Environment Context Factors

Factor	Retailer Weights	Supplier Weights	Technology Provider Weights	All Stakeholders Weights
Privacy	0.055	0.115	0.070	0.115
Security	0.567	0.620	0.595	0.620
Industry forces	0.378	0.265	0.336	0.265
Total	1.000	1.000	1.000	1.000
CR	0.020	0.020	0.000	0.020

4.6.1.8 Sub-Criteria Factors within the Economic Context Category

Finally, within the economic context criteria, respondents were asked to compare and rank the sub-criteria factors hardware and software costs, implementation and training costs and tag costs. The aggregate results showed that the respondents identified tag costs as important (0.594), with implementation and training costs ranking next (0.295). Hardware and software costs were considered the least important (0.111). However, technology providers identified implementation costs as most important (0.496), while retailers and suppliers both ranked tag costs as most important (0.737, 0.639). The CRs were within range. A summary of the analysis is illustrated in Table 4.10.

Table 4.10: Results of the Analytical Hierarchy Process Second-Level Hierarchy: Economic Context Factors

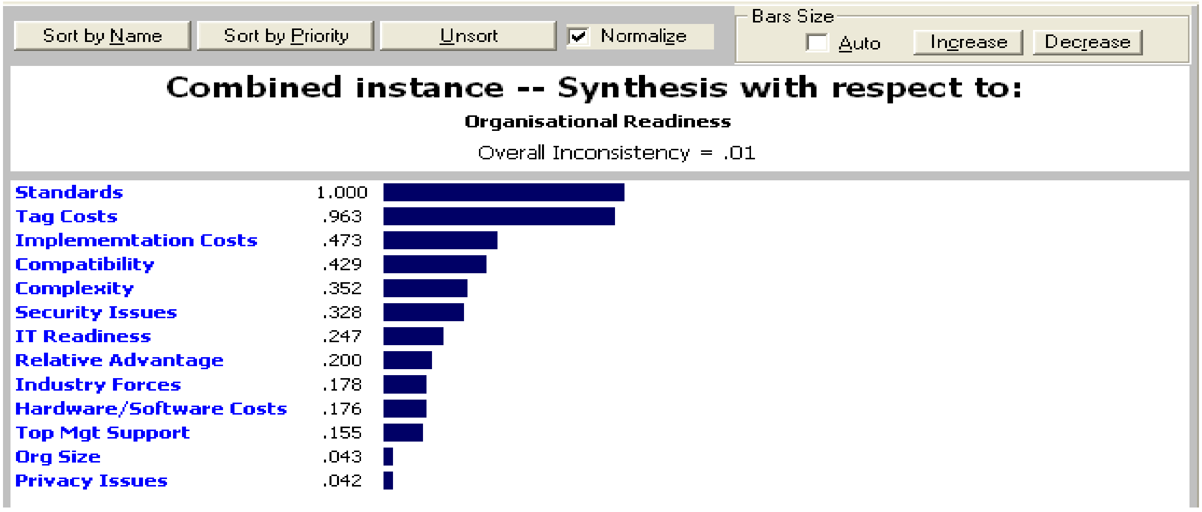
Factor	Retailer Weights	Supplier Weights	Technology Provider Weights	All Stakeholders Weights
Hardwar/software costs	0.096	0.097	0.124	0.111
Implement cost	0.166	0.264	0.496	0.295
Tag costs	0.737	0.639	0.379	0.594
Total	1.000	1.000	1.000	1.000
CR	0.020	0.050	0.040	0.040

4.6.1.9 Synthesis of Sub-Criteria Factors with Respect to Organisational Readiness

The Expert Choice output enabled a global relativity ranking of all sub-criteria with respect to organisational readiness. The aggregate ranking of all stakeholders revealed standards as most important, and normalising this factor (1.0) indicated tag costs as ranking very high (0.963).

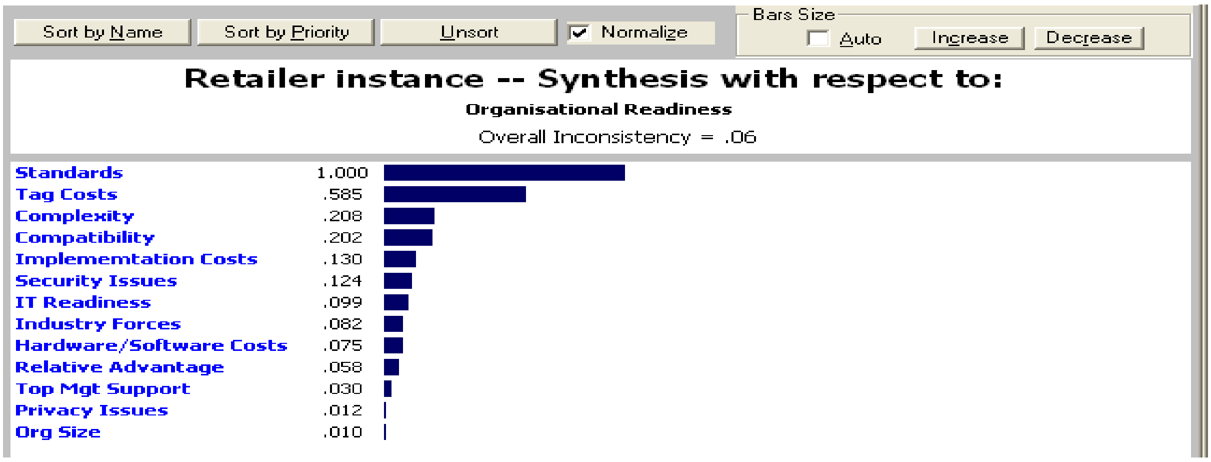
These two factors were almost twice as important as the next two most important factors, implementation costs (0.473) and compatibility (0.429). Complexity and security ranked closely behind at (0.354) and (0.328) respectively, while size and privacy were ranked as least important with respect to organisational readiness (0.043, 0.042) (Figure 4.3).

Figure 4.3 Normalised Combined Synthesis with Respect to Organisational Readiness



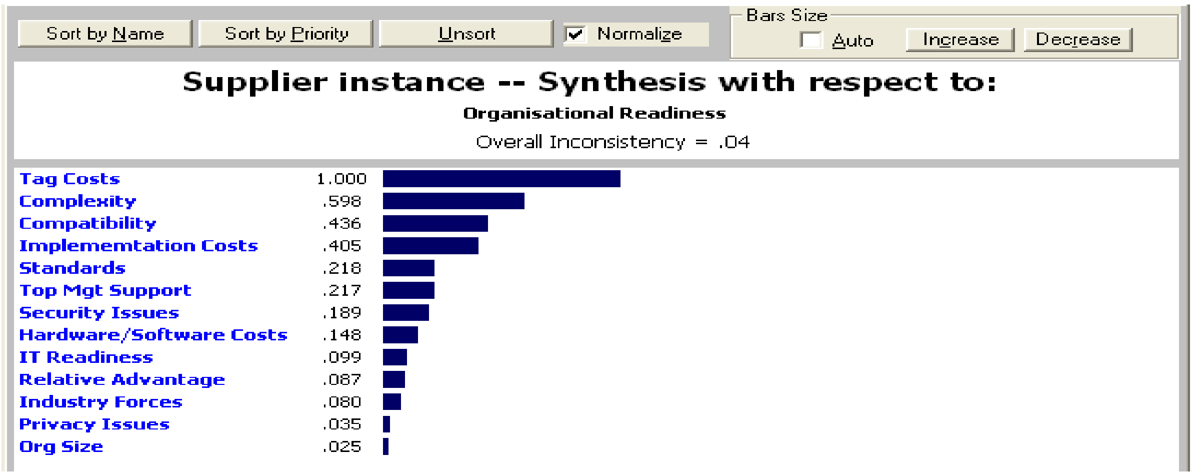
The calculation from each stakeholder group also yielded some interesting results. First, the global ranking for retailers was analysed. Normalising their most important factor, standards (1.0), showed that it was almost twice as important to this stakeholder group as the next ranked factor, tag costs (0.585). Tag costs also happened to be more than twice the ranking of complexity (0.208) and compatibility (0.202). Meanwhile, organisational size and privacy ranked comparatively low (0.012, 0.010) (Figure 4.4).

Figure 4.4: Normalised Retailer Synthesis with Respect to Organisational Readiness



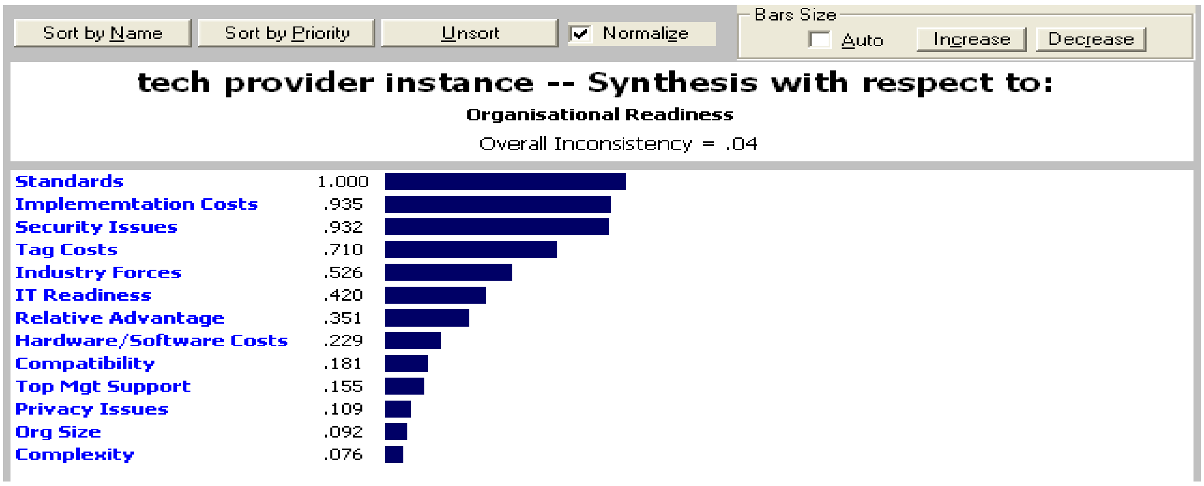
Second, calculating the suppliers' global ranking identified tag costs as most important to this stakeholder group. Normalising this factor indicated around twice the importance compared to complexity (0.598), compatibility (0.436) and implementation costs (0.405). Once again, privacy issues and organisational size ranked low (0.035, 0.025) (Figure 4.5).

Figure 4.5: Normalised Supplier Synthesis with Respect to Organisational Readiness



Lastly, technology providers also identified standards as most important, and normalising this factor indicated that implementation costs (0.935) and security (0.932) were closely ranked in importance. Tags costs (0.710) and industry forces (0.526) ranked further down, with the other factors trailing these. While privacy issues and organisational size ranked low (0.109, 0.092), complexity ranked lowest for this group of stakeholders (0.076) (Figure 4.6).

Figure 4.6: Normalised Technology Provider Synthesis with Respect to Organisational Readiness



4.7 Discussion of the Analytical Hierarchy Process Results

The respondents' perspectives were captured within an AHP framework, and the results of this analysis provided a ranking of importance for each factor in both the criteria and sub-criteria categories. Within the first criteria category, technological context factors and economic context factors ranked highest (0.393; 0.379) (Table 4.6). The respondents perceived a critical relationship between technological and economic criteria with respect to the goal of organisational readiness. Perhaps organisations have recognised the need to continually update their knowledge and be aware of emerging technologies. However, there were inherent difficulties in staying abreast of the high rates of change, particularly with RFID advancements. Intense media attention concentrating on RFID may also have impacted on the respondents' perspectives. Equally, the stakeholders understood the need to maintain a close watch on economic considerations, such as decreasing costs, as part of their organisation's readiness.

Given the high ranking of the technological category, the associated sub-criterion factors deserved focus. The respondents ranked standards (0.505) as the most significant factor. Industry was immersed in developing standards with barcode technology for many years and understands the issues of synchronised data in global supply chains. Organisations have recognised that an effective RFID-enabled network is dependent on distinct well-defined and industry-accepted standards (Table 4.7).

An analysis of the organisational context sub-criteria showed IT readiness (0.554) as most important and once again, this linked to the earlier discussion regarding the importance of the technology. The fourth sub-criterion, external environmental context, identified security issues (0.620) as ranking highly (Table 4.9). The use of the Internet to transmit information and constant media attention regarding security breaches might have influenced these perspectives. Finally, in the economic context the sub-criterion tag costs (0.594) dominated the ranking. It is possible that media comparison of barcode costs to tag costs has influenced this result. Furthermore, the fact that tag costs are an ongoing variable cost may also have influenced this result (Table 4.10).

A comparison of each stakeholder group drew attention to differences as well as similarities in ranking each of the criteria and sub-criteria factors. For example, at the criteria level, retailers ranked technological factors (0.550) much higher than either supplier (0.300) or technology provider (0.304) stakeholders did. This result recognises the concern that retailers have for technological factors associated with the adoption of RFID. On the other hand, suppliers weight economic factors higher (0.495), compared to the weights given by retailers (0.332), and technology providers (0.284). This may be due to suppliers recognising that they would bear any costs associated with RFID implementation. Suppliers were also likely to be responsible for the ongoing costs of buying tags. However, external environmental factors ranked relatively low overall, and all stakeholders seemed to agree that organisational factors, when compared to the other factors, ranked lowest (Table 4.6).

Differences were also identified within the sub-criteria factors. Within the technological category, both retailers and technology providers ranked standards (0.661; 0.608) significantly higher than the suppliers did (0.168) when comparing against complexity, compatibility, and relative advantage. Conversely, the suppliers were more inclined to rank complexity and compatibility as more important (Table 4.7). These results infer suppliers' previous exposure to significant IT implementation problems. The well-publicised failure in ERP systems implementations within the Nestle manufacturing organisation is one case in point (Dieringer 2004). Technology providers perceived that technology complexity was of low importance (0.050) compared to the perceptions of the suppliers (0.443) and this may be due to their developmental work and deeper understanding of the technology. All stakeholder groups appeared to be in agreement with the lower rankings of relative advantage and compatibility.

Variation in ranking was also evident when analysing the stakeholders' judgement of factors within the organisational context sub-criteria. For example, top management ranked highly for supplier stakeholders (0.631), while both retailers and technology providers ranked IT investment highly (0.707, 0.623) (Table 4.8). Suppliers have recognised the importance of support from their top management when embarking on the adoption of IT. Possibly top management within supplier organisations were still uncertain about beginning a journey with RFID. However, there was general agreement regarding the low importance of organisational size.

An analysis of the judgements on external environmental factors showed a degree of accord, with all stakeholders ranking security highest, followed by industry forces, with privacy judged as least important by all (Table 4.9). Finally, the economic sub-criteria factors presented interesting results, with technology providers ranking implementation costs as important, followed by tag costs when comparing the economic context sub-criteria factors. Retailers and suppliers, on the other hand, identified tag costs as most important (0.737, 0.639) (Table 4.10). This was a notable outcome, considering that manufacturers may bear the ongoing cost of buying and attaching tags. Perhaps retailers and suppliers have both recognised the significance of total supply chain costs.

A synthesis of the sub-criteria factors enabled judgements to be evaluated with respect to organisational readiness; both in terms of aggregation (Figure 4.3) and by each stakeholder group (Figures 4.4, 4.5 and 4.6). The aggregate stakeholder synthesis identified the top contender as standards. This result supported the earlier discussion regarding organisations recognising the importance of appropriate standards to integrate a proposed world-wide network. More importantly, this result may suggest that considerable developmental work is still required in this area. Tag costs were also a major factor in RFID adoption, particularly when compared to the relatively cheap existing barcode technology. Organisations will monitor tag costs as they inevitably drop to an acceptable level. Conversely, privacy (0.42) and the size of the organisation (0.43) were least important with respect to organisational readiness. Privacy was perhaps more of a concern for the consumer and less of a concern for the retailers, suppliers and technology providers due to their understanding of easily-implemented solutions such as decommissioning tags at the checkout counter. The low ranking of organisational size was perhaps due to an understanding that larger organisations would take the lead with RFID adoption, with smaller organisations lagging until the costs become acceptable.

The synthesis of sub-criteria factors within each stakeholder group yielded similar results with both retailers and technology providers identifying the factor standards as the most important. Suppliers, on the other hand, placed tags as most important and standards comparatively lower (0.218), supporting their issues with being responsible for ongoing costs of tags.

In summary, the pilot study highlighted organisational readiness as a significant element in any decision to adopt RFID. Organisational readiness was the goal in this model. The results reflected stakeholder divergence in relation to their perspectives of the importance of several criteria and sub-criteria that underpin organisational readiness. Organisations should be congruent in their interpretation of the importance of the challenges faced in decisions to adopt any technology across a supply chain. This enables all parties to concentrate on the development and improvement of the factors considered most important.

CHAPTER 5: SURVEY METHOD AND DESCRIPTIVE INDICATORS

5.1 Introduction

The previous Chapter 4 provided details of the research design that was adopted to guide this study, including the particulars of the methodology. Sections 4.6 and 4.7 explained the AHP pilot study technique and its results. This chapter begins with an explanation of both the survey method in Section 5.2, and the sampling plan in Section 5.3. The data collection process is discussed in Section 5.4, which also draws attention to the role of GS1 in defining and accessing the population surveyed in this study. The data screening and cleaning activities are described in Section 5.5, and Section 5.6 provides an analysis of the respondent details and the associated statistics. Finally, Section 5.7 concludes this chapter with a summary.

5.2 Survey Method

The literature review presentation in chapter 2 in addition to the pilot study results informed the development of the main survey. Furthermore, the questions in the survey were based on questions from empirical studies that supported their appropriateness. The development of this questionnaire fitted with the objectives of the research and enabled complete and accurate information to be gathered within the limits of the available resources and time (Rossi et al. 1983). Surveys are still the most popular technique used to collect information for research purposes from large numbers of people (Monette et al. 1994). The questionnaire entailed a series of questions whereby the respondents either wrote a response or chose fixed answers to the questions. The accuracy and validity of the data collected depends on the information requested and the perception of the questions that elicit the responses. The development of questions for this survey followed a known process of translating research topics into variables, variables into indicators and indicators into questions (Monette et al. 1994; Sarantakos 1993).

5.3 Sampling Plan

The sampling plan reflects the manner in which participants are selected from a population (DeVaus 2002). The objective of a sampling plan is to ensure that a representative sample is obtained from a population. The next sections will describe the rationale behind the population, and the manner in which the sample was obtained for statistical analysis.

5.4 Defining the Population and the Data Collection Process

In research, the term ‘population’ defines all the members of a group being studied (De Vaus 2002). The population for this research comprised retailers and their supplier organisations, as well as the technology providers and consultant organisations involved in the identification of products and/or systems associated with this practice operating within Australia. This entire population could not be tested due to time and cost constraints and therefore the normal practice of collecting data from a sample of the population was undertaken. The main issue with taking samples in research is the ability to demonstrably ‘represent’ the population (Remenyi et al. 2000). Three populations were targeted in this study. The first involved retail organisations that currently used some recognised system of product identification to control inventory. The second group comprised suppliers to retailers, which also used a similar product identification system. In both cases, barcodes were the predominant system for identifying products within their organisations. The third group represented technology providers that were involved in selling or servicing RFID. All organisations involved in product identification would likely be members of GS1 and aware of any developments in identification, including work being conducted with RFID.

5.4.1 GS1

GS1 is an organisation known for managing and servicing product identification and related standards in diverse industries world-wide. GS1 has over 16,000 Australian member organisations and a long and valuable history in managing barcode technology and related standards (GS1 Australia 2010). As discussed in earlier in Section 2.5, EPCGlobal is an initiative of GS1. Their membership, comprising retailers and suppliers to retailers, as well as vendors/consultants, forms the population of organisations selected for this research. Consequently, the sample of participants was obtained from the GS1 database and contacted via mail-out. In order to protect the privacy of participants, GS1 administered the mail-out and information regarding their membership remained confidential. The potential participants were randomly selected from across all GS1 membership, taking into account geographic location. Therefore the percentage of sample from each state was represented, and the number of retailers, suppliers and technology providers broadly followed the expected representation of populations. As the membership did not have financial information, so the potential participants had an equal chance of selection based on this criteria. This approach typifies a probability sampling plan (Deming 1960).

A number of methods are available to contact respondents. These include a mail-out, the Internet via web page or e-mail, personal interviews and telephone interviews. There are advantages and disadvantages associated with each of these four methods of collecting data. Personal interviews and telephone interviews permit a high level of interaction and allow for deeper responses; however, they are costly and likely to display researcher bias (Alreck & Settle 2004). Using the Internet provides access to a large population, similar to using a mail-out, although the administrator might be able to make web pages more visually appealing with animations and video capabilities etc. Mail-outs involve filling addressed envelopes with a questionnaire, a covering letter, and a reply-paid envelope. Mail-outs are considered a viable method for collecting responses to surveys, although the response rate is often low (Kumar 2011). A comparison of methods of collecting data is presented in Table 5.1.

Table 5.1: Comparison of Data Collection Methods

Criteria	Personal interview	Telephone interview	Online	Mail
Costs	High	Medium	Low	Low
Time required	Medium	Low	Medium	High
Sample size for budget	Small	Medium	Large	Large
Data quantity for each respondent	High	Medium	Low	Low
Reaches more participants	Yes	Yes	No	Yes
Reaches widely dispersed participants	No	Maybe	Yes	Yes
Reaches special locations	Yes	Maybe	No	No
Interaction with respondents	Yes	Yes	No	No
Degree of interview bias	High	Medium	None	None
Severity of non-response bias	Low	Low	High	High
Presentation of visual stimuli	Yes	No	Yes	Maybe
Field work training required	Yes	Yes	No	No

(Source: Alreck & Settle 2004)

5.4.2 Mail-Out

A self-administering mail-out approach was used for this research. An envelope containing the survey, a letter outlining the research intentions and a stamped return address envelope were mailed to all participants via Australia Post. This approach enabled the respondents to answer questions and send responses via a prepaid envelope. The ability to reach a large and geographically spread population was one advantage of using a mail-out for this particular study (Alreck & Settle 2004). However, the main reason for choosing a mail-out was time commitments and restricted access to the GS1 database.

The participants were categorised into three separate groups; namely, retailers, suppliers and technology providers. Mail-out leaflet examples are provided in Sections 10.3 to 10.5, Appendices C, D and E. In this study, each member of the population had an equal chance of being chosen and responding to the survey. The mail-out was distributed throughout each state in accordance with the percentage of the GS1 membership in that state. There were more suppliers than retail organisations, which aligned with expectations. Where possible, the mail-out envelope was addressed to the name of the person occupying the role identified in the GS1 database. In all, 678 envelopes out of a total of 2078 envelopes (32.6%) were addressed to a specific person. This represented 573 suppliers, 18 retailers and 87 technology providers. The rest of the envelopes were addressed to the closest position titles on the GS1 mailing list (Section 10.6, Appendix F). The majority of the sample resided in Victoria (36.7 per cent) or New South Wales (31.5 per cent) (Table 5.2).

5.4.3 Response Rate

There were 180 returned envelopes that did not reach their intended destination. One hundred and twenty completed surveys were received and of these, four were rejected due to large omissions or failure to provide adequate detail for use. This resulted in a usable response rate of 116, equating to 5.6 per cent. Given the low response rate, the initial intention to compare retailer, supplier and technology provider responses and perspectives was not possible. However, demographic data was compiled and analysed for each group and is presented later in Section 5.6. A breakdown of the respondents is given in Table 5.2.

Table 5.2: Details of Mail-Out Survey and Response Rates by State

Organisation's address location	Suppliers Frequency	Percentage	Retailers Frequency	Percentage	Technology Providers Frequency	Percentage	Total frequency	Total percentage
VIC	627	37.1	99	32.9	36	40.9	762	36.7
NSW	522	30.9	94	31.2	39	44.3	655	31.5
QLD	186	11.0	57	18.9	9	10.2	252	12.1
SA	184	10.9	19	6.3	0	0.0	203	9.8
WA	142	8.4	20	6.6	2	2.3	164	7.9
NT	7	0.4	0	0.0	0	0.0	7	0.3
ACT	1	0.1	6	2.0	2	2.3	9	0.4
TAS	20	1.2	6	2.0	0	0.0	26	1.3
Total no. of organisations	1,689	100.0	301	100.0	88	100.0	2078	100.0
Overall responses	84		21		15		120	5.8
Usable responses	82		21		13		116	5.6
Number of envelopes sent to named participants	573		18		87		678	

5.5 Data Screening and Cleaning

Screening and cleaning the data ensured that non-response bias and replacement of missing items were performed. Failure to assess the raw data could lead to inaccuracy and therefore unreliable analysis. This process began with the data received from the respondents being manually entered into an Excel spreadsheet by the researcher, in the order in which it was received. A distinct cut-off point between early and late responses was generated from the data when follow-up phone conversations were undertaken with a number of known organisations.

The first stage involved examining the data to ensure accurate entry including numbers within the maximum and minimum range. A random sample of the data entered into the spreadsheets was checked against the original questionnaire responses and found to be correct. All responses, apart from the adoption intentions data, corresponded to the 7-point Likert scale. There were 4 responses that were unusable due to significant breaches of instructions and the remaining 116 responses were entered for further analysis.

5.5.1 Non-Response Bias

Research is based on the premise that the selected sample will represent the population. There is a possibility that participants who did not respond may have a different interpretation from those who did respond. Several methods were used for estimating non-response bias, including comparison with known values for the population, subjective estimates and extrapolation (Armstron & Overton 1977).

The data were analysed to ensure that there was no bias using extrapolation, where the earlier respondents' responses were compared to the later responses. According to Collis et al. (2003), comparing the earlier and later respondent data assists in determining non-response bias. A number of factors were chosen to test for non-response bias. The initial responses to the questionnaires were tabulated and the later responses clearly identified. The early and late respondent groups were compared through the adoption of independent t-tests at the 0.05 significance level. Variables were tested to identify any significant difference between the groups (Table 5.3). No such differences were found and so it was concluded that no major bias exists as a result of non-response.

Table 5.3: Non-Response Bias t-Test Calculations

	Mean	Standard deviation	Squared error of mean	P value	t value	Significance
Early respondents	4.77	1.02	0.057	0.084	1.73	Not significant
Later respondents	4.69	0.85	0.0476			

5.5.2 Replacement of Missing Data

Missing data presents a number of problems. First, loss of data means that information has been lost and so reduces the efficiency of estimates (Gold et al. 2003). Second, incomplete surveys represent smaller datasets for analysis, and finally, most studies require validation of complete datasets in order to function. When the data was originally entered into the spreadsheet, any missing data was noted and the relevant cells were highlighted. Consequently, in order to clean the data the Excel spreadsheet was examined for missing data. The actual number of missing data entries was found to be very low, with only four data points missing out of the entire dataset. These included two respondents that omitted entries to the 'external environment' question on industry forces, one respondent that missed an entry for the 'external environment' question on consumer privacy and a respondent that did not enter data for the technology factor 'compatibility'. There are several methods available to deal with missing data, including full information maximum likelihood, regression imputation, mean substitution and multiple imputation (Olinsky et al. 2003). Due to the very low number of substitutions required, mean substitution was adopted. The missing cells were manually entered with a figure representing the average of the existing factors for that indicator. This process was also verified by SmartPLS software, because data must be validated before any analysis will proceed when using this application.

5.6 Descriptive Data Analysis

The theoretical framework underpinning this research illustrates a set of factors for which relationships must be determined and outcomes predicted. The quantitative technique adopted in this study aligned with the research intentions to develop an understanding of the relationships between the factors associated with the impact of RFID on retail supply chain performance. Three categories of respondents—retailer, retail suppliers and technology providers—were surveyed and the descriptive statistical results will be discussed in the following sections.

5.6.1 Respondent Details

This section presents the demographic information from the respondents and their organisations, based on the returned surveys. The information obtained included a description of the position held by the respondent, the purpose of the organisation, its geographic location and the size of the organisation in terms of its turnover and number of employees. The survey also requested information from the respondents regarding their organisation's level of intentions to adopt RFID and their application of various information technologies, including barcodes.

5.6.1.1 Respondent Categories

As indicated in Table 5.2, there were 116 total usable responses, with the majority of these organisations being suppliers. This category represented 70.7 per cent of respondents. A further 18.1 per cent were retailers and 11.2 per cent technology providers. This was in line with the number of questionnaires sent to each group (Table 5.4).

Table 5.4: Respondent Organisation Categories

Respondent Category	Frequency	Percentage	Mail-out frequency	Percentage
Retailer	21	18.1	301	15
Supplier	82	70.7	1,689	81
Technology Provider	13	11.2	88	4
Total	**116**	**100.0**	**2,078**	**100**

The scope of operations within each category of stakeholders was broad and included a diverse range of activities. Retailer operations were for the most part in the FMCG (52 per cent) and grocery (24 per cent) categories. The rest were evenly spread between furniture, software, department stores, wine retailing and soft furnishing (Table 5.5).

Table 5.5: Retailer Operations

Operations	Frequency	Percentage
FMCG	11	52
Grocery	5	24
Furniture	1	5
Software (retail)	1	5
Department store	1	5
Wine retail	1	5
Soft furnishing	1	5
Total	**21**	**100**

Table 5.6 highlights the diverse range of operations undertaken by the supplier organisations. However, the traditional FMCG (25 per cent) and grocery (20.5 per cent) categories were the largest. In a number of instances, respondents indicated more than one purpose.

Table 5.6: Supplier Operations

Operations	Frequency	Percentage
FMCG	22	25.0
Grocery	18	20.5
Wine wholesalers	5	5.7
White goods	4	4.5
Brown goods	4	4.5
Meat processing	3	3.4
Liquor wholesale	2	2.3
Furniture	2	2.3
Produce	2	2.3
Wholesale plant nursery	1	1.1
Technology solutions	1	1.1
Forage seed wholesaler	1	1.1
Cutting tool and industrial design	1	1.1
Automotive	1	1.1
Small electrical appliances	1	1.1
House building goods	1	1.1
Bed linen and towelling	1	1.1
Pharmacy	1	1.1
Fashion	1	1.1
Olive grove farm	1	1.1
Industrial goods infrastructure	1	1.1
Apparel	1	1.1
Steel manufacturing	1	1.1
Winery sales	1	1.1
Hardware	1	1.1
Petroleum	1	1.1

Automotive aftermarket	1	1.1
Primary industry	1	1.1
Manufacturing	1	1.1
Sealants and adhesive manufacturing	1	1.1
Food service and cafe industry	1	1.1
Textile conversion	1	1.1
Rope and cordage manufacturing distributor	1	1.1
Lubricant products	1	1.1
Electrical appliance wholesaler	1	1.1
Total	**88**	**100.0**

Finally, the technology providers operations were spread between hardware, software, tags and labels, consulting, training, regulation and transport. Once again, in a number of instances respondents indicated more than one purpose (Table 5.7).

Table 5.7: Technology Provider Operations

Operations	Frequency	Percentage
Hardware supplier	5	23
Software supplier	4	18
Tags and labels supplier	4	18
Consulting	3	14
Training	3	14
Education	1	5
Regulation	1	5
Transport	1	5
Total	**22**	**100**

5.6.1.2 Position Descriptions

There were also many different position descriptions throughout the three respondent categories. There were 21 retailer respondents, dominated by logistics managers (33 per cent), IT managers (19 per cent) and supply chain managers (14 per cent) (Table 5.8).

Table 5.8: Position Descriptions from Retailer Respondent Organisations

Position description	Frequency	Percentage
Logistics manager	7	33
IT manager	4	19
Supply chain manager	3	14
Managing director	2	10
Warehouse manager	2	10
Operations manager	1	5
Business systems manager	1	5
E-business manager	1	5
Total	**21**	**100**

Supplier respondent positions, on the other hand, were predominantly IT managers (24 per cent), followed by supply chain managers (13 per cent), general managers (10 per cent) and managing directors (10 per cent). One respondent indicated that they held several positions and so it was assumed, as they represented a smaller organisation, that the respondent was involved in multiple tasks (Table 5.9).

Table 5.9: Position Descriptions from Supplier Organisations

Position description	Frequency	Percentage
IT manager	20	24
Supply chain manager	11	13
Managing director	8	10
General manager	8	10
Business systems manager	7	9
Operations manager	5	6
Chief executive officer	5	6
Logistics manager	5	6
Warehouse manager	3	4
E-business manager	2	2
Business development manager	1	1
Finance manager	1	1
Financial controller	1	1
Production manager	1	1
Marketing manager	1	1
Owner	1	1
Quality manager	1	1
Project manager	1	1
Total	**82**	**100**

The technology provider respondent positions were mainly general managers (38 per cent), followed by IT managers (23 per cent) and business development managers (15 per cent) (Table 5.10).

Table 5.10: Position Descriptions from Technology Provider Respondent Organisations

Position description	Frequency	Percentage
General manager	5	38
IT manager	3	23
Business development manager	2	15
E-business manager	1	8
Business systems manager	1	8
Sales manager	1	8
Total	**13**	**100**

5.6.2 Size of the Organisations

The Australian Bureau of Statistics (ABS) defines the size of organisations in terms of the number of people employed as well as the turnover of the organisation (Pink & Jameieson 2000). In general, the ABS classifies businesses as micro-businesses (employing less than 5 people), small businesses (employing more than 5 but less than 20 people), medium businesses, (employing more than 20 but less than 200) and large businesses (employing 200 or more people) (Pink &Jameieson 2000). This study extended these guidelines to include more categories. In this study, it was noted that retail organisations were dominated by larger organisations in terms of employment, with 57 per cent employing greater than 500 staff. Suppliers, on the other hand, were spread between larger organisations (24 per cent) and smaller organisations (less than 20 employees, 26 per cent; and between 20 and 200, 31.5 per cent), at least in terms of employment. Technology providers were similar. Overall, the results in terms of the number of people employed were 27 per cent of the respondent organisations employed between 20 and 200 people, while another 21 per cent employed less than 20 people, suggesting a large proportion of smaller organisations, at least in terms employment. However, organisations employing over 500 people (31 per cent) were a close second (Table 5.11).

Table 5.11: Size by Employment in Respondent Organisations

	Retailer		Supplier		Technology provider		TOTAL	
Number employed	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
<20	2	9	21	26	1	8	24	21
20–200	1	5	26	32	4	30.5	31	27
200–300	2	10	7	9	2	15	11	9
300–400	1	5	6	7	1	8	8	7
400–500	3	14	2	2	1	8	6	5
>500	12	57	20	24	4	30.5	36	31
Total	**21**	**100**	**82**	**100**	**13**	**100**	**116**	**100**

Similarly, the ABS also defines business size by turnover (Pink & Jameieson 2000). The turnover categories represent less than $1 million, $1 million but less than $5 million, $5 million but less than $10 million, $10 million but less than $20 million, $20 million but less than $50 million and more than $50 million (Pink & Jameieson 2000). This study also extends these guidelines. The majority of respondent organisations were large, with 62 per cent of retailer organisations and 34 per cent suppliers stating their turnover was greater than $200 million. The next category of $50M–$200M was ranked second, with 14 per cent of retailer organisations and 20 per cent of suppliers (Table 5.12).

Table 5.12: Turnover of Respondent Organisations

	Retailer		Supplier		Technology provider		TOTAL	
Turnover	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
<$25K	0	0	2	2	0	0	2	2
$25K–$50K	1	5	4	5	0	0	5	4
$200K–$500K	0	0	1	1	0	0	1	1
$500K–$1M	0	0	3	4	0	0	3	3
$1M–$2M	1	5	6	7	0	0	7	6
$2M–$5M	1	5	5	6	1	8	7	6
$5M–$10M	0	0	8	10	1	8	9	8
$10M–$20M	2	9	5	6	2	15	9	8
$20M–$50M	0	0	4	5	2	15	6	5
$50M–$200M	3	14	16	20	2	15	21	18
>$200M	13	62	28	34	5	39	46	40
Total	**21**	**100**	**82**	**100**	**13**	**100**	**116**	**100**

5.6.3 Geographic location

The majority of respondent organisations classified their geographic location as Australia-wide (Table 5.13).

Table 5.13: Major Geographic Location for Operations

	Retailer		Supplier		Technology provider		TOTAL	
Geographic location	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Australia	12	57	46	56	8	61	66	57
International	5	23	15	18	3	23	23	20
State	2	10	14	17	1	8	17	15
Regional	2	10	7	9	1	8	10	8
Total	**21**	**100**	**82**	**100**	**13**	**100**	**116**	**100**

5.6.4 RFID Adoption Intentions

A primary focus of this research was to find out the intentions of retail organisations concerning adopting RFID. One of the questions in the survey invited respondents to define at what stage their organisation was in terms of its intentions to adopt RFID. A vast majority (48 per cent) of retailer organisations responded that they had formally investigated RFID. These organisations were exposed to the increasing level of information about RFID through various media, which resulted in a more thorough examination of this technology. Fourteen per cent had undertaken a pilot study examining the potential of RFID. A further 24 per cent indicated informal discussions about RFID within the organisation, while another 14 per cent had not yet considered RFID.

Interestingly, the majority of suppliers had not yet considered RFID (43 per cent) while a further 24 per cent had discussed RFID informally within their organisation and only 15 per cent had formally investigated RFID. Another 7 per cent had completed an RFID pilot study. Unlike retailers, 10 per cent of suppliers were intending to either launch a pilot or were currently running a pilot, while one supplier had indicated that they had implemented RFID.

Technology providers were requested to nominate the percentage level at which they considered retailing supply chain organisations might consider adopting RFID. Forty-four per cent believed that organisations had formally investigated RFID. A further 27 per cent believed that organisations had informally discussed RFID and 23 per cent felt that supply chain organisations had not considered RFID. No organisation had completed a pilot and intended to implement RFID. These results are documented in Table 5.14.

Table 5.14: Level of Considering Adopting RFID

	Retailer		Supplier		Technology provider
Intentions to adopt RFID	**Freq.**	**Percent**	**Freq.**	**Percent**	**Percent**
Have not considered RFID yet	3	14	35	43	23
Spoken informally about RFID	5	24	20	24	27
Formally investigated RFID	10	48	12	15	44
Planning to launch an RFID pilot	0	0	3	4	2
Currently running an RFID pilot	0	0	5	6	1
Completed a pilot and intended to implement RFID	0	0	0	0	0
Have completed a pilot and will not be implementing RFID	3	14	6	7	2
Currently implementing RFID	0	0	1	1	1
Total	**21**	**100**	**82**	**100**	**100**

5.6.5 Organisations' Use of Technology

The extent to which organisations supported IT was also captured in the survey and most organisations utilised multiple technologies. The majority of all respondent organisations identified barcode technology as a primary technology. Eighty-seven per cent of organisations either used barcodes or, as in the case of technology providers, supported barcode technology. This was understandable, given that the membership of GS1 was surveyed and that this organisation manages barcode technologies. However, a minority of retailers (10 per cent), suppliers (15 per cent) and technology providers (8 per cent) did not nominate barcodes as being supported. This may be due to their product composition or services; for example, consulting or training organisations may not support barcodes. The second notable IT supported by 63 per cent of organisations was the Intranet. ERP systems came a close third, at 60 per cent. ERP was a technology used widely within many industries, including retailing supply chains. Other IT supported by at least half of the respondent organisations included web services (59 per cent), EDI (56 per cent) and data warehouses (53 per cent). Extranets and customer relationship management systems dominated within the retailer organisations, at

71 per cent each. Unsurprisingly, technology providers dominated RFID support, with 46 per cent supporting tags through to 69 per cent supporting RFID hardware. However, while retailers had almost no support for RFID, a small number of suppliers did indicate support for some RFID. Ten per cent supported RFID tags, 9 per cent RFID readers, 7 per cent RFID hardware, 5 per cent RFID software and 2 per cent RFID infrastructure. There was a broad spectrum of other technologies that were also supported (Table 5.15).

5.7 Summary

This chapter has provided demographic information regarding the three respondent groups and analysed this data separately for each group. The information gained from the respondent groups presented in this chapter was considered significant; for instance, the use of IT outlined above indicated the breadth of IT currently being used across the retail sector. The next chapter will continue this analysis, using an advanced statistical technique, Structural Equation Modelling (SEM).

Table 5.15: The Organisations' Support for IT

IT supported within the organisation	Retailer		Supplier		Technology provider		TOTAL	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
Bar-coding	19	90	70	85	12	92	101	87
Intranets	16	76	47	57	10	77	73	63
ERP	16	76	46	56	8	62	70	60
Web services	12	57	49	60	8	62	69	59
EDI XML/EDI	11	52	49	60	5	38	65	56
Data warehouse	14	67	41	50	6	46	61	53
Business intelligence tools	10	48	42	51	5	38	57	49
Customer resource management	15	71	32	39	7	54	54	47
Extranets	15	71	29	35	10	77	54	47
Supply chain planning software	12	57	33	40	7	54	52	45
RF communication	6	29	25	30	7	54	38	33
Advanced shipment notification	5	24	28	34	3	23	36	31
Content management software	6	29	23	28	5	38	34	29
Portal technologies	5	24	21	26	6	46	32	28
Advance planning and scheduling system	2	10	23	28	3	23	28	24
Voice input interfaces	3	14	11	13	3	23	17	15
Product life cycle management software	5	24	10	12	1	8	16	14
RFID hardware	1	5	6	7	9	69	16	14
RFID readers	0	0	7	9	8	62	15	13
RFID tags	0	0	8	10	6	46	14	12
RFID software	0	0	4	5	8	62	12	10
RFID infrastructure	0	0	2	2	7	54	9	8
Satellite communication	4	19	7	9	1	8	12	10
Decision support system	4	19	4	5	1	8	9	8
TOTAL	**21**	**100**	**82**	**100**	**13**	**100**	**116**	**100**

CHAPTER 6: DATA ANALYSIS AND RESULTS

6.1 Introduction

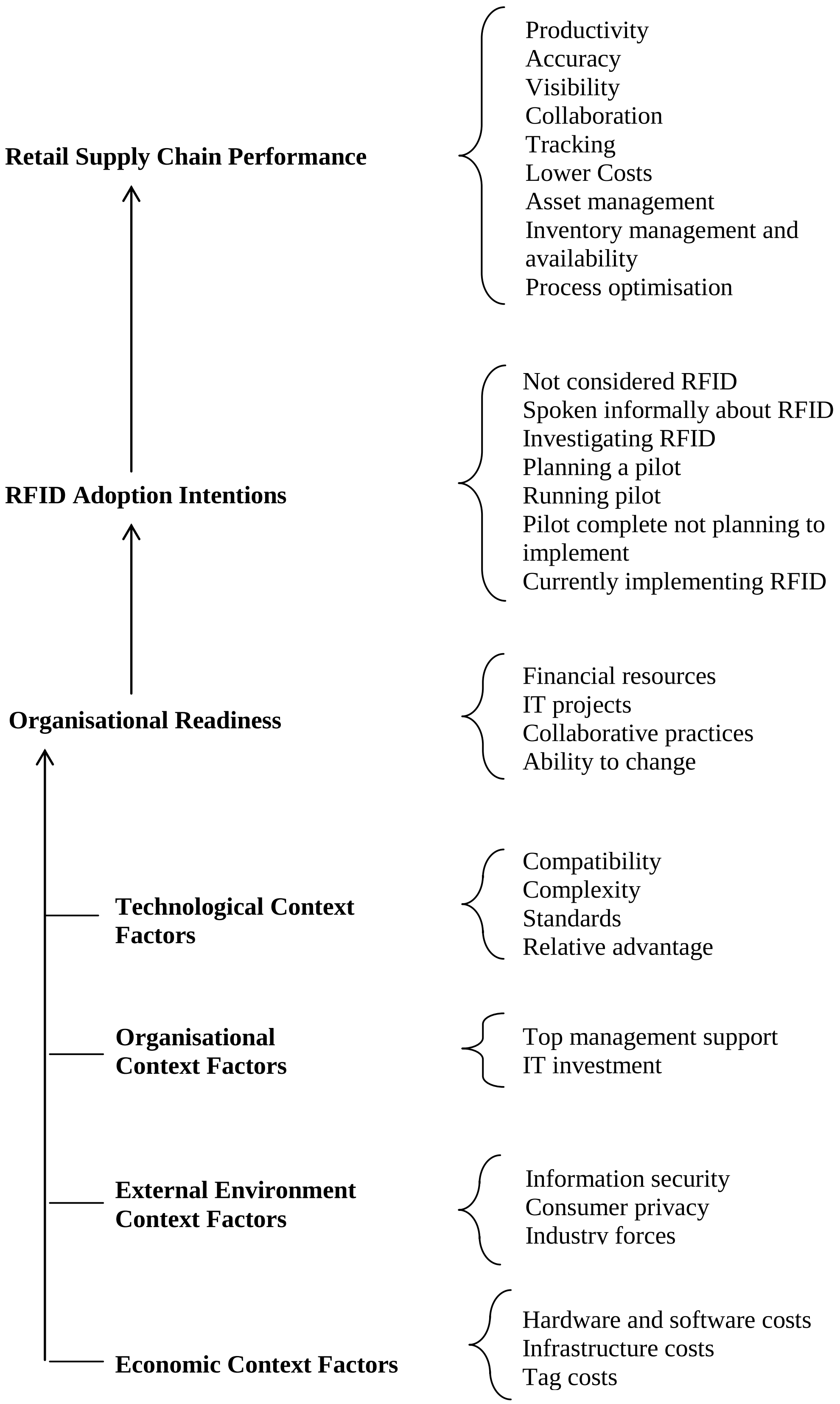
This thesis has so far provided a review of the literature surrounding RFID, in addition to a theoretical framework for an investigation of the issues affecting intentions to adopt this technology, a survey and a questionnaire (Chapter 2 & 3). Chapter 4 described the research design for this study, reinforcing the original research questions and providing evidence of sound methodology. Section 4.6 presented a formal pilot study using the AHP method, which was used to endorse the factors identified as important in the literature review, and subsequently the design of the questionnaire. Chapter 5 described the survey method, sampling plan and the data collection process, in addition to giving descriptive information about the respondents and their organisations.

Chapter 6 now sets out to analyse the data obtained in the main surveys. Section 6.2 presents the operationalisation of the constructs and Section 6.3 justifies the statistical method used to analyse the data, PLS-SEM. Section 6.4 describes the details of this method, including information about PLS-SEM and a comparison with other techniques such as Covariance Based Structural Equation Modelling (CB-SEM). Section 6.5 interprets the PLS-SEM model output, while Section 6.6 outlines the path model construction. Section 6.7 provides the results of analysis, including an optimised path model and validates this model. Finally, Section 6.8 summarises the results of the analysis, leading into the discussion, presented in Chapter 7.

6.2 Analysis and Operationalisation of the Constructs

An appropriate statistical method was required to convert the theoretical framework outlined in Chapter 4 and replicated below into a predictive statistical model (Figure 6.1). The aim was to predict the level of retail supply chain performance from the levels of RFID adoption, the factor organisational readiness and the various contextual factors (technological, organisational, economic, and external environment).

Figure 6.1: Research Theoretical Framework



The factors identified in the research framework (Figure 6.1) were grouped into categories, with each category represented by a factor. There were 15 factors and sub-factors to be statistically analysed, using the respondents' feedback from the questionnaires as set out in Section 3.3 of Chapter 3. The completed questionnaires represent predefined clusters of interrelated item scores that represent a unifying concept. Based on the results of the pilot study, organisational size was determined to be of low importance and was omitted from further analysis. Descriptive data regarding organisational size can be found in Chapter 5, Section 5.6.2. In addition, the economic sub-factors were not in the original questionnaire. These items were therefore categorised into three sets of sub-factors closely relating to the theoretical framework. Each item contributing to a factor was scored using a 7-point Likert scale, ranging from 1, coding for 'strongly disagree' to 7, coding for 'strongly agree'. All the items were ranked in the same logical direction and no items were measured in an opposite direction, so there was no need to use reverse scores. The factors are presented in Tables 6.1 through to 6.7.

Table 6.1: Retail Supply Chain Performance and Related Items for Analysis

Factors	Code name	Item Description
Retail Supply Chain Performance	RSCP	1. Higher shipping and receiving productivity 2. Increased order accuracy 3. Better returns processing 4. Improved materials receipts accuracy 5. Better inventory management 6. Better receiving labour productivity 7. Better asset use through tracking of vehicles 8. Better reusable container control 9. Visibility of high-value assets 10. Improved recall management 11. Improved tracking and traceability of inventory 12. Better expiration date management 13. Improvements in shrink 14. Reduction in inventory and working capital 15. Improved revenue through reduction in OOSs 16. Reduced expediting costs 17. Higher product availability

Table 6.2: Organisational Readiness Category and Related Items for Analysis

Factors	Code name	Item Description
Organisational Readiness	OR	1. Organisations have access to the financial resources to pay for implementation expenses 2. Organisations have access to the financial resources to pay for enhancement and ongoing expenses 3. Organisations have access to the required technological resources for implementing RFID 4. Organisations have access to the required technological resources for maintaining RFID 5. Organisations are culturally ready to implement RFID 6. Organisations place importance on accessing information about emerging technologies 7. Organisations have systems in place to facilitate changes that may occur as the result of adopting RFID 8. Organisations have been involved in similar IT projects 9. Organisations are not intimidated by technology

Table 6.3: Technological Category Factors and their Related Items for Analysis.

Factors	Sub-Factors	Code name	Item Description
Technological Factors	Compatibility	TFCm	1. RFID is compatible with my organisation's current hardware and software investment 2. RFID is compatible with my organisation's ICT 3. Employees at my organisation do not fear potential job losses that may result from adoption of RFID technologies 4. Employees at my organisation do not fear the adoption of RFID technologies because they may currently lack the skills to use these technologies 5. RFID is acceptable to my organisation because there is an agreed set of global standards 6. Implementing changes due to the new RFID technologies is compatible with our firm's values and beliefs 7. RFID is compatible with our experience with similar systems 8. Compatibility of hardware and software among potential trading partners will be critical to the success of RFID implementation 9. The ability to integrate RFID with existing information systems is critical to success
	Complexity	TFCx	1. RFID will be very difficult to integrate into organisations 2. The skills needed to implement RFID are too complex 3. The skills required to use RFID are too complex 4. RFID is conceptually difficult to understand from a technical perspective 5. RFID is conceptually difficult to understand from a business perspective 6. It is difficult to understand and visualise RFID in the whole process of an organisation 7. It will be difficult to make organisational changes to accommodate the introduction of RFID
	Standards	TFSt	1. The work done by standards making bodies make it easier to consider using RFID 2. Standards will assure the performance of RFID 3. Standards enable compatibility between future technologies 4. Standards enable greater integration with trading partners when considering RFID 5. Dominant customers have the ability to drive standards 6. Widely accepted RFID standards will be critical to the success of RFID implementation 7. Organisations adopt standards to enable better integration across applications 8. Frequency standards are globally harmonised for use with RFID 9. Numbering standards are globally harmonised for use with RFID

	Relative Advantage	TFRA	1. RFID would be more advantageous to my organisation than barcodes 2. RFID will afford my organisation better visibility of our inventory 3. The benefits of adopting RFID will be greater than the cost 4. RFID will provide timely and accurate information for decision-making 5. RFID will enhance the effectiveness and efficiency of my organisation 6. It would be less expensive to conduct business with several trading partners utilising RFID than using barcodes 7. RFID will enable the organisation to cut costs in our operations 8. Implementing RFID will increase the profitability of our business

Table 6.4: Organisational Category Factors and their Related Items for Analysis

Factors	Sub-Factors	Code name	Item Description
Organisational Factors	Top Management Support	OFTM	1. Top management provides strong and involved leadership when it comes to information systems in my organisation 2. Top management would support the implementation of RFID in my organisation 3. Top management has a desire to portray my organisation as a leader in the use of IT 4. Top management is willing to take the risks (financial and organisational) involved in adopting RFID 5. Top management has established clear goals and a clear picture of how RFID might help these goals 6. Top management understands the potential opportunities from adopting RFID in my organisation 7. Top management is interested in RFID in my organisation 8. Top management understands the importance of RFID 9. Top management considers RFID a potential strategic resource in my organisation
	IT Investment	OFIT	1. The IT department within my organisation has sufficient expertise to implement and integrate RFID 2. My organisation will be able to adapt to the process and informational needs of RFID 3. My organisation is willing to train employees to implement and maintain RFID 4. I feel comfortable with the level of external support available for RFID 5. Our organisation often adopts IT as a component of an information-based innovation 6. Technology/solution vendors have an influence over my organisation’s ICT decisions 7. Our organisation’s IT department is encouraged to learn about new technologies 8. Our organisation has a willingness to invest in IT relative to our revenues 9. Our organisation’s IT department closely follows trends in new technologies

Table 6.5: External Environmental Category Factors and their Related Items for Analysis

Factors	Sub-Factors	Code name	Item Description
External Environment Factors	Security	EES	1. Designing appropriate and dependable security and auditing processes for transmitting data will be critical to the success of RFID implementation 2. Internet security is a major concern to our firm when deciding to adopt RFID-based B2B transactions 3. The nature of the business data regularly exchanged between our firm and our trading partners requires a secured communication medium 4. Data exchanged during the transaction when using RFID must be accurate 5. Data exchanged when using RFID must be restricted to legitimate users only 6. My organisations is aware of the importance of IT security 7. Information security compliance, enforcement and monitoring is essential for RFID success
	Consumer Privacy	EECP	1. It is unlikely that someone will use RFID to steal my personal information 2. It is unlikely that my privacy will be violated as a result of RFID 3. Minimal harm would be done if someone broke into RFID databases containing my private personal information 4. Minimal harm would be done if an organisation that employs RFID abused my information 5. Minimal harm would be done if consumers' personal information is stolen because of RFID 6. If given the choice between a RFID product and a non-RFID product, I would choose the product that was tagged with RFID 7. Organisations must inform shoppers fully about the collection of consumer purchasing and profile information via RFID tags and how collected information will be used
	Industry Forces	EEIF	1. My organisation's biggest competitors are planning to adopt RFID in their facilities 2. My organisation will be at a competitive disadvantage if it does not implement RFID 3. My organisation reacts to what our competitors are doing in terms of ICT 4. We will lose customers to our competitors if we do not adopt RFID technologies 5. It is a strategic necessity to use RFID technologies to compete in the marketplace 6. An industry move to utilise RFID inter-organisational communications would put pressure on my firm to do the same 7. The pressure to adopt RFID placed on our organisation by our competitors is high

Table 6.6: Economic Category Factors and their Related Items for Analysis

Factors	Sub-Factors	Code name	Item Description
Economic Factors	Hardware and Software Costs	EFChs	1. The cost of hardware resources required to support RFID systems will be high 2. The cost of software resources required to support RFID systems will be high 3. The costs of integrating RFID with other information systems will be high
	Investment Costs	EFCi	1. The costs of implementing RFID will be high 2. Initial investment in RFID will be high
	Ongoing Costs (including tags)	EFCt	1. Organisations have high investment in existing systems 2. The costs (time and money) of training in RFID will be high 3. The costs of supporting RFID will be high for organisations

The level of intention to adopt RFID was not a factor comprising multiple interrelated item scores, but rather a categorical variable ranked on a simple ordinal scale from 1, ‘have not considered RFID yet’ to 7 ‘currently implementing RFID’. These are highlighted in Table 6.7. The premise is that the higher the score, the more likely the organisation is to adopt RFID. There were no responses corresponding to the item ‘have completed a pilot and will be implementing RFID,’ so this item was excluded from the analysis.

Table 6.7: Ordinal Levels of Intention to Adopt RFID

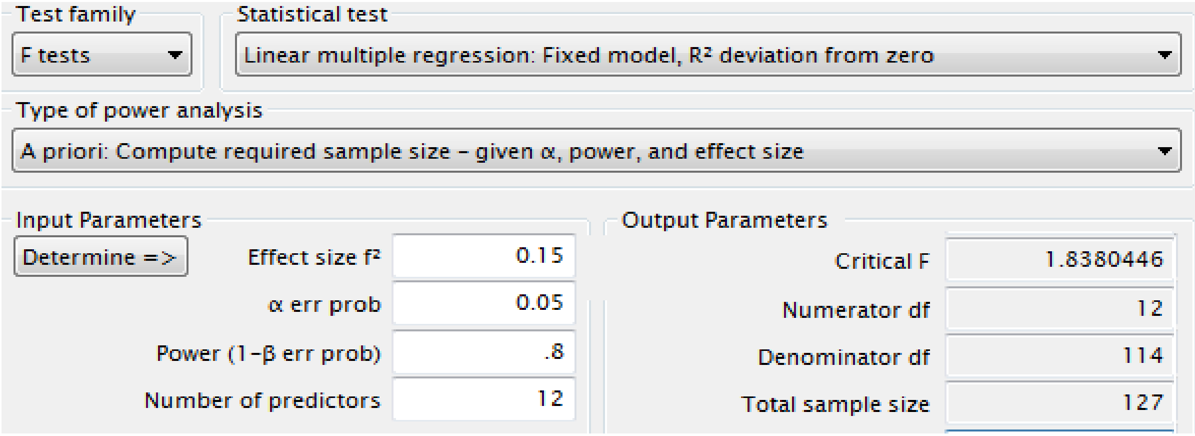
Variable	Code	Items
RFID Adoption Intention	ADI	1. Have not considered RFID yet 2. Spoken informally about RFID 3. Formally investigated RFID 4. Planning to launch an RFID pilot 5. Currently running an RFID pilot 6. Have completed a pilot and not planning to implement RFID 7. Currently implementing RFID

6.3 Choice of Statistical Model

This research required several variables in a set of relationships to be evaluated. Multivariate analysis was therefore considered an appropriate statistical approach for analysing the data in this study. Multivariate analysis has been defined as a statistical method concentrating on simultaneous relationships and their structure for three or more phenomena (Sheth 1977). Three types of multivariate approaches were considered for this study: Ordinary Least Squares (OLS) multiple linear regression, Covariance Based Structural Equation Modelling (CB-SEM) and Partial Least Squares Structural Equation Model (PLS-SEM).

The major problem with OLS regression is that if the sample size is too small, then Type II errors are likely to occur (i.e., it will be found that the model is not a statistically significant fit to the data, even though in fact it should be) (Hair et al. 2010). To determine the minimum sample size required to reject the null hypothesis that R^2 (the proportion of the variance explained by the model) is zero, a power analysis was performed using G*Power software (Faul et al. 2007). The input parameters were a moderate effect size (f^2=0.15, equivalent to R^2=13 per cent), a conventional statistical significance level of α=0.05, and a conventional power value of β-1=0.8, assuming 12 predictors. The output from G*Power (Figure 6.2) indicated that the minimum total sample size should be 127 respondents. The sample size used in this study was 116 respondents, and so was considered insufficient to obtain meaningful results using OLS multiple linear regression.

Figure 6.2: Output from G*Power to Compute the Minimum Sample Size for Ordinary Least Squares Regression



6.4 Structural Equation Modelling

SEM is a method used to analyse the links between variables in order to understanding the distinguishing features of these relationships. SEM is defined as a ‘multivariate technique combining aspects of factor analysis and multiple regression that enables the researcher to simultaneously examine a series of interrelated dependence relationships among the measured variables and latent constructs (variates) as well as between several latent constructs’ (Hair et al. 2010, p. 616). SEM is conducted on representations of endogenous (independent) and exogenous (dependent) variables and often diagrammatically represented as paths.

6.4.1 Path Analysis

Path analysis was a method adopted to interpret multiple relationships before the development of SEM. Path analysis uses simple bivariate correlations to determine the strength of paths. SEM extended individual path analysis to estimate all the relationships using the information for every equation in the model at the same time (Hair et al. 2010).

SEM is based on three analytical developments

- Path analysis, using covariance structure equations and path diagrams as well as through the decomposition of total effects between any two variables into total, direct and indirect effects
- Latent variable modelling, demonstrating how errors in variables can be separated from errors in equations
- General covariance estimation methods (Bollen 1989).

SEM deals with issues in which multiple outcomes are possible, a predictor can be explained by another and unobserved variables (latent) introduced. The design of` structural equation models includes selecting the variables, creating a pattern of relationships and assessing how well the model fits (Falissard 2012). The considerable differences between these models (CB-SEM and PLS-SEM) are outlined below.

6.4.2 CB-SEM

CB-SEM develops a theoretical covariance matrix related to a set of structural equations. The focus is on estimating model parameters where the difference between the theoretical covariance matrix and the estimated covariance matrix is minimised. LInear Structural RELations (LISREL) is the most common SEM programme used to analyse data in this form (Rigdon 1998). CB-SEM has stringent requirements that must be met in order for it to be applied successfully. For example, multivariate normality of data requires a minimum number of respondents based on the number of parameters. In this research the number of responses required to adopt CB-SEM would be between 5–10 times each measured variable and since there were over 100 variables, equates to between 500–1,000 respondents (Kline 2010).

6.4.3 PLS-SEM

PLS-SEM is an SEM technique that has become increasingly prominent in recent times as an alternative to CB-SEM (Hair et al. 2010). PLS-SEM was developed by Wold (1982) to analyse data in low structure environments. The reasons for PLS-SEM's acceptance include:

- This method is appropriate when the sample size is small
- The model may have many variables and paths
- This method is best when distributions are skewed or the independence of the observations are not known
- This model can be used as an alternative to CB-SEM due to the algorithm enabling unrestricted computation of cause-and-effect relationship models for reflective and formative situations

The advantages of PLS-SEM are presented in Table 6.8.

Table 6.8: The Advantages of PLS-SEM

	Advantages
i.	It is robust
ii.	It can handle both formative and reflective constructs
iii.	It is insensitive to smaller sample size (as low as 30 responses)
iv.	It is able to handle large numbers of variables and so there are no issues with complexity
v.	A PLS-SEM model is good when the measurement is poor

(Sources: Adapted from Henseler et al. 2009 and Hair et al. 2011)

Another distinction between CB-SEM and PLS-SEM relates the researchers' intentions, because if the goal is theory testing, then CB-SEM is preferred. However, if the goal is exploratory and includes the prediction of key target constructs, as is the case in this study, PLS-SEM is more appropriate. PLS-SEM is a method of predicting the effect of causes by maximising the explained variance of the dependent variables (Henseler, et al. 2009). From a conceptual position, PLS-SEM can be likened to using multiple regression as a tool for examining the relationships between variables. According to Hair et al. (2010), PLS-SEM is insensitive to the size of the sample and is appropriate for generating estimates with very small sample sizes (less than 30). The sample size of 116 used in this study was therefore more than adequate to construct a PLS-SEM path model. Unlike CB-SEM, which extracts latent variables from patterns in a covariance matrix to explain causal relationships, PLS-SEM operates by maximising the partitioning of the variance between the variables to predict causal relationships (Haenlen & Kaplan 2004; Hair et al. 2010). It is assumed that all of the variance is useful and can be explained. Consequently, there is no concern for residual or unexplained variance, which is a major issue when using OLS regression or SEM. The general rules for selecting CB-SEM or PLS-SEM are shown in Table 6.9.

Table 6.9: Rules for the Selection of CB-SEM or PLS-SEM

Research Goals If the goal is predicting key target constructs or identifying key 'driver' constructs, select PLS-SEM If the goal is theory testing, theory confirmation or comparison of alternative theories, select CB-SEM If the research is exploratory or an extension of an existing structural theory, select PLS-SEM
Measurement Model Specification If formative constructs are part of the structural model, select PLS-SEM Note that formative measures can also be used with CB-SEM but to do so requires accounting for relatively complex and limiting specification rules If error terms require additional specification, such as covariation, select CB-SEM
Structural Model If the structural model is complex (many constructs and many indicators), select PLS-SEM If the model is non-recursive, select CB-SEM
Data Characteristics and Algorithm If the data meet the CB-SEM assumptions exactly, for example, with respect to the minimum sample size and the distributional assumptions, select CB-SEM; otherwise, PLS-SEM provides a good approximation of CB-SEM results
Sample Size Considerations If the sample size is relatively low, select PLS-SEM. With large datasets, CB-SEM and PLS-SEM results are similar, provided that a large number of indicator variables are used to measure the latent constructs (consistency at large) PLS-SEM minimum sample size should be equal to the larger of the following: (1) ten times the largest number of formative indicators used to measure one construct or (2) ten times the largest number of structural paths directed at a particular latent construct in e structural model If the data are to some extent non-normal, use PLS-SEM; otherwise, under normal data conditions, CB-SEM and PLS-SEM results are similar, with CB-SEM providing slightly more precise model estimates If CB-SEM requirements cannot be met (e.g., model specification, identification, non-convergence, data distributional assumptions), use PLS-SEM as a good approximation of CB-SEM results CB-SEM and PLS-SEM results should be similar. If not, check the model specification to ensure that CB-SEM was appropriately applied. If not, PLS-SEM results are a good approximation of CB-SEM results
Model Evaluation If you need to use latent variable scores in subsequent analyses, PLS-SEM is the best approach If your research requires a global goodness-of-fit criterion, then CB-SEM is the preferred approach If you need to test for measurement model invariance, use CB-SEM

(Source: Hair et al. 2011)

6.4.3.1 PLS-SEM Components

PLS-SEM has two main components; namely, the inner and outer models. The structural model is the inner model and depicts the paths between latent constructs. The outer model is the measurement model. These are represented by the 'unidirectional predictive relationships' between the latent variables and the measured indicators (Hair et al. 2011). PLS path modelling involves the construction of latent variables from indicator variables measured by the researcher using factor analysis. Each latent variable is assumed to consist of only one factor. The main assumption is that the latent variables are reliably measured (i.e., that the indicators hang together strongly to define a unidimensional factor, or unifying concept). An internal consistency reliability of each factor is estimated using Cronbach's alpha. An alpha value of greater than 0.70 is assumed to indicate adequate reliability (Allen & Yen 2002).

PLS-SEM analysis is therefore a very robust method, meaning that it can operate simultaneously on a large number of variables with minimal assumptions about their distributional or measurement characteristics. PLS-SEM was used as a descriptive and exploratory tool to analyse the data collected in this study. The aim was to produce a visual illustration of the strengths of the relationships between the data, rather than to compute statistics to test hypotheses. Consequently, unlike OLS regression and CB-SEM, it was not necessary to carry out null hypothesis significance tests in order to compute p-values and determine if the model was a statistically significant fit to the data.

PLS-SEM has become increasingly popular in the last decade for examining business fields (Anderson & Swaminathan 2011; Henseler et al. 2009; Hrivnak 2009; Temme et al. 2006; Wetzels et al. 2009), including research in supply chains (Braunscheidel et al. 2010; Vandaele & Gemmel 2006; Vivek & Ravindran 2009). PLS-SEM is not supported by generalised statistics packages such as SPSS, and requires the use of dedicated software. Several software programmes are available to analyse data using PLS-SEM. Information about the major software packages, including PLS-GUI, VisualPLS, PLS-Graph, SmartPLS and SPAD-PLS is available (Temme et al. 2006). SmartPLS was chosen for this study because:

- All the essential elements are present
- The software is user-friendly
- It has an established research base
- It supports the estimation of interaction effects
- The software is downloadable from www.smartpls.de (Ringle et al. 2005; Temme et al. 2006)

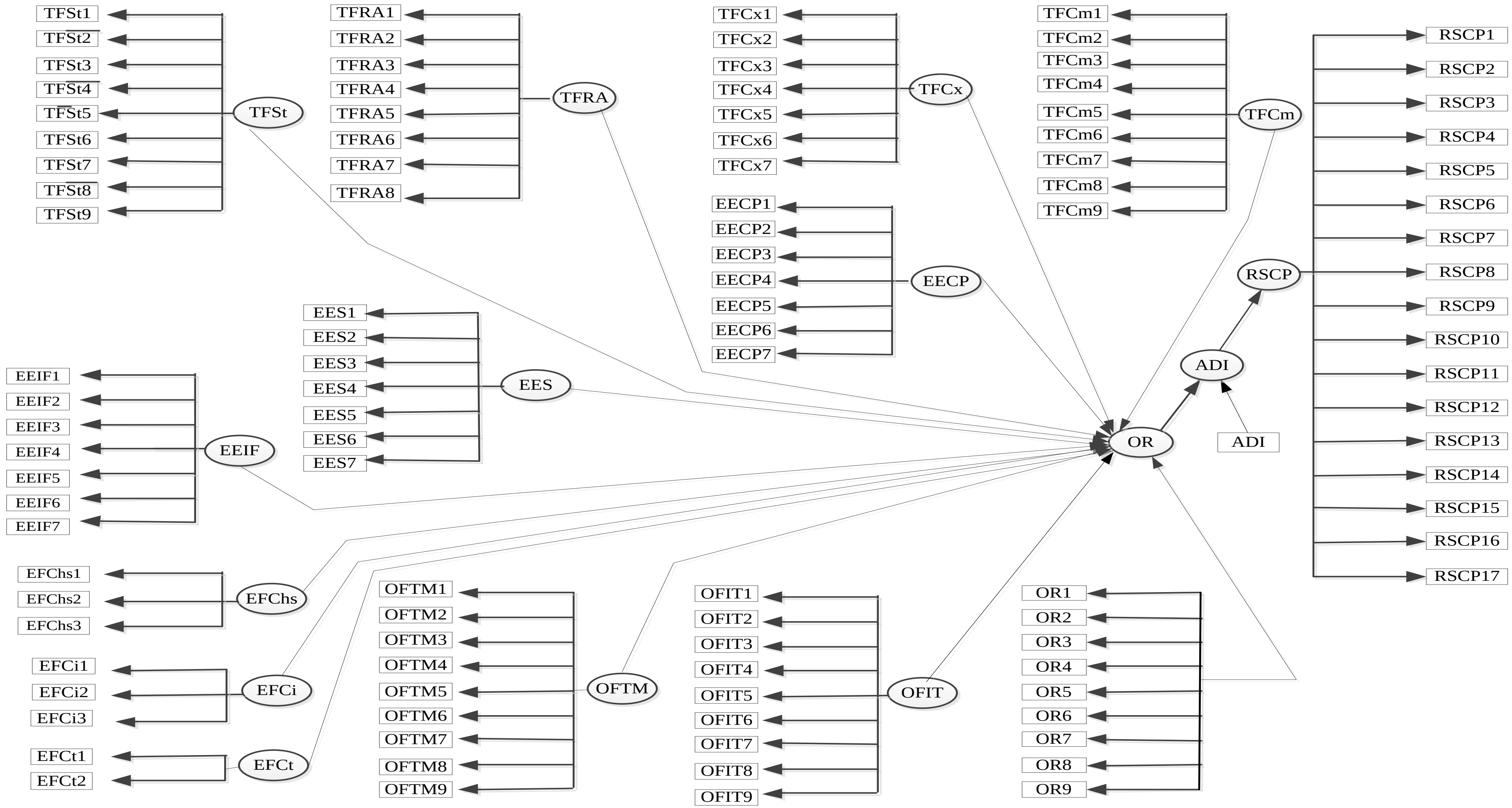
SmartPLS allows the direct import of data from other applications such as Excel, and has a graphic user interface that includes tools to enhance the colour, size and layout of the path diagram. Consequently, the analysis can be performed relatively quickly.

6.4.3.2 PLS-SEM Path Diagram

A path diagram was constructed using the graphic user interface of SmartPLS and all available indicators and latent variables (Figure 6.3). The variables were functionally defined as either indicator variables or latent variables. The indicator variables, specified in the path diagram using rectangular symbols, were the individual item scores to be measured using the RFID instruments, and imported into SmartPLS from a CSV (comma delimited) Microsoft Excel file. Each indicator variable was alphanumerically coded using the variable names in Table 6.1 to Table 6.7 so that they could be identified in the PLS path diagram. The latent variables or factors (i.e., the variables computed by the SmartPLS algorithm using factor analysis) were specified in the path diagram using oval symbols. Arrows were drawn between the symbols to represent hypothetical relationships. A fan of at least two arrows pointing out from a latent variable to cluster of indicators represented a reflective relationship. This meant that the latent variable was assumed to be the common cause, and the indicator variables assumed to be the inter-correlated effects, measured in terms of multiple item scores exhibiting internal consistency, reliability and convergent validity. All but one of the relationships in the PLS path model were reflective. An arrow pointing out from an indicator into a latent variable represented a formative relationship, implying that the indicator is a causal factor, which does not reflect the multiple effects of the latent variable. The only formative indicator in the model was RFID adoption intentions (ADI), which was measured using an ordinal scale from 1 to 7.

An arrow pointing out of one latent variable into another latent variable represented a predictive relationship between a hypothesised cause and a hypothesised effect. All the arrows between the latent variables flowed unidirectionally into OR (organisational readiness) through ADI (level of intention to adopt RFID) and finally into RSCP (the level of retail supply chain performance), which was the ultimate predicted outcome of the model (Figure 6.3)

Figure 6.3: Partial Least Squares Path Model (Adapted from SmartPLS)



6.5 Interpretation of Model Parameters

After constructing a path diagram, the SmartPLS algorithm was used to compute the model parameters without intervention or manipulation by the user (Ringle et al. 2005). Three types of model parameters were computed: (i) the factor loadings, located next to the arrows between the indicators and the latent variables; (ii) the path coefficients (rP), located next to the arrows between all latent variables; and (iii) the coefficient of determination (R^2) values, located inside the oval symbols (Figure 6.4).

Since the sample size of 116 cases used in this study was too low to support bootstrapping, the statistical significance had to be interpreted subjectively. The loadings were represented by the strengths and directions of the relationship results and identified as correlation coefficients. Consequently, factor loadings ranged from -1.0 to +1.0 and any loadings above 0.5 were interpreted as strong (DeVellis 2003). If the majority of the factor loadings for a latent variable were strong, then it was concluded that its convergent validity would be high (DeVellis 2003).

The path coefficients define how the multi-dimensional variance is partitioned. Each path coefficient measures the partial correlation between two latent variables after the effects of correlations with other latent variables has been partialled out. Consequently, if the root cause of a zero order correlation between two latent variables is their joint correlation with another latent variable, then the zero order correlation is reduced in magnitude (Waliczek 1996). For example, if the root cause of a correlation between organisational readiness and economic factors was that RFID provided an organisational advantage relative to the use of barcodes, then the correlation between economic factors and organisational readiness would be reduced. Consequently, the contribution of each latent variable to the multi-dimensional variance is not considered in isolation, but in the context of inter-correlations with other latent variables.

The size of a path coefficient (rP) indicates the relative strength and direction (positive or negative) of the relationship between two latent variables. The path coefficients were standardised to take into account the different units of measurement of each variable, consequently they ranged from –1.0 to +1.0, and were interpreted in the same way as the standardised regression coefficients in an OLS regression equation. Based on Cohen's (1992) criteria, the interpretation of the path coefficients was <0.15= weak, 0.15–0.45= moderate; >0.45= strong. SmartPLS also computed the R^2 values to estimate the proportion of the variance in a latent variable explained by the other latent variables leading into it. The interpretation of the R^2 values was < 0.05= small, 0.06–0.35= medium, and > 0.35= large (Cohen 1992).

6.6 Partial Least Squares Path Model Construction

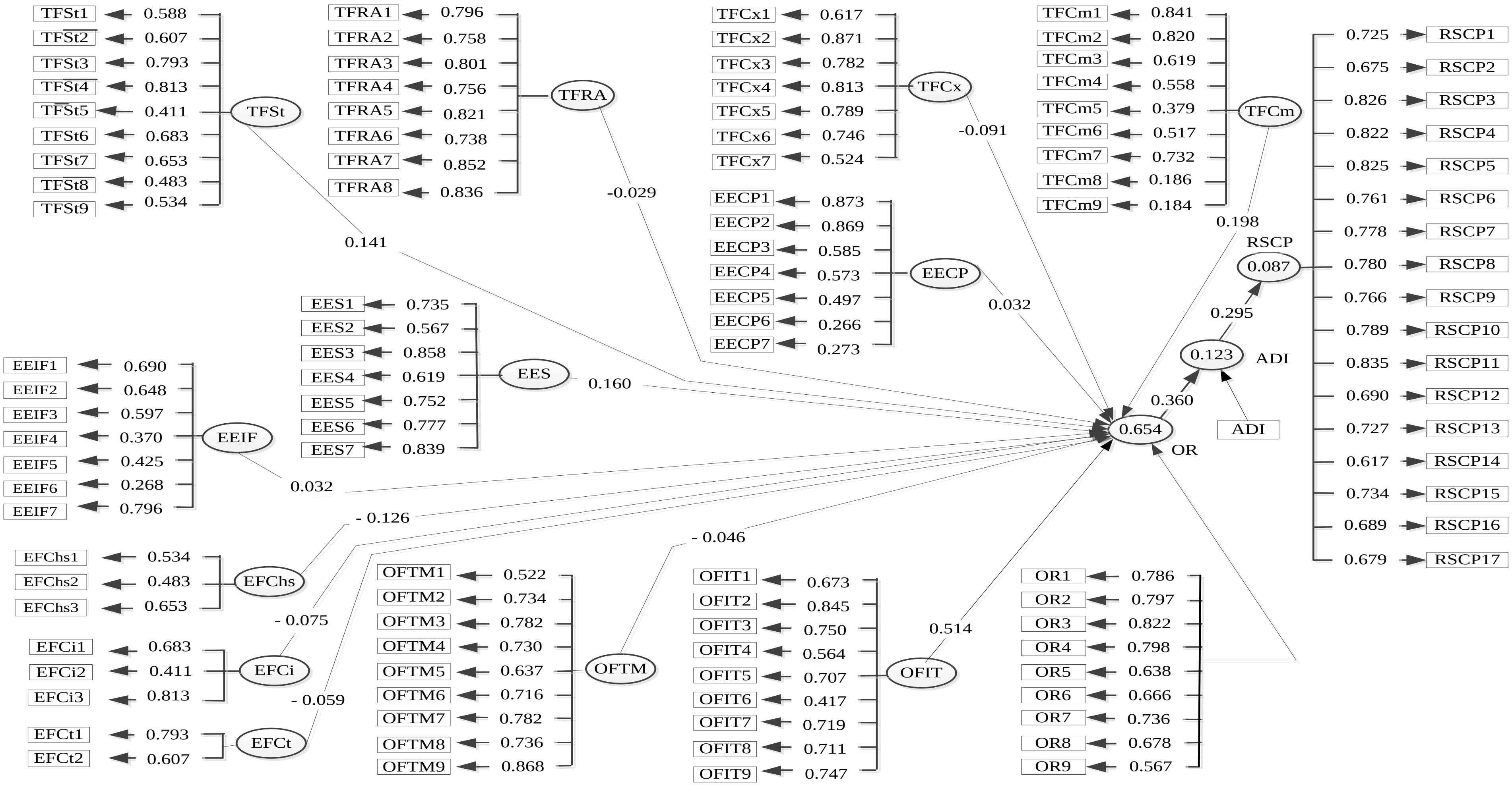
The first PLS path model was constructed using all of the available data. The indicators with weak loadings and low path coefficients were then excluded in order to construct an optimised model. The elimination of weak relationships using this trial-and-error process assisted in improving the reliability and validity of the latent variables, and ensured that the model was truly representative of the sample and not over-specified by including irrelevant data that contributed little or nothing to the partitioning of the variance (Hair et al. 2010).

6.7 Results of the Analysis

6.7.1 Partial Least Squares Path Model Using all Available Data

The PLS path diagram output by SmartPLS, calibrated with factor loadings, rP values, and R^2 values is illustrated in Figure 6.4. This path model illustrates the all factors, paths, and their relationships. In addition, the factor loadings, path coefficients, and R^2 values are also included.

Figure 6.4: Partial Least Squares Path Model Constructed Using SmartPLS



6.7.2 SmartPLS Output

The results of the output included in Figure 6.4 are now discussed in more detail. There were a total of 106 items representing latent variables measured. The rP values between OR and the factors TFSt, TFCx, TFRA, EECP, EEIF, OFTM, EFChs, EFCi, and EFCt were less than 0.15, indicating that these factors contributed relatively little to the variance in OR. A strong relationship existed between OFIT and OR (rP=0.514). Moderately strong relationships existed between OR and ADI (rP=0.360), and lower relationships between OR and TFCm, and EES, as well as between ADI and RSCP. In addition, a large proportion of the variance (R^2=65.4 per cent) in OR was collectively explained by the technological, organisational, economic, and external environment factors. A proportion of the variance in ADI (R^2=12.3 per cent) was explained by OR, while a smaller proportion of the variance in RSCP (R^2=8.7 per cent) was explained by ADI. Comprehensive details for the complete PLS-SEM model, including reliability indices, construct reliability, Cronbachs alpha (α), composite reliability, and AVE are presented in Section 10.7, Appendix G.

There were 13 factors from 106 below the 0.50 factor loading cut-off representing low convergent validity, and these were excluded from further analysis. In addition, 9 latent variables were found to have low path coefficients (<0.15) and also excluded from further analysis. A final 'optimised model' was then generated to improve the prediction objective.
The values of the Cronbach alpha output by SmartPLS for each of the latent variables using all the available reflective indicators ranged from 0.710–0.953 (Table 6.10). These are therefore higher than the 0.70 advised minimum (DeVellis 2003). Consequently, the model was well specified in terms of the reliability of its latent variables.

The interpretation of the output from SmartPLS (Figure 6.4) reveals that the majority of the factor loadings were >0.5, indicating adequate convergent validity. The exceptions included TFSt5 (0.411), TFSt8 (0.483), TFCm5 (0.379), TFCm8 (0.186), TFCm9 (0.184), EECP5 (0.490), EECP6 (0.266), EECP7 (0.273), EEIF4 (0.370), EEIF5 (0.425), EEIF6 (0.268), EFChs2 (0.483), EFCi2 (0.411) and OFIT6. (0.417). It was assumed these indicators contributed very little to the variance in their respective latent variables, resulting in low factor loadings. Factors loading are shown next to the factor codes in the path model in Figure 6.4.

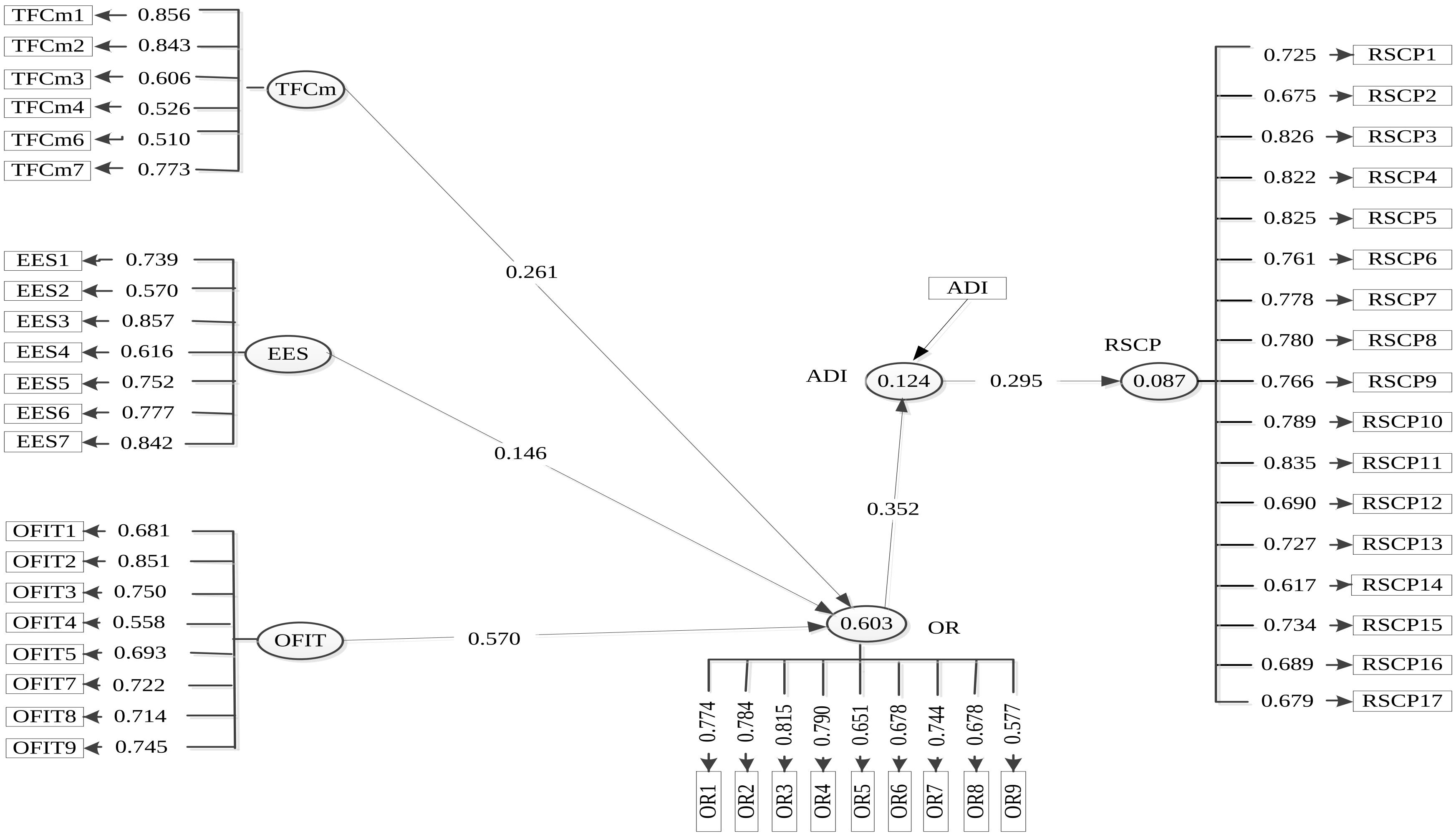
Table 6.10: Internal Consistency Reliability

Latent Variable	Cronbach Alpha
RSCP	0.953
OR	0.885
TFCm	0.730
TFCx	0.867
TFSt	0.802
TFRA	0.917
OFIT	0.885
OFTM	0.889
EECP	0.725
EES	0.885
EEIF	0.749
EFCi	0.769
EFChs	0.710
EFCt	0.847

6.7.3 Optimised Model

The optimised model shows a strong relationship between OR and the factor OFIT, and a moderate relationship between TFCm and OR. The rP values were 0.570 and 0.261 respectively. A lesser relationship was found between OR and EES (rP=0.146). The factors all contribute to the variance in OR. In addition, moderate relationships also existed between OR and ADI (rP=0.352), and ADI and RSCP (rP=0.295). A large proportion of the variance (R^2=60.3 per cent) in OR was collectively explained by TFRCm, EES and OFIT. A proportion of the variance in ADI (R^2=12.4 per cent) was explained by OR, while a smaller proportion of the variance in RSCP (R^2=8.7 per cent) was explained by ADI. The optimised path model is illustrated in Figure 6.5, and the results of this analysis will be discussed in Chapter 7.

Figure 6.5: Optimised Partial Least Squares Path Model Constructed Using SmartPLS



6.7.4 Validity

Validity refers to the manner in which a test measures what it is supposed to measure. The three main tests of validity used in this study measured the convergent validity, construct validity, and discriminant validity.

6.7.4.1 Convergent Validity

In the context of a PLS path model, convergent validity implies the degree to which the indictors of a latent variable converge upon the unifying factor that they are supposed to be measuring. Factor loadings of greater than 0.50 are considered to be strong indicators of convergent validity (DeVellis 2003). All the factor loadings in the optimised model were greater than 0.50, implying strong convergent validity.

6.7.4.2 Construct Validity

In the context of a PLS path model, construct validity refers to the ability of a latent variable to measure what it is supposed to measure without error. Construct validity was measured using Cronbach's alpha, composite reliability and Average Variance Extracted (AVE). The Cronbach's alpha values for the optimised model ranged between 0.784 and 0.953 and were all greater than 0.70, the cut-off for reliability (DeVellis 2003). In addition, the lowest value obtained for composite reliability was 0.847, again indicating a reliable construct. The AVE, which is a measure of the percentage error, provided an index of construct validity. The suggested minimum threshold value for AVE in a PLS path model is 0.50 per cent (Chin 1998). The AVE values for all factors were 0.50 or greater, supporting construct reliability. The construct, composite reliability indices and factor loadings are shown in Table 6.11.

Table 6.11: Optimised Model Reliability Indices and Factor Loadings for Constructs

	Retail supply chain performance	Adoption intentions	Organisational readiness	Technological compatibility	Organisational IT investment	External environment security	Construct reliability	Composite reliability	AVE
RSCP1	0.725	0.136	0.272	0.197	0.231	0.236	0.953	0.956	0.563
RSCP2	0.675	0.084	0.149	0.140	0.068	0.047			
RSCP3	0.826	0.154	0.268	0.287	0.244	0.182			
RSCP4	0.822	0.161	0.256	0.334	0.300	0.215			
RSCP5	0.825	0.209	0.230	0.314	0.286	0.328			
RSCP6	0.761	0.205	0.237	0.239	0.206	0.225			
RSCP7	0.778	0.295	0.329	0.294	0.305	0.225			
RSCP8	0.780	0.259	0.324	0.280	0.264	0.237			
RSCP9	0.766	0.203	0.217	0.200	0.192	0.285			
RSCP10	0.789	0.281	0.236	0.317	0.211	0.239			
RSCP11	0.835	0.346	0.258	0.314	0.287	0.248			
RSCP12	0.690	0.318	0.287	0.306	0.291	0.126			
RSCP13	0.727	0.111	0.116	0.100	0.175	0.102			
RSCP14	0.617	0.051	0.116	0.166	0.125	0.022			
RSCP15	0.734	0.155	0.203	0.169	0.201	0.026			
RSCP16	0.689	0.107	0.104	0.143	0.122	-0.009			
RSCP17	0.679	0.133	0.185	0.197	0.206	0.070			
ADI	0.295	1.000	0.352	0.399	0.399	0.062			
OR1	0.090	0.193	0.774	0.396	0.523	0.132	0.885	0.908	0.526
OR2	0.120	0.219	0.784	0.350	0.561	0.132			
OR3	0.252	0.318	0.815	0.449	0.582	0.220			
OR4	0.183	0.254	0.790	0.471	0.545	0.257			

OR5	0.323	0.295	0.651	0.444	0.523	0.070			
OR6	0.393	0.220	0.678	0.390	0.570	0.238			
OR7	0.293	0.221	0.744	0.417	0.523	0.198			
OR8	0.257	0.389	0.678	0.391	0.415	0.214			
OR9	0.156	0.167	0.577	0.303	0.517	0.322			
TFCm1	0.343	0.425	0.472	0.856	0.395	0.072	0.784	0.847	0.500
TFCm2	0.339	0.376	0.524	0.843	0.424	0.034			
TFCm3	-0.002	0.180	0.318	0.607	0.356	0.086			
TFCm4	0.121	0.201	0.299	0.526	0.310	-0.080			
TFCm6	0.280	0.155	0.248	0.510	0.253	0.134			
TFCm7	0.276	0.244	0.402	0.773	0.384	-0.031			
OFIT1	0.183	0.306	0.579	0.386	0.681	0.108	0.891	0.912	0.539
OFIT2	0.188	0.320	0.620	0.381	0.851	0.131			
OFIT2	0.188	0.320	0.620	0.381	0.851	0.131			
OFIT3	0.285	0.346	0.574	0.489	0.750	0.210			
OFIT4	0.305	0.295	0.315	0.366	0.558	0.087			
OFIT5	0.280	0.279	0.486	0.404	0.693	0.153			
OFIT7	0.174	0.298	0.535	0.334	0.722	0.066			
OFIT8	0.168	0.201	0.473	0.278	0.715	0.270			
OFIT9	0.367	0.275	0.555	0.360	0.746	0.194			
EES1	0.289	0.038	0.132	0.057	0.076	0.739	0.885	0.894	0.551
EES2	0.038	-0.013	-0.018	-0.100	-0.019	0.570			
EES3	0.263	0.045	0.334	0.070	0.201	0.857			
EES4	-0.035	0.043	0.099	-0.012	0.143	0.616			
EES5	0.099	0.008	0.025	-0.108	0.058	0.752			
EES6	0.142	0.075	0.201	0.035	0.180	0.777			
EES7	0.220	0.033	0.093	-0.042	0.111	0.842			

6.7.4.3 Discriminant Validity

Discriminant validity is a measure of whether factors that are supposed to be unrelated are in fact unrelated. An objective evaluation of discriminant validity involves testing the correlation between factors that measure theoretically different concepts (John & Benet-Martinez 2000). Discriminant validity can be determined by examining the correlations between the items in the constructs. The correlations were predominantly lower than the square root of the AVE shared by items within a construct. The variable OFIT displayed a larger value than the AVE, and so it could be concluded that these two variables have some similarity. However, overall the model supported discriminant validity (Xu et al. 2012). For details of the results, see Table 6.12.

Table 6.12: Correlation of Latent Variables for the Optimised Model

	Retail supply chain performance	**Adoption intentions**	**Organisational readiness**	**Technological compatibility**	**Organisational IT investment**	**External environment security**
RSCM	**0.751**					
ADI	0.295	**1.000**				
OR	0.321	0.352	**0.725**			
TFCm	0.340	0.399	0.558	**0.701**		
OFIT	0.314	0.399	0.735	0.509	**0.734**	
EES	0.252	0.062	0.274	0.046	0.203	**0.743**

The diagonal elements in bold represent the square root of AVE

6.8 Summary

The analysis of the data collected from the respondents has provided evidence to support the contention that organisational readiness is an important element for industry leaders interested in the future implementation of emerging technologies. In this study, several factors were highlighted as more important to organisational readiness with respect to RFID adoption. For instance, investment in technology, technology compatibility and security were identified as critical to organisational readiness. These results in the optimised model indicate that investment in technology, an organisational category, produced the highest path coefficient of

0.570. The next highest was compatibility, a technology context factor, at 0.261. These were followed by an external environmental factor, security (0.146). The next chapter will discuss these results in detail.

CHAPTER 7: DISCUSSION OF RESULTS

7.1 Introduction

The prior chapter explains the relationships between the factors in a predictive framework. The aim is to answer the research questions as set out in Section 1.7. In this chapter, Section 7.2 discusses the PLS-SEM results and Section 7.3 discusses the outer model of PLS. Finally, Section 7.4 then discusses the inner model, drawing reference to organisational readiness, intention to adopt and retail supply chain performance.

7.2 Discussion of the PLS-SEM Results

The PLS-SEM path model displaying all factors and indicators (Figure 6.4) was analysed using SmartPLS algorithms and factors found to be not contributing to the construct were removed. The factors removed included relative advantage, complexity, standards, all cost factors, consumer privacy, industry forces and top management support. These factors were not supported by the model because the measurement of their path coefficients fell below the 0.15 cut-off representing low convergent validity, and so they were deemed to have contributed little to the variance in organisational readiness. Relative advantage, complexity and top management support all displayed low negative scores, suggesting that these factors actually produced a negative contribution to organisational readiness. Cost factors also displayed negative scores, although this indicated that as costs increased this change would have a negative influence on OR. However, the path coefficients for costs were also below the cut-off for adequate convergent validity and so this factor was also removed from the model. Industry forces and consumer privacy both had low path coefficients and did not contribute to the variance in organisational readiness. Finally, the factor standards displayed a low score and removed from further analysis. The intention was to improve the model by removing all factors with path coefficients less than 0.15.

An optimised model, displayed in Figure 6.5, provided important information. The measurement of the factor loadings in the outer weights reflects unified latent variables. In addition, the measurement of path coefficients defines the inner model weights. Finally, measurements of the coefficient of determination indicate the strength of the latent variables. The following sections provide a discussion of these results.

7.3 The Outer Model

The outer model represents the factor loadings on each latent variable in the optimised version. These latent variables included the challenges associated with the intentions to adopt RFID and embraced a technological factor, compatibility (TFCm), an external environmental factor, security (EES), and an organisational factor, technology investment (OFIT). These linked forward to the latent variables, organisational readiness (OR), intentions to adopt (ADI) and retail supply chain performance (RSCP). SmartPLS provides the outer weights as factor loadings and if these are greater than 0.50 provides evidence of a unified factor that they are all supposed to represent.

The factor loadings for the initial PLS path model are provided in Table 7.1., and confirm that the vast majority of item loadings were greater than 0.50. However, there were four items below the 0.50 cut-off and thus did not contribute to the variance of their respective factors. Results related to the optimised model are identified in italics, and the following section discusses all items in more detail.

Table 7.1: PLS-SEM Path Model Factor Loadings

Item No.	TFCm	EES	OFIT	OR	RSCP
1	0.841	0.735	0.673	0.786	0.725
2	0.820	0.567	0.845	0.797	0.675
3	0.619	0.858	0.750	0.822	0.826
4	0.558	0.619	0.564	0.798	0.822
5	***0.379***	0.752	0.707	0.638	0.825
6	0.517	0.777	***0.417***	0.666	0.761
7	0.713	0.839	0.719	0.736	0.778
8	***0.186***		0.711	0.678	0.780
9	***0.184***		0.747	0.567	0.766
10					0.789
11					0.835
12					0.690
13					0.727
14					0.617
15					0.734
16					0.689
17					0.679

7.3.1. Technological Factor: Compatibility Items

There were three items (33 per cent) that did not support the technological factor compatibility. These included Items 5, 8, and 9 as shown in table 7.2 .

Table 7.2: Technology Factor: Items not Supporting Compatibility

Item Number	Item Description
5.	RFID is acceptable to my organisation because there is an agreed set of global standards in place
8.	Compatibility of hardware and software among potential trading partners will be critical to the success of RFID implementation
9.	The ability to integrate RFID with existing information systems is critical to success

These were not supported and contributed little to the technological factor compatibility. These three items did not come together in the same manner as Items 1, 2, 3, 4, 6 and 7 to embody a unifying factor. There were no indications in the data as to why Items 5, 8 and 9 did not contribute to compatibility. Perhaps the respondents did not view these specific questions consistently. However, the majority of items (67 per cent) did contribute to compatibility, enabling this factor to be classified as unified.

Items 1 and 2 in the compatibility factor were closely aligned with the literature with respect to ensuring that current IT was harmonious with any RFID (Moon & Ngai 2008). Items 3, 4, 6 and 7 appeared to relate to less tangible elements such skills, jobs, values and experience. The high factor loadings for these elements suggest that managers recognise these as cohesive characteristics (Table 7.3). The literature supports the view that these are important compatibility elements (Brown & Russell 2007; Moon & Ngai 2008).

Table 7.3: Technology Factor: Items Supporting Compatibility

Item Number	Item Description
1.	RFID is compatible with my organisation's current hardware and software investment
2.	RFID is compatible with my organisation's ICT
3.	Employees at my organisation do not fear potential job losses that may result from adoption of RFID technologies
4.	Employees at my organisation do not fear the adoption of RFID technologies because they may currently lack the skills to use these technologies
6.	Implementing changes due to the new RFID technologies is compatible with our firm's values and beliefs
7.	RFID is compatible with our experience with similar systems

7.3.1 External Environmental Factor: Security Items

All items in the external environmental factor security (EES) were greater than the cut-off of 0.50, indicating high convergence. These items included 1,2,3,4,5,6 and 7 Table 7.4. Security is therefore considered to be a unifying factor based on these items. Managers conclusively viewed the factor security in these terms, and the literature supports this stance (Fabian & Günther 2009; Juels 2006).

Table 7.4: External Environmental Factor: Items Supporting Security

Item Number	Item Description
1.	Designing appropriate and dependable security and auditing processes for transmitting data will be critical to the success of RFID implementation
2.	Internet security is a major concern to our firm when deciding to adopt RFID-based B2B transactions
3.	The nature of the business data regularly exchanged between our firm and our trading partners requires a secured communication medium
4.	Data exchanged during the transaction when using RFID must be accurate
5.	Data exchanged when using RFID must be restricted to legitimate users only
6.	My organisations is aware of the importance of IT security
7.	Information security compliance, enforcement and monitoring is essential for RFID success

7.3.2 Organisational Factor: IT Investment Items

One item (11 per cent), Item 6, did not support the organisational factor IT investment (OFIT) (Table 7.5.)

Table 7.5: Organisational Factor: Items Not Supporting Investment Items

Item Number	Item Description
6.	Technology/solution vendors have an influence over my organisation's ICT decisions

This item differed markedly from the other items in this category and therefore it may be inferred that it would not unify in a supporting manner. However, all other items (89 per cent) did contribute to IT investment, enabling a unifying factor (Table 7.6.). These items included internal and external IT support, organisational adaptability and training, organisational innovation, financial investment and considering emerging technologies. Once again, the literature supports these items (Jeong & Lu 2008; Sharma et al. 2007).

Table 7.6: Organisational Factor: Items Supporting Investment Items

Item Number	Item Description
1.	The IT department within my organisation has sufficient expertise to implement and integrate RFID
2.	My organisation will be able to adapt to the process and informational needs of RFID
3.	My organisation is willing to train employees to implement and maintain RFID
4.	I feel comfortable with the level of external support available for RFID
5.	Our organisation often adopts IT as a component for an information-based innovation
7.	Our organisation's IT department is encouraged to learn about new technologies
8.	Our organisation has a willingness to invest in IT relative to our revenues
9.	Our organisation's IT department closely follow trends in new technologies

7.3.3 Organisational Readiness Items

All items in the organisational readiness factor (OR) were greater than the cut-off of 0.50, indicating high convergence. These items included 1,2,3,4,5,6,7,8, and 9 (Table 7.7) Organisational readiness included financial and technological resources, cultural aspects, access to information about future technologies, change management processes and previous involvement with technology. The literature supports all these items (Kim & Garrison 2010; Lee & Shim 2007; Tsai et al. 2010).

Table 7.7: Organisational Readiness Factor: Items Supporting Organisational Readiness

Item Number	Item, Description
1.	Organisations have access to financial resources to pay for implementation expenses
2.	Organisations have access to financial resources to pay for enhancement and ongoing expenses
3.	Organisations have access to the required technological resources for implementing RFID
4.	Organisations have access to the required technological resources for maintaining RFID
5.	Organisations are culturally ready to implement RFID
6.	Organisations place importance on accessing information about emerging technologies
7.	Organisations have systems in place to facilitate changes that may occur as a result of adopting RFID
8.	Organisations have been involved in similar IT projects
9.	Organisations are not intimidated by technology

7.3.4 Retail Supply Chain Performance Items

Finally, all items in the retail supply chain performance (RSCP) were greater than the cut-off of 0.50, indicating high convergence. These items included 1 – 17, (Table 7.8.)

Table 7.8: Retail Supply Chain Performance Factor: Supporting Items

Item Number	Item Description
1.	Higher shipping and receiving productivity
2.	Increased order accuracy
3.	Better returns processing
4.	Improved materials receipts accuracy
5.	Better inventory management
6.	Better receiving labour productivity
7.	Better asset use through tracking of vehicles
8.	Better reusable container control
9.	Visibility of high-value assets
10.	Improved recall management
11.	Improved tracking and traceability of inventory
12.	Better expiration date management
13.	Improvements in shrinkage
14.	Reduction in inventory and working capital
15.	Improved revenue through reduction in OOSs
16.	Reduced expediting costs
17.	Higher product availability

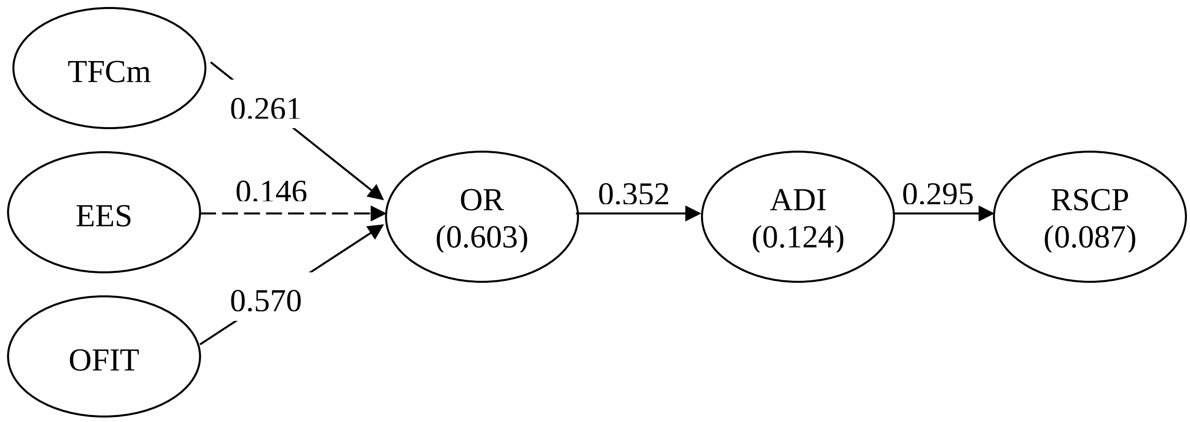
All items included in the factor retail supply chain performance were unified and the literature discusses these in relation to performance (Shih et al. 2008).

As previously mentioned, the construct intentions to adopt (ADI) was a formative model and ranked on an ordinal scale from 1, 'have not considered RFID' to 7, 'currently implementing RFID'. However, the proposition was that the higher the score for ADI, the more likely the organisation was to adopt RFID.

7.4 Inner Model

The inner model represents the structural model and is represented by paths between the latent variables. Given that the outer model has been justified, the inner model will provide predictive results to illustrate the strengths of the relationships between all latent variables. Figure 7.1 is adapted from Figure 6.5 and presents the path coefficients (Rp) on the arrows between each latent variable and the coefficient of determination (R^2) below organisational readiness (OR), intentions to adopt (ADI) and retail supply chain performance (RSCP) for the optimised model.

Figure 7.1: Partial Least Squares Model Latent Variables, Path Coefficients and R^2 Values



7.4.1 Organisational Readiness

The three major factors contributing to organisational readiness were a technological factor, compatibility (TFCm), an external environmental factor, security (EES), and an organisational factor, technology investment (OFIT). However, recalculation after the removal of factors with low path coefficients revealed a slight shift in the path coefficients. While the path coefficients between OR, ADI and RSCP remained relatively stable, the path coefficients between TFCm, EES and IFIT changed with respect to OR. Interestingly, the path coefficient for security (EES) decreased to a measurement below the 0.15 cut-off, and this was offset by increased coefficients for compatibility (TFCm) and investment in IT (OFIT) (Table 7.9).

Table 7.9: Changes to Path Coefficients

Factor	Measure prior to optimisation	Optimised measure
TFCm	0.198	0.261
EES	0.160	0.146
OFIT	0.514	0.570

The literature supports the assertion that the adoption of RFID, in the form of an EPCGlobal model, has not been realised and there were very few installations (Wamba et al. 2008b). Current research in this area is examining a futuristic RFID scenario (Smart et al. 2010). Central to this thesis is the claim that organisations need to prepare for emerging technologies such as RFID. Organisational readiness is a primary focus and differentiates this research from other studies examining the potential of RFID and adoption intentions.

Following the exclusion of the weakest relationships the optimised PLS path model indicated that a technological factor (compatibility), an external environmental factor (security) as well as an organisational factor (IT investment) collectively account for 60.3 per cent of the variance in organisational readiness. These factors were deemed the most important with regards to organisational readiness. The model also predicted that the most important factor contributing to the variance in organisational readiness was the organisational factor IT investment, which has a strong positive influence on organisational readiness (0.570). This translates into organisational readiness being predicted to increase with respect to an increase in IT investment. IT investment includes the expertise available, the level of external support, the organisation's willingness to invest in information technologies, access to IT resources, the ability to adapt to RFID, the willingness to train staff and the manner in which the organisation encourages learning about new technologies (Mahmoud & Mann 2005). Compatibility, another IT factor, has a moderate influence on organisational readiness. Compatibility is another factor acknowledged in the literature. The success of RFID is linked to the degree of compatibility, both between RFID technologies and between RFID technologies and other software and hardware systems (Attaran 2007; Davenport & Brooks 2004). Security also features in the calculations, although this factor only has a low impact on organisational readiness, with a coefficient of 0.146. In this study security relates to the unauthorised access to information or systems (Juels 2006). Countermeasures are constantly being upgraded (Pietro & Molva 2011), although these results suggest security is still an important factor.

Interestingly, despite tag cost being well represented in the pilot study, no such importance has been placed on these costs in the PLS-SEM analysis. This was one of several factors measured in this study with low path loadings that contributed little or nothing to organisational readiness, explaining their exclusion from the optimised model.

7.4.2 Intentions to Adopt

The PLS-SEM analysis also showed a relationship between organisational readiness and intentions to adopt. The strength of this relationship was measured using an ordinal scale from 1, ‘have not considered RFID yet’ to 7, ‘currently implementing RFID’. The reliability of this scale is unknown, since it was collected by one measurement. However, the path coefficient indicates a moderately positive relationship (0.352), such that intention to adopt is positively related to organisational readiness. On the other hand, the proportion of variance of intention to adopt explained by organisational readiness is also low. In fact, only 12.4 per cent of the latent factor intention to adopt can be explained by organisational readiness. Therefore, it must be assumed that intention to adopt is also influenced by other factors. Notwithstanding, this result was also positive, and so it can be argued that as organisational readiness increases than so will intentions to adopt.

7.4.3 Retail Supply Chain Performance

The PLS-SEM analysis indicated a positive relationship between intention to adopt and retail supply chain performance. The strength of this relationship, as defined by the path coefficient, indicates a moderately positive relationship (0.295). However, the strength of this relationship was found to be low. Only 8.7 per cent of the latent factor retail supply chain performance can be explained by intention to adopt. Therefore, a large number of unmeasured factors explained the variability in retail supply chain performance, of which the intention to adopt RFID played a relatively small part. Despite a low R^2 value, this result is positive, implying that as intentions to adopt increase, then so will retail supply chain performance. Furthermore, the indicators all yield relatively high factor loadings. This suggests that all indicators converge, and measure what they are supposed to measure.

7.4.4 Comparison of PLS-SEM Output with Pilot Study Results

There was mixed support when comparing PLS-SEM output results to AHP pilot study results. The AHP analysis enabled separate appraisal and differences between Retailers, Suppliers and Technology providers. However, Figure 4.3 combines the results into a normalised synthesis and allowing comparison with PLS-SEM results. As mentioned earlier, the high importance of tag costs found in the pilot study were not replicated from the main survey using PLS-SEM analysis. In fact, tag costs were one of the factors excluded from the optimised PLS-SEM model due to low path coefficients. In addition, standards, ranked most important in the pilot study were also excluded. Conversely, compatibility, ranking third in the pilot study did rank high (second) in the PLS-SEM analysis. Security ranked fifth in the pilots study contrasting with third in the PLS-SEM output. Finally, IT investment ranked 6th in AHP analysis compared to being a most important factor contributing to organisational readiness in PLS-SEM analysis. The diverse results may be as a result of the low number of respondents participating in the pilot AHP surveys. Furthermore the pilot study using AHP was designed to simply gauge potential factors for inclusion in the main PLS-SEM analysis.

CHAPTER 8: IMPLICATIONS OF RESULTS AND CONCLUSIONS

8.1 Introduction

The purpose of this research was to examine the factors impacting on the intention of industries within the Australian retail supply chain sector to adopt RFID. A theoretical framework was developed in a previous chapter (Figure 6.1) to show the relationships between challenging factors and organisational readiness, intention to adopt, and consequent retail supply chain performance. The results of a pilot study using AHP confirmed the reliability of these factors. The aim was to explain the relationships between these factors within a predictive framework in order to answer the research questions set out in Section 1.7, Chapter 1.

In this concluding chapter, Section 8.2 presents the implications of this study for both managers and academics. Section 8.3 follows with a discussion of the results of earlier analysis of stakeholder perspectives, while Section 8.4 revisits the research questions with respect to the benefits and challenges associated with the adoption of RFID. Section 8.5 explains the limitations of this study and offers recommendations for future researchers in this field, and finally, Section 8.6 concludes this thesis.

8.2 Implications for Academics and Managers

Both academics and managers stand to benefit from the contribution of this research. Academics will gain through increased knowledge of an emerging technology, RFID. Managers also will benefit by being able to focus their resources on the most important elements with respect to their RFID adoption intentions. These implications are presented in the next two sections.

8.2.1 Implications for Academia

Few empirical studies of RFID exist, and even fewer concentrate on the EPCGlobal network model. The notable exceptions are the work of Bottani et al. (2009, 2010), Theisse et al. (2009) and the empirical studies by Bottani (2009), Bottani et al. (2010), Thiesse et al. (2009b), Wamba et al. (2010), Wamba and Boeck (2008) and Wamba et al. (2008b). This is possibly a result of the difficulties associated with studying an application that at this stage is not yet accepted by industry (Roh et al. 2009). This thesis fills this gap and contributes to the existing knowledge by studying the EPCGlobal model. A summary of the major extant studies follows, in order to draw attention to the distinguishing features of this research.

A study of retail organisations in South Africa has used descriptive statistics and interviews with a small number of retailers to examine the factors influencing their adoption intentions (Brown & Russell 2007). Organisational readiness was one of the factors examined, and the results showed that organisations were not financially, operationally or culturally ready to adopt RFID, at least in South Africa. There was uncertainty about the costs and benefits associated with adoption, as well as a need to justify the business case and the ROI. This particular study found that retail organisations were not intending to adopt RFID. This conclusion supported the view that organisational readiness influences RFID adoption (Brown and Russell, 2007).

A study by Lee and Shim (2007) also examined the role of organisational readiness in the context of RFID adoption. Three categories of factors: technology push, need pull and the presence of champions, were found to influence the intentions to adopt RFID within hospital settings (Lee & Shim 2007). Organisational readiness was included as a ‘moderator’ between the factors and intentions to adopt RFID. The results from this study were somewhat surprising in that one conclusion was that financial resources did not have any impact on the intention to adopt RFID, at least as affected by technology push and need pull factors (Lee & Shim 2007). However, the rationale provided by these researchers suggests that irrespective of their financial position, organisations might delay RFID due to other considerations. Their study also found that technology knowledge was a significant moderator, and more importantly, that this was found to differentiate adopters and non-adopters (Lee & Shim 2007). These researchers also concluded that organisational IT knowledge was the most important element of organisational readiness. Furthermore, a lack of understanding of RFID could result in organisations disregarding the technology and so greater knowledge will reduce uncertainty about RFID (Lee & Shim 2007).

Lastly, a study of users’ behaviour and the factors impacting on RFID adoption intentions in South Korea upheld the hypothesis that organisational readiness in the form of financial resources and technological knowledge had a positive effect on any intentions to evaluate RFID (Kim & Garrison 2010).

There are notable differences between the above studies and this thesis. For instance, Brown and Russell's (2007) study used descriptive statistics and interviewed a small sample (n=6) of retailer participants. This dissertation adopts PLS-SEM, an established statistical predictive model, and the number of respondents in this study is also much larger, at 116. Lee and Shim's (2007) study seemed to be discussing 'RFID' in a generic sense, not EPCGlobal, and the factors impacting intentions to adopt, including technology push, need pull, and the presence of champions differed from those investigated in this study. Lee and Shim's (2007) study related to internal organisational closed systems specifically within the healthcare sector. Kim and Garrison's (2010) study provided insightful information. The surveys asked participants to identify if they were at the evaluation stage, adoption stage or integration stage, and 72 per cent stated that they were either adopting RFID or at the integration phase. This study comprised 278 organisations, of which 114 organisations had already adopted the technology and a further 86 had integrated this technology into their routines (Kim & Garrison 2010). This was an interesting result, because no other known study revealed such high adoption rates. Perhaps the generic RFID models as well as the EPCGlobal model were both included in their research.

Evidence also suggests that RFID is becoming a topic of interest for supply chain management scholars (Chao et al. 2007; Irani et al. 2010). A large number of studies on RFID were presented in the literature review. The contribution of this particular research extends to two existing theories: network externalities theory and diffusion of innovations theory. The contribution of this research study towards these two theories is detailed below.

8.2.1.1 Network Externality Theory

Network externalities theory argues that the value a user derives from a product will alter depending on how many other users exist (Katz & Shapiri 1986). A classic example is the telephone, which is highly valued due to its established client base. Similarly, the value of the Internet is high due to its large number of users. Dew and Read (2007) discuss network externality as it relates to RFID. These authors highlight a 'problem stage', or challenges, associated with RFID and suggest the need for a coordination mechanism. The coordination of information between the technology provider and the potential user is critical to 'common knowledge'. Accordingly, attention needs to be focused on the role discourse plays in providing and sharing information about the technology (Dew & Read 2007). This thesis focuses on organisational readiness, for which the search for knowledge is a primary consideration. How organisations prepare depends on their understanding of RFID. Importantly, these perceptions are moderated by the manner in which information flows between the various stakeholders.

8.2.1.2 Diffusion of Innovations Theory

The diffusion of innovations describes the way in which innovations are communicated through various channels over time, and explains the rate by which technology is adopted (Rogers 1995). Although this theory centres on consumer society, there are industrial applications. RFID is at the very early stages of diffusion, which involve the dissemination of information. The anticipated diffusion patterns of RFID were investigated by Sheffi (2004) by comparison with other similar technologies and not surprisingly, this determined that RFID was at the first stage of diffusion, involving gathering information. However, the Wal-Mart seal of approval provided the requisite approval for adoption, a later stage in technology take-up (Sheffi 2004). Once again, the focus of this research supports the notion that organisational readiness is an important factor in the process due to the essential need to access information about RFID in preparation for possible diffusion.

8.2.2 Implications for Management

There are several reasons why the results of this study are important for managers. Retailing managers, manufacturing and distribution managers and technology provider managers can all benefit by understanding not only the importance of the factors involved, but also the relationships between these factors. This information will assist them to focus on specific future directions regarding the potential adoption of emerging technologies such as RFID.

First, the results of the PLS-SEM output described in Section 6.7.2 show strong positive path coefficients between IT investment, compatibility and security with respect to organisational readiness. These are presented in the optimised model shown in Figure 6.5. This study identified a strong positive relationship between IT investment and organisational readiness. The implications for managers include rethinking their organisation's strategy and engaging in higher levels of investment in IT if they wish to successfully compete in their respective industries. Furthermore, organisations need to reconsider their financial position and make provision for funding IT into the future. Retailing executives and their supplier executives need to strengthen their policies with regards to activities associated with the preparation for technology adoption. IT investment also includes access to expertise, and consequently technology providers have a role to play in meeting the future demand for experienced and knowledgeable RFID professionals (Sharma et al. 2007). The technology will stabilise and a lack of skilled RFID technicians would then have adverse consequences. Finally, an essential element is an organisation's willingness to embrace new technology, including potentially reduced levels of productivity in the beginning. Leading organisations will have a long term view and increasingly focus on the potential benefits arising from being able to quickly exploit emerging technology capabilities.

In addition, this study also discovered positive relationships between compatibility, a technological factor, and organisational readiness. In other words, all applicable technology must connect, transact and communicate in a seamless, smooth and stable manner (Curtin et al. 2007). The results propose that the focus for executives should be alignment, by ensuring that advancements in technology are compatible with their organisations' existing systems. Equally important is a harmonious relationship between RFID and the needs of users, existing needs and practices and the organisation's strategy. In particular, technology providers responsible for manufacturing and installing RFID need to be mindful of this factor. Technology providers will need to update their policies and procedures in order to satisfy user concerns.

Security was another factor identified as having a positive relationship with organisational readiness. Although minor, the evidence supports the conjecture that security impacts on organisational readiness. Retailers, suppliers and technology providers all play a role in focusing on the security of information. Once again, policies and procedures must be upgraded to reflect this notion. For example, the inclusion of protocols that will reduce security issues related to the transmission of data through the Internet, authority to access data and threats to infrastructure are all essential requirements for supply chain security (Shih et al. 2005).

Although minor, there were also positive relationships between organisational readiness and intentions to adopt, and in turn between intentions to adopt and supply chain performance.

This reinforces the proposal that higher levels of organisational readiness will facilitate adoption intentions, and in turn, retail supply chain performance. These results infer that once the RFID challenges described earlier in Section 2.9, Chapter 2 are removed, organisations will be in a position to take advantage of the technology's potential, including improvements in performance.

Second, the R^2 values revealed in the analysis supported the executives' focus on the above three factors. The R^2 values generated from the PLS-SEM model confirmed the proportion of variance in organisational readiness explained by the contributing factors IT investment, compatibility and security. In essence, 60.3 per cent of organisational readiness in this model can be attributed to these three factors (Figure 6.5). Organisations' recognition of the importance of IT investment, compatibility and security will enable the allocation of scarce resources to the appropriate sectors and negate the hype surrounding other non-essential elements of the process of preparing organisations for adopting RFID.

Organisations no longer compete in isolation, but rather as supply chains (Coyle et al. 2008), and competition is changing, particularly in the retail sector. Organisations continually search for an elusive 'killer application' (Smart et al. 2010), and often IT provides such outcomes. Knowledge about the critical factors and their interaction with respect to RFID will have important consequences for managers. This research establishes a path forward. Emerging technologies such as RFID are not 'plug-and-play' (Lewis 2004), and as a result, organisations must increase their level of preparedness. This study centres its attention on organisational readiness and the results will assist organisations to understand and appreciate this feature.

Retailers and their suppliers will be required to align their policies and strategies in accordance with the findings of this study. For example, a retailing organisation's strategy will need to provide funding for investment in technology. Equally, organisations will be inclined towards devoting additional time and effort to understanding emerging technologies, including running pilot studies and ongoing analysis. In addition, organisations must either upgrade their internal IT expertise, or strengthen their ongoing access to external IT expertise. Their policies in relation to security, particularly Internet security, will also need to be upgraded. Finally, technology providers should now focus on the compatibility of new technology with other existing technologies.

8.3 Discussion Regarding Stakeholder Analysis

Three stakeholder categories—retailers, suppliers to retailers and technology providers—were analysed with respect to adopting RFID. Due to the low number of responses, analysis and comparison of these stakeholders using PLS-SEM was not possible. However, information was obtained from the pilot study, and descriptive statistics were obtained from the main surveys. The pilot study concentrated on the challenging factors and their association with the goal of the study, organisational readiness. Ranking based on pairwise comparison revealed differences to the main survey. First, while all stakeholders placed technological and economic factors as the most important, retailers ranked technological factors much more highly than did either the suppliers or the technology providers. Retailers were evidently concerned about the challenges posed by RFID. However, the suppliers identified economic factors as the most important. This was expected and ties in with the literature. Costs dominate the literature when discussing RFID adoption (Roberti 2011; Smart et al. 2010; Ustundag & Tanyas 2009; Wen et al. 2010). More importantly, the literature also describes the possible imbalance between suppliers and retailing facilities with regards to the apportionment of costs, with suppliers being expected to attach tags and bear the cost of this exercise (Gaukler et al. 2007).

There were also informative results in the analysis of the sub-criterion factors. Notably, standards ranked highly for both retailers and technology providers, but less so for suppliers. However, an overall synthesis of all factors weighted standards as first. The literature presents several standards as important for RFID, comprising numbering standards, frequency standards and power standards (Shepard 2005). However, the differences in perspectives observed in this study do not align with the literature and it is not evident as to why suppliers ranked other technological factors such as complexity and compatibility so highly. It is possible that suppliers already have standards well entrenched in their daily processes. Suppliers were also less inclined to rank IT investment, an organisational sub-criterion, unlike their counterpart retailer and technology providers. Again this does not align with the literature, and more importantly, does not match the PLS-SEM analysis, which unequivocally measured IT investment as extremely important. IT investment includes financial resources and technical resources in addition to skills and access to the experts required to support RFID (Sharma et al. 2007). Interestingly, the suppliers considered that top management support was more important. This could be due to the perception that top management was less inclined to assist with IT projects (Brown & Russell 2007). The external environmental factor security was ranked as highly important by all stakeholders, and this supports its inclusion in the main survey. Security is an ongoing challenge and is particularly important when contemplating the adoption of RFID (Fabian & Günther 2009; vanDeursen & Radomirovic 2009; Weber 2010). Finally, tag costs were determined to be the most important factor within the economic sub-category and were a close second when all factors were synthesised. Nonetheless, technology providers judged implementation costs a little higher. It is likely that the costs of installing RFID are better known by the experts in this field.

The main survey revealed a number of important differences between the stakeholder groups that are worthy of mention. First, results from the analysis of the factor intentions to adopt RFID differed markedly. The majority of retailers surveyed indicated that they had formally investigated RFID, and some had extended this to completing a pilot study. Conversely, many suppliers had not yet considered RFID, or had only spoken informally about the technology. Technology providers were asked to comment on their perceptions of retail supply chain intentions and agreed with retailers that most had formally investigated RFID (Table 5.14). This outcome aligns with the literature that depicts retailers as renowned for investing in cutting edge technology (Jacenko & Gunasekera 2005; Tong &Tong 2006).

8.4 Addressing the Research Questions

This section addresses the research questions from the introduction chapter 1, Section 1.7.

8.4.1 How does RFID Impact on Retail Supply Chain Performance?

Retail supply chain performance was conceptually measured using 17 items The performance factors included productivity, accuracy, visibility, collaboration, tracking, lower costs, asset management, inventory management and availability and processing optimisation (Figure 6.1). However, this central research question also required the identification and subsequent analysis of factors associated with RFID adoption to answer this question. The results will provide the importance of each of these factors for comparison and discussion. The literature review exposed a large number of factors and this research adopted four categories of factors namely technological, organisational, external environmental and economic factors to be analysed in the context of RFID adoption.

8.4.2 How do Technological, Organisational, External Environmental and Economic Factors Impact on Organisational Readiness?

The approach undertaken to categorise factors impacting on organisational readiness was underpinned by technological, organisational and external environmental (TOE) theory (Tornatzky & Fleischer 1990). Several previous studies have adopted these categories, in the context of RFID justifying this approach (Brown & Russell 2007; Kim & Garrison 2010; Lin & Ho 2009; Wang et al. 2010; Wen et al. 2009). These were summarised in Table 2.9 in the literature review. Within this framework, and under the technological category, a number of factors including compatibility, complexity, standards, data volume and relative advantage were discussed. Compatibility and complexity are generic factors and have been described in previous IT adoption literature (Rogers 2003). However, there were also factors that were specifically related to RFID. For example, standards were a factor defined in the literature, and data volume also mentioned. The former was included as a key technological factor; however, the latter was dismissed as low priority and removed from the study. Organisational factors were also evident in the literature, with most sources discussing top management support, IT investment and the organisation's size as considerations. Top management support and IT investment were considered important and were included in the study, while organisational size, due to the results of the pilot study, was not included as part of the predictive model. The size of organisations was a demographic factor and therefore incorporated in the statistical description. The external environmental factors discussed in the literature review consisted of industry forces, security and privacy factors. The literature and pilot study results also identified these as critical to RFID adoption. Finally, the literature placed significant emphasis on costs supporting the creation of an economic context category. The economic category factors were identified as variable or ongoing costs, such as tag costs, implementation and investment costs, hardware and software costs and training/consultant costs. The results of the PLS-SEM output found compatibility, a technological factor, security an external environmental factor, and IT investment an organisational factor as contributing significantly towards organisational readiness.

8.4.3 How does Organisational Readiness Impact on the Intentions to Adopt RFID?

Organisational readiness included factors that highlight level of preparedness for the implementation of emerging technologies. Organisational readiness was described in terms of availability of financial and technological resources, cultural preparedess and experience in innovative technological adoption (Chwelos et al. 2001; Wu 2004). Organisational readiness was identified as under researched, particularly in RFID studies. All the items associated with organisational readiness were found to be sound in the PLS-SEM analysis. Organisational readiness was identified as a significant factor contributing to intentions to adopt RFID. Although the association was quite low, it was positive.

8.4.4 How do the Intentions to Adopt RFID Impact on Retail Supply Chain Performance?

One goal of this research was to find out the intentions of retail organisations with regards adoption of RFID. The intentions to adopt factor was measured using ordinal scale. This factor centred on eight ranks from: have not considered RFID yet, have spoken informally about RFID, formally investigated RFID, planning to launch a RFID pilot, currently running a RFID pilot, have completed a pilot and will not be implementing RFID, have completed a pilot and are planning to implement RFID, and currently implementing RFID. Results from survey responses indicated that most organisations belonged to three categories - formally investigated RFID , spoken informally about RFID or not yet considered RFID. Conversely, very few had launched a pilot, were currently running a pilot, or had completed a pilot and decided not to implement RFID. Survey responses indicated that only one supplier had implemented RFID. The results of the PLS-SEM output provided evidence that the intentions to adopt RFID had a moderate positive relationship with retail supply chain performance.

8.4.5 RFID Factor Relationships

The above factors defined the scope of this study. The next part of the main research question set out to establish how these factors were related. The relationship between these concepts formed the main construct and was shown in Chapter 3. In summary, supply chain performance was affected by intentions to adopt RFID, and in turn, the intention to adopt was affected by organisational readiness. Organisational readiness intervened between challenges and the intentions to adopt RFID. A diagrammatic representation was presented in Figure 3.2, and a discussion of these relationships can be found in Chapter 3.

8.5 Limitations and Future Research

There are limitations to this research that may be resolved by future researchers. For example, this research study was cross-sectional and as such, a static investigation. This means that some degree of caution needs to be taken with the results of the predictive cause and effect model. Individuals' perceptions may change over time and future researchers might consider extending this research with longitudinal studies to overcome this limitation.

The second shortcoming relates to the fact that a single participant in each organisation was contacted, and probably responded in isolation, and thus their responses may not represent the perspectives of their organisation. This may have introduced the potential for respondent bias. These shortcomings were overcome to a certain extent because the respondents were drawn from the membership of GS1 and would understand the benefits and challenges associated with automatic identification in the form of barcodes. They would probably be involved in any discussions within their organisation regarding RFID. Future research might consider multiple participants within each organisation in order to enhance the results.

The third limitation regards people interpreting questions differently and not always having an opportunity to provide more precise answers in surveys, including standardised questionnaires (Rossi et al. 1983). This survey overcame these difficulties by utilising known previous relevant survey questions. It is impossible to prevent certain of the limitations associated with questionnaires that elicit answers regarding peoples' thoughts, feelings and behaviours, as opposed to analysing their actual thoughts, feelings and behaviour (Monette et al. 1994). However, given the requirement to collate responses from large-scale surveys, as in this research, there were few alternatives. In addition, only by measuring and demonstrating a phenomenon repeatedly can a researcher guarantee that it is a reliable finding and not just an accident of sampling (Allen & Yen 2002). Finally, the construction of a statistical model based on a single set of data does not provide sufficient evidence to definitively prove or disprove a phenomenon. Therefore, to test the conclusions of this study, future researchers would need to repeat the survey using a different instrument with different respondents. If similar conclusions were obtained after the survey was repeated, then this would provide more convincing support for the results.

8.6 Overall Conclusion

The motivation behind this research stemmed from industry's increasing interest in an emerging technology that has the potential to redefine the supply chain environment. The setting was restricted to the Australian retail sector and the importance of this sector to society was established in Chapter 2. Industry already has a number of recognised RFID processes. However, in this study RFID related to the EPCGlobal model, which differs from other installations due to the involvement of supply chain organisational networks. Despite frequent citation of the benefits of this technology throughout the literature (Rekik et al. 2006; Roh et al. 2009; Sellitto et al. 2007), RFID is not being widely implemented. A primary reason for the lack of RFID rollout, and equally well cited throughout the literature, were the multiplicity of challenges (Fabian & Günther 2009; Kumar et al. 2009; Wu et al. 2006) that have restricted the effectiveness of RFID.

Intentions to adopt RFID are wedged between the benefits and challenges. A forward-looking organisation understands that future advances in technology will ease the problems currently associated with RFID and place it in a position to be adopted throughout industry (Poirier & McCollum 2006). This study draws attention to this future scenario. This research proposes that a missing factor in the jigsaw to fully realise the potential of RFID at some point in the future is an organisation's level of preparedness. This factor, defined as organisational readiness (Tsai et al. 2010), was positioned as a critical intermediary factor between the challenges associated with RFID and the intention to adopt this technology. Organisational readiness is expressed in literature in terms of the financial and technical resources required and available within the organisation (Lee & Shim 2007). Organisational readiness is also described as the awareness of factors that affect adoption intentions; specifically, knowledge of the innovation, needs-fit analysis and skills requirements (Tsai et al. 2010; Wu 2004), a compelling consideration directly related to this study. The way in which the benefits, challenges and organisational readiness factors interrelate with intentions to adopt RFID are central to this research.

CHAPTER 9: REFERENCES

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10.1 Appendix A: Respondent 'a' Supplier Calculation

Survey Respondent

Organisational Readiness

Note: The ranking of importance for each factor must be consistent when compared (i.e. technological, organisational, external environmental and economic). If you rank a factor higher this indicates that you are more satisfied with this factor compared to others in a consistent manner. For example, if you rate technological higher than economic, and economic higher that organisational, then it is not consistent when rating organisational to consider this factor higher that technological

Supplier a

In the following Table compare the category on the left vertical with

	Technological	Economic	Organisationa	External Environmental	SUM(B10:B13/B10)					Weights	Products	Ratio
Technologica	1.00	2.00	5.00	7.00	0.543	0.615	0.375	0.350		0.471	2.046	4.348
Economic	0.50	1.00	7.00	9.00	0.271	0.307	0.525	0.450		0.388	1.704	4.388
Orgnaisationa	0.20	0.14	1.00	3.00	0.109	0.044	0.075	0.150		0.094	0.384	4.069
External Environmental	0.14	0.11	0.33	1.00	0.078	0.034	0.025	0.050		0.047	0.188	4.039
									CI=	0.070	CI/RI=	0.078

Technological

	Complexity	Compatibility	Relative advantage	Standards						Weights	Products	Ratio
Complexity	1.00	0.33	9.00	3.00	0.225	0.195	0.375	0.367		0.291	1.270	4.370
Compatibility	3.00	1.00	8.00	4.00	0.675	0.585	0.333	0.490		0.521	2.307	4.429
Relative advantage	0.11	0.13	1.00	0.17	0.025	0.073	0.042	0.020		0.040	0.162	4.049
Standards	0.33	0.25	6.00	1.00	0.075	0.146	0.250	0.122		0.148	0.616	4.149
									CI=	0.083	CI/RI=	0.092

Economic

	H/S ware Costs	Implement Cost	Tag Cost				CI	Weights	Products	Ratio
H/S ware Cost	1.00	0.20	0.20	0.091	0.063	0.118		0.090	0.272	3.014
mplement Co	5.00	1.00	0.50	0.455	0.313	0.294		0.354	1.083	3.063
Tag Cost	5.00	2.00	1.00	0.455	0.625	0.588		0.556	1.715	3.085
							CI=	0.027	CI/RI=	0.046

Organisational

	Top Mgt Sup	IT Readiness	Size				CI	Weights	Products	Ratio
Top Mgt Sup	1.00	3.00	7.00	0.677	0.714	0.538		0.643	2.008	3.121
IT Readiness	0.33	1.00	5.00	0.226	0.238	0.385		0.283	0.866	3.062
Size	0.14	0.20	1.00	0.097	0.048	0.077		0.074	0.222	3.013
							CI=	0.033	CI/RI=	0.056

External Environmental

	Privacy	Security	ndustry Forces				CI	Weights	Products	Ratio
Privacy	1.00	0.14	0.20	0.077	0.097	0.048		0.074	0.222	3.013
Security	7.00	1.00	3.00	0.538	0.677	0.714		0.643	2.008	3.121
ndustry Force	5.00	0.33	1.00	0.385	0.226	0.238		0.283	0.866	3.062
							CI=	0.033	CI/RI=	0.056

10.2 Appendix B: Cover Letter Sent to Participants

INVITATION TO PARTICIPATE IN A RESEARCH PROJECT

PROJECT INFORMATION STATEMENT

Project Title:

The Impact of Radio Frequency Identification (RFID) on Retail Supply Chain Performance.

Investigator:

- Mr Stephen Waters, PhD student RMIT University. E-mail S3176669@student.rmit.edu.au, Phone + (61 2) 96859252.

Supervisors:

- Professor Shams Rahman, Principle Supervisor and Senior Lecturer RMIT University. E-mail shams.rahman@rmit.edu.au, Phone + (61 3) 9925-5530.
- Dr Shahadat Khan. Co Supervisor and Senior Lecturer RMIT University. E-mail shahadat.khan@rmit.edu.au, Phone + (61 3)9925-5536.

Dear Manager,

You are invited to participate in a research project being conducted by RMIT University. This information sheet describes the project in straightforward language, or 'plain English'. Please read this sheet carefully and be confident that you understand its contents before deciding whether to participate. If you have any questions about the project, please ask the investigator or one of the supervisors.

Who is involved in this research project? Why is it being conducted?

The principal researcher in this project is Stephen Waters, a PhD student from the RMIT University. The supervisor for this research is Associate Professor Shams Rahman, and the co-supervisor Dr Shahadat Khan. Associate Professor Shams Rahman, and Dr Shahadat Khan are both academics from RMIT with extensive research background and they will ensure that the research is conducted in a professional manner. The RMIT Human Research Ethics Committee has approved this project. The results of this research will be examined and published as part of the requirements for PhD award.

Why have you been approached?

You have been selected because you work as a manager within an organisation that forms part of a retail supply chain or provides technology solutions to these organisations. Your organisation was identified from a membership list provided by one of the following: The National Retailer Association, GS1 Association Australia, Australia Industry Group, or Australian business telephone index. Your position title indicates potential involvement in the future deployment of emerging technology such as Radio Frequency Identification (RFID).

What is the project about? What are the questions being addressed?

The purpose of this research is to investigate the impact of RFID on retail supply chain performance. RFID is an innovative technology that is being considered within supply chains to replace barcodes. The RFID technology includes Ultra High Frequency (UHF) Radio Frequency Identification tags attached to products/cases/pallets, and readers, capable of picking up information from passing tagged products. Information is made available to supply chain members via the Internet. RFID does not need line of sight, unlike barcodes and the tags can hold a large amount of information. RFID in this research comprises those RFID technologies incorporated in the proposed EPCGlobal network. EPCGlobal is part of an industry organisation, GS1, which administers the development of standards suitable for Radio Frequency Identification (RFID). EPCGlobal is the platform used to administer the implementation, maintenance and infrastructure required for this network. Literature describes a range of benefits that will accompany implementation of the EPCGlobal network. The literature also identifies a number of technological, organisational, economic, and external environmental factors that are preventing widespread implementation.

This research examines your perspectives about EPCGlobal RFID benefits and challenges as well as relationships.

Our study aims to gather perspectives from stakeholders within three different categories of stakeholders:

1. Retailer organisations;
2. Supplier of logistics services and products for resale to retailer organisations;
3. RFID Technology and Solution providers.

The aim is to investigate and explain relationships between factors influencing the intention to adopt RFID.

The central research question is:

- How does RFID technology impact on retail supply chain performance?

There are a number of sub-questions:

- How do technological factors impact on organisational readiness?
- How do organisational factors impact on organisational readiness?
- How do economic factors impact on organisational readiness?
- How do external environmental factors impact on organisational readiness?
- How does organisational readiness impact on RFID adoption patterns?
- How does RFID adoption impact on retail supply chain performance?

A survey questionnaire will capture data and information that will assist in answering these research questions. A questionnaire has accompanied this letter. It is expected approximately two thousand organisations will take part in this survey.

If I agree to participate, what will I be required to do?

Once you have read and understood this letter, if you agree to participate, you will be required to answer statements related to RFID. A typical statement is – RFID technology will not be difficult to integrate into organisations. Your answer will be captured by circling a number between 1 – 7 (1 being strongly disagree and 7 being strongly agree). You will also be asked for your point of view about factors which may influence your organisations preparedness to implement RFID. There are also questions about your position and characteristics of the organisation you work for. The questionnaire should only take approximately 30 minutes of your time.

If you agree to participate please complete the questionnaire and return in the stamped and addressed envelope. Return of the survey will constitute your consent to participate in this research.

What are the risks or disadvantages associated with participation?

There are no known risks with participating in this research. However, if you are unduly concerned about your responses to any of the questionnaire items or if you find participation in the project distressing, you should contact the investigator Stephen Waters as soon as convenient to discuss your concerns.

There is very little research about RFID particularly in relation to the 'proposed' EPCGlobal's RFID enabled network model. Greater understanding of this model in terms of benefits, challenges, and relationships between relevant variables will enable managers to focus on critical areas more likely to lead to improvement. Increased knowledge will prevent unnecessary allocation of scarce resources by industry.

What will happen to the information I provide?

The results of the surveys are confidential and no details of individuals or organisations will be published. The data will be aggregated to provide the final results. Information will only be viewed by the research team identified at the beginning of this letter. The results will be published as part of the requirements of PhD candidature. Additionally, results may form the basis of published journal and conference proceedings. All information about specific individuals or organisations will remain confidential. The research data will be kept secured at the School of Management RMIT Offices for a period of 2 years before being destroyed by shredding hard copies or deletion of computer files.

What are my rights as a participant?

You have the right to withdraw their participation at any time, without prejudice. You have the right to have any unprocessed data withdrawn and destroyed, provided it can be reliably identified, and provided that so doing does not increase the risk for the participant. You also have the right to have any questions answered at any time

Whom should I contact if I have any questions?

If you have any questions regarding any aspect of this project, please contact one of the following:
The principal supervisor.
Professor Shams Rahman
School of Management
Building 108, Level 16 Room 95
108 Bourke Street Melbourne
Phone: 61 3 9925 5530
E-mail: shams.rahman@rmit.edu.au

Co Supervisor
Dr Shahadat Khan.
School of Management
Building 108, Level 16 Room 15
108 Bourke Street Melbourne
Phone + (61 3)9925-5536
E-mail shahadat.khan@rmit.edu.au,

Investigator
Mr Stephen Waters
School of Management
PhD student, RMIT University
(61 2) 6859252
E-mail S3176669@student.rmit.edu.au

Yours Sincerely

Mr Stephen Waters
M.B.A.

Professor Shams ur-Rahman
PhD

Dr Shahadat Khan
PhD

Any complaints about your participation in this project may be directed to the Secretary, Portfolio Human Research Ethics Sub Committee, Business Portfolio, RMIT, GPO Box 2476V, Melbourne, 3001. The telephone number is (03) 9925 5594 or e-mail address rdu@rmit.edu.au. Details of the complaints procedure are available from the above address or http://ww.rmit.edu.au/council/hrec

10.3 Appendix C: Questionnaire Sent to Retailer Participants

Survey II Retailer

Questionnaire

A Study of the Impact of Radio Frequency Identification Technology (RFID) on Retail Supply Chain Performance

Instructions

Thank you for your consent to complete this survey. Please read the information provided at the beginning of each section and follow the instructions. Please answer all questions. This questionnaire should take approximately 30 minutes to complete.

Important Note: In this survey we define Radio Frequency Identification Technology (RFID) as technologies associated with EPCGlobal's RFID enabled network. Please answer questions about RFID in this context.

Results: If you would like to receive the results of this survey, please request a copy to the following e-mail address: S3176669@student.rmit.edu.au

Stephen Waters
School of Management
RMIT University

Part A.
Organisational Characteristics

The following questions in part A relate to characteristics of your organisation. Please tick against the most appropriate statement or write a brief statement where appropriate.

1. Which category best describes the main purpose of your organisation?

Product Group	**If relevant, tick more than one group ✓**
Grocery	
Fast Moving Consumer Goods (FMCG)	
Furniture	
White Goods	
Brown Goods	
Other (Please specify):	

2. Which statement best describes your position within the organisation?

	✓				
CEO		Supply Chain Manager		Information Technology Manager	
Managing Director		Logistics Manager		Business Systems Manager	
Retail Store Manager		Warehouse Manager		Inventory Manager	
General Manager		Operations Manager		e-Business Manager	
Other (Please specify):					

3. How many people does your organisation employ? Please tick the relevant size.

Organisational Size	✓
Employing less than 20 people	
Employing 20 or more people, but less than 200	
Employing 200 or more people, but less than 300	
Employing 300 or more people, but less than 400	
Employing 400 or more people, but less than 500	
Employing more than 500 people	

4. What is the turnover of your organisation? Please tick the relevant turnover.

Organisational Turnover	✓
Less than $25K	
$25K to less than $50K	
$50K to less than $75K	
$75K to less than $100K	
$100K to less than $150K	
$150K to less than $200K	
$200K to less than $500K	
$500K to less than $1M	
$1M to less than $2M	
$2M to less than $5M	
$5M to less than $10M	
$10M to less than $20M	
$20M to less than $50M	
$50M to less than $200M	
More than $200M	

5. Please nominate the major geographic location for your operations. Please tick the relevant locations.

Geographic Location	✓
State	
Australia	
Regional	
International	

6. Please nominate the level at which your organisation is considering adopting RFID technology?

Considering adopting RFID technology	✓
Have not considered RFID yet	
Spoken informally about RFID	
Formally investigated RFID	
Planning to launch a RFID pilot	
Currently running a RFID pilot	
Have completed a pilot and will not be implementing RFID	
Have completed a pilot and planning to implement RFID	
Currently implementing RFID	

Part B The Organisation's Use of Information Technology

The following question in Part B relates to your organisation's information technology (IT).

7. What is the extent of information technology supported by your organisation? Please tick the relevant **technologies used** in your organisation.

Information Technology **To what extent are the following products or technologies supported by your organisation?**	
If relevant, tick more than one product/technology	☐✓
• Enterprise Resource Planning	
• CRM Systems	
• Supply chain planning software	
• Data warehouse	
• Business Intelligence tools	
• Web services	
• Content management software	
• Product life cycle management software	
• Electronic data interchange (EDI XML/EDI)	
• Advance planning and scheduling system	
• Advanced shipment notification	
• Bar-coding	
• Portal technologies	
• RF communication	
• Voice input interfaces	
• RFID hardware	
• RFID software	
• RFID readers	
• RFID infrastructure	
• RFID tags	
• Extranets	
• Intranets	
• Satellite communication	
• Decision support system	
• Other (Please specify):	

Part C. Technological Factors Impacting RFID Adoption

The questions in part C relate to your perspectives about technological variables that impact on RFID adoption.

8. With respect to EPCGlobal's RFID network please address the following statements in relation to **technological compatibility**. Please circle the appropriate number for each statement.

	Technological factors ***Compatibility***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1.	RFID technology is compatible with my organisation's current hardware and software investment	1	2	3	4	5	6	7
2.	RFID technology is compatible with my organisation's information and communication technology (ICT)	1	2	3	4	5	6	7
3.	Employees at my organisation do not fear potential job losses that may result from adoption of RFID technologies	1	2	3	4	5	6	7
4.	Employees at my organisation do not fear the adoption of RFID technologies because they may currently lack the skills to use these technologies	1	2	3	4	5	6	7
5.	RFID technology is acceptable to my organisation because there is an agreed set of global standards in place	1	2	3	4	5	6	7
6.	Implementing changes due to the new RFID technologies is compatible with our firm's values and beliefs	1	2	3	4	5	6	7
7.	RFID is compatible with our experience with similar systems	1	2	3	4	5	6	7
8.	Compatibility of hardware and software among potential trading partners will be critical to the success of RFID implementation	1	2	3	4	5	6	7
9.	The ability to integrate RFID with existing information systems is critical to success	1	2	3	4	5	6	7

9. With respect to EPCGlobal's RFID network, please address the following statements in relation to **technological complexity**. Please circle the appropriate number for each statement.

	Technological factors *Complexity*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1.	RFID technology will be very difficult to integrate into my organisation	1	2	3	4	5	6	7
2.	The skills needed to implement RFID technology are too complex for my organisation	1	2	3	4	5	6	7
3.	The skills required to use RFID are too complex for our employees	1	2	3	4	5	6	7
4.	RFID is conceptually difficult to understand from a technical perspective	1	2	3	4	5	6	7
5.	RFID is conceptually difficult to understand from a business perspective	1	2	3	4	5	6	7
6.	It is difficult to understand and visualise RFID in the whole process in our organisation	1	2	3	4	5	6	7
7.	It will be difficult to make organisational changes to accommodate the introduction of RFID technology	1	2	3	4	5	6	7

10. With respect to EPCGlobal’s RFID network please address the following statements in relation to **technological standards**. Please circle the appropriate number for each statement.

	Technological factors ***Standards***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1.	The work done by standards making bodies make it easier to consider using RFID technology	1	2	3	4	5	6	7
2.	Standards will assure the performance of RFID technology	1	2	3	4	5	6	7
3.	Standards enable compatibility between future technologies	1	2	3	4	5	6	7
4.	Standards enable greater integration with trading partners when considering RFID technology	1	2	3	4	5	6	7
5.	Dominant customers have the ability to drive standards	1	2	3	4	5	6	7
6.	Widely accepted RFID standards will be critical to the success of RFID technology implementation	1	2	3	4	5	6	7
7.	Organisations adopt standards to enable better integration across applications	1	2	3	4	5	6	7
8.	Frequency standards are globally harmonised for use with RFID technology	1	2	3	4	5	6	7
9.	Numbering standards are globally harmonised for use with RFID technology	1	2	3	4	5	6	7

11. With respect to EPCGlobal's RFID network, please address the following statements in relation to **relative advantage**. Please circle the appropriate number for each statement.

	Technological factors *Relative Advantage*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1.	RFID technology would be more advantageous to my organisation than barcodes	1	2	3	4	5	6	7
2.	RFID technology will afford my organisation better visibility of our inventory	1	2	3	4	5	6	7
3.	The benefits of adopting RFID will be greater than the costs	1	2	3	4	5	6	7
4.	RFID technology will provide timely and accurate information for decision-making	1	2	3	4	5	6	7
5.	RFID technology will enhance the effectiveness and efficiency of my organisation	1	2	3	4	5	6	7
6.	It would be less expensive to conduct business with several trading partners utilising RFID than using barcodes	1	2	3	4	5	6	7
7.	RFID will enable the organisation to cut costs in our operations	1	2	3	4	5	6	7
8.	Implementing RFID will increase the profitability of our business	1	2	3	4	5	6	7

Part D.

Economic Factors Impacting RFID Adoption

The questions in part D relate to your perspectives about economic variables that impact on RFID adoption.

12. With respect to EPCGlobal's RFID network, please address the following statements in relation to **economic factors**. Please circle the appropriate number for each statement.

	Economic factors ***Hardware and Software Costs, Tag costs, Implementation Costs and Training Costs***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1.	The costs of implementing RFID will be high.	1	2	3	4	5	6	7
2.	The cost of hardware resources required to support RFID systems will be high.	1	2	3	4	5	6	7
3.	The cost of software resources required to support RFID systems will be high	1	2	3	4	5	6	7
4.	Initial investment in RFID will be high	1	2	3	4	5	6	7
5.	Organisations have high investment in existing systems	1	2	3	4	5	6	7
6.	The costs (time and money) of training in RFID technology will be high	1	2	3	4	5	6	7
7.	The costs of integrating RFID with other information systems will be high	1	2	3	4	5	6	7
8.	The costs of supporting RFID technology will be high for organisations	1	2	3	4	5	6	7

Part E.

Organisational Factors Impacting RFID Adoption

The questions in part E relate to your perspectives about organisational variables that impact on RFID adoption.

13. With respect to EPCGlobal's RFID network please address the following statements in relation to **top management support**. Please circle the appropriate number for each statement.

	Organisational factors *Top Management Support*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1.	Top management provides strong and involved leadership when it comes to information systems in my organisation	1	2	3	4	5	6	7
2.	Top management would support the implementation of RFID technology in my organisation	1	2	3	4	5	6	7
3.	Top management has a desire to portray my organisation as a leader in the use of information technology	1	2	3	4	5	6	7
4.	Top management is willing to take the risk (financial and organisational) involved in adopting RFID technology	1	2	3	4	5	6	7
5.	Top management has established clear goals and a clear picture of how RFID technology might help these goals	1	2	3	4	5	6	7
6.	Top management understands the potential opportunities from adopting RFID in my organisation	1	2	3	4	5	6	7
7.	Top management is interested in RFID technology in my organisation	1	2	3	4	5	6	7
8.	Top management understands the importance of RFID	1	2	3	4	5	6	7
9.	Top management considers RFID a potential strategic resource in my organisation	1	2	3	4	5	6	7

14. With respect to EPCGlobal's RFID network please address the following statements in relation to **information technology investment.** Please circle the appropriate number for each statement.

	Organisational factors *Information Technology (IT) investment*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1.	The IT department within my organisation has sufficient expertise to implement and integrate RFID technology	1	2	3	4	5	6	7
2.	My organisation will be able to adapt to the process and informational needs of RFID technology	1	2	3	4	5	6	7
3.	My organisation is willing to train employees to implement and maintain RFID technology	1	2	3	4	5	6	7
4.	I feel comfortable with the level of external support available for RFID technology	1	2	3	4	5	6	7
5.	Our organisation often adopts IT as a component for an information based innovation	1	2	3	4	5	6	7
6.	Technology/solution vendors have an influence over my organisation's ICT decisions	1	2	3	4	5	6	7
7.	Our organisation's IT department is encouraged to learn about new technologies	1	2	3	4	5	6	7
8.	Our organisation has a willingness to invest in IT relative to our revenues	1	2	3	4	5	6	7
9.	Our organisation's IT department closely follow trends in new technologies	1	2	3	4	5	6	7

Part F.

External Environmental Factors Impacting RFID Adoption

The questions in part F relate to your perspectives about external environmental variables that impact on RFID adoption.

15. With respect to EPCGlobal's RFID network please address the following statements in relation to security. Please circle the appropriate number for each statement.

	External Environmental factors ***Security***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1.	Designing appropriate and dependable security and auditing processes for transmitting data will be critical to the success of RFID implementation	1	2	3	4	5	6	7
2.	Internet security is a major concern to our firm when deciding to adopt RFID based business-to-business transactions	1	2	3	4	5	6	7
3.	The nature of the business data regularly exchanged between our firm and our trading partners requires a secured communication medium	1	2	3	4	5	6	7
4.	Data exchanged during the transaction when using RFID must be accurate.	1	2	3	4	5	6	7
5.	Data exchanged when using RFID must be restricted to legitimate users only.	1	2	3	4	5	6	7
6.	My organisations is aware of the importance of information technology security	1	2	3	4	5	6	7
7.	Information security compliance, enforcement and monitoring is essential for RFID success	1	2	3	4	5	6	7

16. With respect to EPCGlobal's RFID network, please address the following statements in relation to RFID **industry forces.** Please circle the appropriate number for each statement.

	External Environmental factors ***Industry Forces***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1.	My organisation's biggest competitors are planning to adopt RFID technology in their facilities	1	2	3	4	5	6	7
2.	My organisation will be at a competitive disadvantage if it does not implement RFID technology	1	2	3	4	5	6	7
3.	My organisation reacts to what our competitors are doing in terms of information and communication technology (ICT)	1	2	3	4	5	6	7
4.	We will lose customers to our competitors if we do not adopt RFID technologies	1	2	3	4	5	6	7
5.	It is a strategic necessity to use RFID technologies to compete in the marketplace	1	2	3	4	5	6	7
6.	An industry move to utilise RFID inter-organisational communications would put pressure on my firm to do the same	1	2	3	4	5	6	7
7.	The pressure to adopt RFID placed on our organisation by our competitors is high	1	2	3	4	5	6	7

17. With respect to EPCGlobal's RFID network, please address the following statements in relation to RFID **privacy**. Please circle the appropriate number for each statement.

	External Environmental factors *Consumer Privacy*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1.	It is unlikely that someone will use RFID to steal my personal information	1	2	3	4	5	6	7
2.	It is unlikely that my privacy will be violated as a result of RFID	1	2	3	4	5	6	7
3.	Minimal harm would be done if someone broke into RFID databases containing my private personal information	1	2	3	4	5	6	7
4.	Minimal harm would be done if an organisation that employs RFID abused my information	1	2	3	4	5	6	7
5.	Minimal harm would be done if consumers' personal information is stolen because of RFID	1	2	3	4	5	6	7
6.	If given the choice between a RFID product and a non-RFID product, I would choose the product that was tagged with RFID.	1	2	3	4	5	6	7
7.	Organisations must inform shoppers fully about the collection of consumer purchasing and profile information via RFID tags and how collected information will be used	1	2	3	4	5	6	7

Part G.

Organisational Readiness Impacting RFID Adoption Intention

The questions in part G relate to your perspectives about organisational readiness variables that impact on RFID adoption.

18. With respect to EPCGlobal's RFID network, please address the following statements in relation to **organisational readiness.** Please circle the appropriate number for each statement.

	Organisational Readiness	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1.	The organisation has access to financial resources to pay for implementation expenses	1	2	3	4	5	6	7
2.	The organisation has access to financial resources to pay for enhancement and ongoing expenses	1	2	3	4	5	6	7
3.	The organisation has access to the required technological resources for implementing RFID technology	1	2	3	4	5	6	7
4.	The organisation has access to the required technological resources for maintaining RFID technology	1	2	3	4	5	6	7
5.	The organisation is culturally ready to implement RFID technology	1	2	3	4	5	6	7
6.	The organisation places importance in accessing information about emerging technologies	1	2	3	4	5	6	7
7.	The organisation has systems in place to facilitate changes that may occur as the result of adopting RFID	1	2	3	4	5	6	7
8.	The organisation has been involved in similar information technology projects	1	2	3	4	5	6	7
9.	The organisation is not intimidated by technology	1	2	3	4	5	6	7

Part H.

Retail Supply Chain Performance

The following questions in Part H relate to your perspectives about the potential impact of RFID on retail supply chain performance.

19. With respect to EPCGlobal's RFID network, please address the following statements in relation to the impact of RFID on retail **supply chain performance**. Please circle the appropriate number for each statement.

	Retail Supply Chain Performance ***RFID will provide…***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
1.	Higher shipping and receiving productivity	1	2	3	4	5	6	7
2.	Increased order accuracy	1	2	3	4	5	6	7
3.	Better returns processing	1	2	3	4	5	6	7
4.	Improved materials receipts accuracy	1	2	3	4	5	6	7
5.	Better inventory management	1	2	3	4	5	6	7
6.	Better receiving labour productivity	1	2	3	4	5	6	7
7.	Better asset use through tracking of vehicles	1	2	3	4	5	6	7
8.	Better reusable container control	1	2	3	4	5	6	7
9.	Visibility of high-value assets	1	2	3	4	5	6	7
10.	Improved recall management	1	2	3	4	5	6	7
11.	Improved tracking and traceability of inventory	1	2	3	4	5	6	7
12.	Better expiration date management	1	2	3	4	5	6	7
13.	Improvements in shrink	1	2	3	4	5	6	7
14.	Reduction in inventory and working capital	1	2	3	4	5	6	7
15.	Improved revenue through reduction in out-of-stocks	1	2	3	4	5	6	7
16.	Reduced expediting costs	1	2	3	4	5	6	7
17.	Higher product availability	1	2	3	4	5	6	7

10.4 Appendix D: Questionnaire Sent to Supplier Participants

Survey III Supplier Questionnaire

A Study of the Impact of Radio Frequency Identification Technology (RFID) on Retail Supply Chain Performance

Instructions

Thank you for your consent to complete this survey. Please read the information provided at the beginning of each section and follow the instructions. Please answer all questions. This questionnaire should take approximately 30 minutes to complete.

Important Note: In this survey we define Radio Frequency Identification Technology (RFID) as technologies associated with EPCGlobal's RFID enabled network. Please answer questions about RFID in this context.

Results: If you would like to receive the results of this survey, please request a copy to the following email address: S3176669@student.rmit.edu.au

Stephen Waters
School of Management
RMIT University

Part A.

Organisational Characteristics

The following questions in part A relate to characteristics of your organisation. Please tick against the most appropriate statement or write a brief statement where appropriate.

1. Which category best describes the main purpose of your organisation?

Product Group	**If relevant, tick more than one group ✓**
Grocery	
Fast Moving Consumer Goods (FMCG)	
Furniture	
White Goods	
Brown Goods	
Other (Please specify):	

2. Which statement best describes your position within the organisation?

	✓				
CEO		Supply Chain Manager		Information Technology Manager	
Managing Director		Logistics Manager		Business Systems Manager	
Business Development Manager		Warehouse Manager		Inventory Manager	
General Manager		Operations Manager		e-Business Manager	
Other (Please specify):					

3. How many people does your organisation employ? Please tick the relevant size.

Organisational Size	✓
Employing less than 20 people	
Employing 20 or more people, but less than 200	
Employing 200 or more people, but less than 300	
Employing 300 or more people, but less than 400	
Employing 400 or more people, but less than 500	
Employing more than 500 people	

4. What is the turnover of your organisation? Please tick the relevant turnover.

Organisational Turnover	✓
Less than $25K	
$25K to less than $50K	
$50K to less than $75K	
$75K to less than $100K	
$100K to less than $150K	
$150K to less than $200K	
$200K to less than $500K	
$500K to less than $1M	
$1M to less than $2M	
$2M to less than $5M	
$5M to less than $10M	
$10M to less than $20M	
$20M to less than $50M	
$50M to less than $200M	
More than $200M	

5. Please nominate the major geographic location for your operations. Please tick the relevant locations.

Geographic Location	✓
State	
Australia	
Regional	
International	

6. Please nominate the level at which your organisation is considering adopting RFID technology?

Considering adopting RFID technology	✓
Have not considered RFID yet	
Spoken informally about RFID	
Formally investigated RFID	
Planning to launch a RFID pilot	
Currently running a RFID pilot	
Have completed a pilot and will not be implementing RFID	
Have completed a pilot and planning to implement RFID	
Currently implementing RFID	

Part B The Organisation's Use of Information Technology

The following question in Part B relates to your organisation's information technology (IT).

7. What is the extent of information technology supported by your organisation? Please tick the relevant **technologies used** in your organisation.

Information Technology **To what extent are the following products or technologies supported by your organization?**	
If relevant, tick more than one product/technology	☐✓
• Enterprise Resource Planning	
• CRM Systems	
• Supply chain planning software	
• Data warehouse	
• Business Intelligence tools	
• Web services	
• Content management software	
• Product lifecycle management software	
• Electronic data interchange (EDI XML/EDI)	
• Advance planning and scheduling system	
• Advanced shipment notification	
• Bar-coding	
• Portal technologies	
• RF communication	
• Voice input interfaces	
• RFID hardware	
• RFID software	
• RFID readers	
• RFID infrastructure	
• RFID tags	
• Extranets	
• Intranets	
• Satellite communication	
• Decision support system	
• Other (Please specify):	

Part C.

Technological Factors Impacting RFID Adoption

The questions in part C relate <u>to your perspectives about technological variables that impact on RFID adoption.</u>

8. With respect to EPCGlobal's RFID network please address the following statements in relation to **technological compatibility**. Please circle the appropriate number for each statement.

	Technological factors *Compatibility*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
10.	RFID technology is compatible with my organisation's current hardware and software investment	1	2	3	4	5	6	7
11.	RFID technology is compatible with my organisation's information and communication technology (ICT)	1	2	3	4	5	6	7
12.	Employees at my organisation do not fear potential job losses that may result from adoption of RFID technologies	1	2	3	4	5	6	7
13.	Employees at my organisation do not fear the adoption of RFID technologies because they may currently lack the skills to use these technologies	1	2	3	4	5	6	7
14.	RFID technology is acceptable to my organisation because there is an agreed set of global standards in place	1	2	3	4	5	6	7
15.	Implementing changes due to the new RFID technologies is compatible with our firm's values and beliefs	1	2	3	4	5	6	7
16.	RFID is compatible with our experience with similar systems	1	2	3	4	5	6	7
17.	Compatibility of hardware and software among potential trading partners will be critical to the success of RFID implementation	1	2	3	4	5	6	7
18.	The ability to integrate RFID with existing information systems is critical to success	1	2	3	4	5	6	7

9. With respect to EPCGlobal's RFID network, please address the following statements in relation to **technological complexity**. Please circle the appropriate number for each statement.

	Technological factors *Complexity*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
8.	RFID technology will be very difficult to integrate into my organisation	1	2	3	4	5	6	7
9.	The skills needed to implement RFID technology are too complex for my organisation	1	2	3	4	5	6	7
10.	The skills required to use RFID are too complex for our employees	1	2	3	4	5	6	7
11.	RFID is conceptually difficult to understand from a technical perspective	1	2	3	4	5	6	7
12.	RFID is conceptually difficult to understand from a business perspective	1	2	3	4	5	6	7
13.	It is difficult to understand and visualise RFID in the whole process in our organisation	1	2	3	4	5	6	7
14.	It will be difficult to make organisational changes to accommodate the introduction of RFID technology	1	2	3	4	5	6	7

10. With respect to EPCGlobal's RFID network please address the following statements in relation to **technological standards**. Please circle the appropriate number for each statement.

	Technological factors ***Standards***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
10.	The work done by standards making bodies make it easier to consider using RFID technology	1	2	3	4	5	6	7
11.	Standards will assure the performance of RFID technology	1	2	3	4	5	6	7
12.	Standards enable compatibility between future technologies	1	2	3	4	5	6	7
13.	Standards enable greater integration with trading partners when considering RFID technology	1	2	3	4	5	6	7
14.	Dominant customers have the ability to drive standards	1	2	3	4	5	6	7
15.	Widely accepted RFID standards will be critical to the success of RFID technology implementation	1	2	3	4	5	6	7
16.	Organisations adopt standards to enable better integration across applications	1	2	3	4	5	6	7
17.	Frequency standards are globally harmonised for use with RFID technology	1	2	3	4	5	6	7
18.	Numbering standards are globally harmonised for use with RFID technology	1	2	3	4	5	6	7

11. With respect to EPCGlobal's RFID network, please address the following statements in relation to **relative advantage**. Please circle the appropriate number for each statement.

	Technological factors *Relative Advantage*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
9.	RFID technology would be more advantageous to my organisation than barcodes	1	2	3	4	5	6	7
10.	RFID technology will afford my organisation better visibility of our inventory	1	2	3	4	5	6	7
11.	The benefits of adopting RFID will be greater than the costs	1	2	3	4	5	6	7
12.	RFID technology will provide timely and accurate information for decision making	1	2	3	4	5	6	7
13.	RFID technology will enhance the effectiveness and efficiency of my organisation	1	2	3	4	5	6	7
14.	It would be less expensive to conduct business with several trading partners utilising RFID than using barcodes	1	2	3	4	5	6	7
15.	RFID will enable the organisation to cut costs in our operations	1	2	3	4	5	6	7
16.	Implementing RFID will increase the profitability of our business	1	2	3	4	5	6	7

Part D.

Economic Factors Impacting RFID Adoption

The questions in part D relate <u>to your perspectives about economic variables that impact on RFID adoption.</u>

12. With respect to EPCGlobal's RFID network, please address the following statements in relation to **economic factors**. Please circle the appropriate number for each statement.

	Economic factors *Hardware and Software Costs, Tag costs, Implementation Costs and Training Costs*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
9.	The costs of implementing RFID will be high.	1	2	3	4	5	6	7
10.	The cost of hardware resources required to support RFID systems will be high.	1	2	3	4	5	6	7
11.	The cost of software resources required to support RFID systems will be high	1	2	3	4	5	6	7
12.	Initial investment in RFID will be high	1	2	3	4	5	6	7
13.	Organisations have high investment in existing systems	1	2	3	4	5	6	7
14.	The costs (time and money) of training in RFID technology will be high	1	2	3	4	5	6	7
15.	The costs of integrating RFID with other information systems will be high	1	2	3	4	5	6	7
16.	The costs of supporting RFID technology will be high for organisations	1	2	3	4	5	6	7

Part E.

Organisational Factors Impacting RFID Adoption

The questions in part E relate to your perspectives about organisational variables that impact on RFID adoption.

13. With respect to EPCGlobal's RFID network please address the following statements in relation to **top management support**. Please circle the appropriate number for each statement.

	Organisational factors *Top Management Support*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
10.	Top management provides strong and involved leadership when it comes to information systems in my organisation	1	2	3	4	5	6	7
11.	Top management would support the implementation of RFID technology in my organisation	1	2	3	4	5	6	7
12.	Top management has a desire to portray my organisation as a leader in the use of information technology	1	2	3	4	5	6	7
13.	Top management is willing to take the risk (financial and organisational) involved in adopting RFID technology	1	2	3	4	5	6	7
14.	Top management has established clear goals and a clear picture of how RFID technology might help these goals	1	2	3	4	5	6	7
15.	Top management understands the potential opportunities from adopting RFID in my organisation	1	2	3	4	5	6	7
16.	Top management is interested in RFID technology in my organisation	1	2	3	4	5	6	7
17.	Top management understands the importance of RFID	1	2	3	4	5	6	7
18.	Top management considers RFID a potential strategic resource in my organisation	1	2	3	4	5	6	7

14. With respect to EPCGlobal’s RFID network please address the following statements in relation to **information technology investment.** Please circle the appropriate number for each statement.

	Organisational factors *Information Technology (IT) investment*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
10.	The IT department within my organisation has sufficient expertise to implement and integrate RFID technology	1	2	3	4	5	6	7
11.	My organisation will be able to adapt to the process and informational needs of RFID technology	1	2	3	4	5	6	7
12.	My organisation is willing to train employees to implement and maintain RFID technology	1	2	3	4	5	6	7
13.	I feel comfortable with the level of external support available for RFID technology	1	2	3	4	5	6	7
14.	Our organisation often adopts IT as a component for an information based innovation	1	2	3	4	5	6	7
15.	Technology/solution vendors have an influence over my organisation’s ICT decisions	1	2	3	4	5	6	7
16.	Our organisation’s IT department is encouraged to learn about new technologies	1	2	3	4	5	6	7
17.	Our organisation has a willingness to invest in IT relative to our revenues	1	2	3	4	5	6	7
18.	Our organisation’s IT department closely follow trends in new technologies	1	2	3	4	5	6	7

Part F.

External Environmental Factors Impacting RFID Adoption

The questions in part F relate to your perspectives about external environmental variables that impact on RFID adoption.

15. With respect to EPCGlobal's RFID network please address the following statements in relation to security. Please circle the appropriate number for each statement.

	External Environmental factors ***Security***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
8.	Designing appropriate and dependable security and auditing processes for transmitting data will be critical to the success of RFID implementation	1	2	3	4	5	6	7
9.	Internet security is a major concern to our firm when deciding to adopt RFID based business-to-business transactions	1	2	3	4	5	6	7
10.	The nature of the business data regularly exchanged between our firm and our trading partners requires a secured communication medium	1	2	3	4	5	6	7
11.	Data exchanged during the transaction when using RFID must be accurate.	1	2	3	4	5	6	7
12.	Data exchanged when using RFID must be restricted to legitimate users only.	1	2	3	4	5	6	7
13.	My organisations is aware of the importance of information technology security	1	2	3	4	5	6	7
14.	Information security compliance, enforcement and monitoring is essential for RFID success	1	2	3	4	5	6	7

16. With respect to EPCGlobal's RFID network, please address the following statements in relation to RFID **industry forces.** Please circle the appropriate number for each statement.

	External Environmental factors *Industry Forces*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
8.	My organisation's biggest competitors are planning to adopt RFID technology in their facilities	1	2	3	4	5	6	7
9.	My organisation will be at a competitive disadvantage if it does not implement RFID technology	1	2	3	4	5	6	7
10.	My organisation reacts to what our competitors are doing in terms of information and communication technology (ICT)	1	2	3	4	5	6	7
11.	We will lose customers to our competitors if we do not adopt RFID technologies	1	2	3	4	5	6	7
12.	It is a strategic necessity to use RFID technologies to compete in the market place	1	2	3	4	5	6	7
13.	An industry move to utilize RFID interorganizational communications would put pressure on my firm to do the same	1	2	3	4	5	6	7
14.	The pressure to adopt RFID placed on our organisation by our competitors is high	1	2	3	4	5	6	7

17. With respect to EPCGlobal's RFID network, please address the following statements in relation to RFID **privacy**. Please circle the appropriate number for each statement.

	External Environmental factors ***Consumer Privacy***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
8.	It is unlikely that someone will use RFID to steal my personal information	1	2	3	4	5	6	7
9.	It is unlikely that my privacy will be violated as a result of RFID	1	2	3	4	5	6	7
10.	Minimal harm would be done if someone broke into RFID databases containing my private personal information	1	2	3	4	5	6	7
11.	Minimal harm would be done if an organization that employs RFID abused my information	1	2	3	4	5	6	7
12.	Minimal harm would be done if consumers' personal information is stolen because of RFID	1	2	3	4	5	6	7
13.	If given the choice between a RFID product and a non-RFID product, I would choose the product that was tagged with RFID.	1	2	3	4	5	6	7
14.	Organisations must inform shoppers fully about the collection of consumer purchasing and profile information via RFID tags and how collected information will be used	1	2	3	4	5	6	7

Part G.

Organisational Readiness Impacting RFID Adoption Intention

The questions in part G relate to your perspectives about organisational readiness variables that impact on RFID adoption.

18. With respect to EPCGlobal's RFID network, please address the following statements in relation to **organisational readiness.** Please circle the appropriate number for each statement.

	Organisational Readiness	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
10.	The organisation has access to financial resources to pay for implementation expenses	1	2	3	4	5	6	7
11.	The organisation has access to financial resources to pay for enhancement and ongoing expenses	1	2	3	4	5	6	7
12.	The organisation has access to the required technological resources for implementing RFID technology	1	2	3	4	5	6	7
13.	The organisation has access to the required technological resources for maintaining RFID technology	1	2	3	4	5	6	7
14.	The organisation is culturally ready to implement RFID technology	1	2	3	4	5	6	7
15.	The organisation places importance in accessing information about emerging technologies	1	2	3	4	5	6	7
16.	The organisation has systems in place to facilitate changes that may occur as the result of adopting RFID	1	2	3	4	5	6	7
17.	The organisation has been involved in similar information technology projects	1	2	3	4	5	6	7
18.	The organisation is not intimidated by technology	1	2	3	4	5	6	7

Part H.

Retail Supply Chain Performance

The following questions in Part H relate to your perspectives about the potential impact of RFID on retail supply chain performance.

19. With respect to EPCGlobal's RFID network, please address the following statements in relation to the impact of RFID on retail **supply chain performance**. Please circle the appropriate number for each statement.

	Retail Supply Chain Performance ***RFID will provide…***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
18.	Higher shipping and receiving productivity	1	2	3	4	5	6	7
19.	Increased order accuracy	1	2	3	4	5	6	7
20.	Better returns processing	1	2	3	4	5	6	7
21.	Improved materials receipts accuracy	1	2	3	4	5	6	7
22.	Better inventory management	1	2	3	4	5	6	7
23.	Better receiving labour productivity	1	2	3	4	5	6	7
24.	Better asset use through tracking of vehicles	1	2	3	4	5	6	7
25.	Better reusable container control	1	2	3	4	5	6	7
26.	Visibility of high-value assets	1	2	3	4	5	6	7
27.	Improved recall management	1	2	3	4	5	6	7
28.	Improved tracking and traceability of inventory	1	2	3	4	5	6	7
29.	Better expiration date management	1	2	3	4	5	6	7
30.	Improvements in shrink	1	2	3	4	5	6	7
31.	Reduction in inventory and working capital	1	2	3	4	5	6	7
32.	Improved revenue through reduction in out-of-stocks	1	2	3	4	5	6	7
33.	Reduced expediting costs	1	2	3	4	5	6	7
34.	Higher product availability	1	2	3	4	5	6	7

10.5 Appendix E: Questionnaire Sent to Technology Provider Participants

Survey IV RFID Technology/Solutions Provider Questionnaire

A Study of the Impact of Radio Frequency Identification Technology (RFID) on Retail Supply Chain Performance

Instructions

Thank you for your consent to complete this survey. Please read the information provided at the beginning of each section and follow the instructions. Please answer all questions. This questionnaire should take approximately 30 minutes to complete.

Important Note: In this survey we define Radio Frequency Identification Technology (RFID) as technologies associated with EPCGlobal's RFID enabled network. Please answer questions about RFID in this context.

Results: If you would like to receive the results of this survey, please request a copy to the following email address: S3176669@student.rmit.edu.au

Stephen Waters

School of Management

RMIT University

Part A.
Organisational Characteristics

The following questions in part A relate to characteristics of your organisation and the customers your organisation serves. Please tick against the most appropriate statement or write a brief statement where appropriate.

1. Which category best describes the main purpose of your organisation.

Product Group	**If relevant , tick more than one group** ✓
Hardware supplier	
Software supplier	
Tags and labels supplier	
Consulting	
Education	
Training	
Regulation	
Other (Please specify):	

2. Which statement best describes your position within the organisation?

	✓				
CEO		e-Business Manager		Information Technology Manager	
Managing Director		Business Development Manager		Business Systems Manager	
General Manager		Operations Manager			
Other (Please specify):					

3. How many people does your organisation employ? Please tick the relevant size.

Organisational Size	✓
Employing less than 20 people	
Employing 20 or more people, but less than 200	
Employing 200 or more people, but less than 300	
Employing 300 or more people, but less than 400	
Employing 400 or more people, but less than 500	
Employing more than 500 people	

4. What is the turnover of your organisation? Please tick the relevant turnover.

Organisational Turnover	✓
Less than $25K	
$25K to less than $50K	
$50K to less than $75K	
$75K to less than $100K	
$100K to less than $150K	
$150K to less than $200K	
$200K to less than $500K	
$500K to less than $1M	
$1M to less than $2M	
$2M to less than $5M	
$5M to less than $10M	
$10M to less than $20M	
$20M to less than $50M	
$50M to less than $200M	
More than $200M	

5. Please nominate the major geographic location for your operations. Please tick the relevant locations.

Geographic Location	✓
State	
Australia	
Regional	
International	

6. With regards your perspectives of the retail industry, please nominate by percentage the level by which you believe organisations within retail supply chains are considering adopting RFID technology?

Considering adopting RFID technology	**%**
Have not considered RFID yet	
Spoken informally about RFID	
Formally investigated RFID	
Planning to launch a RFID pilot	
Currently running a RFID pilot	
Have completed a pilot and will not be implementing RFID	
Have completed a pilot and planning to implement RFID	
Currently implementing RFID	

Part B.
The Organisation's Use of Information Technology

The following question in Part B relates to your organisation's manufacturing, sales, marketing, consulting, education and regulation of the following information technology (IT).

7. To what extent does your organisation support the following information technology? Please tick the relevant **technologies supported**.

Information Technology **To what extent are the following products or technologies supported by your organization?**	
	If relevant, tick more than one product/technology ✓
• Enterprise Resource Planning	
• CRM Systems	
• Supply chain planning software	
• Data warehouse	
• Business Intelligence tools	
• Web services	
• Content management software	
• Product lifecycle management software	
• Electronic data interchange (EDI XML/EDI)	
• Advance planning and scheduling system	
• Advanced shipment notification	
• Bar-coding	
• Portal technologies	
• RF communication	
• Voice input interfaces	
• RFID hardware	
• RFID software	
• RFID readers	
• RFID infrastructure	
• RFID tags	
• Extranets	
• Intranets	
• Satellite communication	
• Decision support system	
• Other (Please specify):	

Part C.
Technological Factors Impacting RFID Adoption

The questions in part C relate to your perspectives about technological variables that impact on RFID adoption within the Retail Supply Chain.

8. With respect to EPCGlobal's RFID network please address the following statements in relation to **technological compatibility**. Please circle the appropriate number for each statement.

	Technological factors ***Compatibility***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
19.	RFID technology is compatible with current hardware and software investment	1	2	3	4	5	6	7
20.	RFID technology is compatible with information and communication technology (ICT)	1	2	3	4	5	6	7
21.	Our customer's employees do not fear potential job losses that may result from adoption of RFID technologies	1	2	3	4	5	6	7
22.	Our customer's employees do not fear the adoption of RFID technologies because they may currently lack the skills to use these technologies	1	2	3	4	5	6	7
23.	RFID technology is acceptable because there is an agreed set of global standards in place	1	2	3	4	5	6	7
24.	Implementing changes due to the new RFID technologies is compatible with our customer's values and beliefs	1	2	3	4	5	6	7
25.	RFID is compatible with our customer's experience with similar systems	1	2	3	4	5	6	7
26.	Compatibility of hardware and software among potential trading partners will be critical to the success of RFID implementation	1	2	3	4	5	6	7
27.	The ability to integrate RFID with existing information systems is critical to success	1	2	3	4	5	6	7

9. With repect to EPCGlobal's RFID network, please address the following statements in relation to **technological complexity**. Please circle the appropriate number for each statement.

	Technological factors ***Complexity***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
15.	RFID technology will be very difficult to integrate into organisations	1	2	3	4	5	6	7
16.	The skills needed to implement RFID technology are too complex	1	2	3	4	5	6	7
17.	The skills required to use RFID are too complex	1	2	3	4	5	6	7
18.	RFID is conceptually difficult to understand from a technical perspective	1	2	3	4	5	6	7
19.	RFID is conceptually difficult to understand from a business perspective	1	2	3	4	5	6	7
20.	It is difficult to understand and visualise RFID in the whole process in an organisation	1	2	3	4	5	6	7
21.	It will be difficult to make organisational changes to accommodate the introduction of RFID technology	1	2	3	4	5	6	7

10. With respect to EPCGlobal's RFID network please address the following statements in relation to **technological standards**. Please circle the appropriate number for each statement.

	Technological factors ***Standards***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
19.	The work done by standards making bodies make it easier to consider using RFID technology	1	2	3	4	5	6	7
20.	Standards will assure the performance of RFID technology	1	2	3	4	5	6	7
21.	Standards enable compatibility between future technologies	1	2	3	4	5	6	7
22.	Standards enable greater integration with trading partners when considering RFID technology	1	2	3	4	5	6	7
23.	Dominant customers have the ability to drive standards	1	2	3	4	5	6	7
24.	Widely accepted RFID standards will be critical to the success of RFID technology implementation	1	2	3	4	5	6	7
25.	Organisations adopt standards to enable better integration across applications	1	2	3	4	5	6	7
26.	Frequency standards are globally harmonised for use with RFID technology	1	2	3	4	5	6	7
27.	Numbering standards are globally harmonised for use with RFID technology	1	2	3	4	5	6	7

11. With respect to EPCGlobal's RFID network, please address the following statements in relation to **relative advantage**. Please circle the appropriate number for each statement.

	Technological factors ***Relative Advantage***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
17.	RFID technology would be more advantageous than barcodes	1	2	3	4	5	6	7
18.	RFID technology will afford better visibility of inventory	1	2	3	4	5	6	7
19.	The benefits of adopting RFID will be greater than the costs	1	2	3	4	5	6	7
20.	RFID technology will provide timely and accurate information for decision making	1	2	3	4	5	6	7
21.	RFID technology will enhance the effectiveness and efficiency of organisations	1	2	3	4	5	6	7
22.	It would be less expensive to conduct business with several trading partners utilising RFID than using barcodes	1	2	3	4	5	6	7
23.	RFID will enable organisations to cut costs in operations	1	2	3	4	5	6	7
24.	Implementing RFID will increase the profitability of business	1	2	3	4	5	6	7

Part D.
Economic Factors Impacting RFID Adoption

The questions in part D relate to your perspectives about economic variables that impact on RFID adoption.

12. With respect to EPCGlobal's RFID network, please address the following statements in relation to **economic factors**. Please circle the appropriate number for each statement.

	Economic factors ***Hardware and Software Costs, Tag costs, Implementation Costs and Training Costs***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
17.	The costs of implementing RFID will be high.	1	2	3	4	5	6	7
18.	The cost of hardware resources required to support RFID systems will be high.	1	2	3	4	5	6	7
19.	The cost of software resources required to support RFID systems will be high	1	2	3	4	5	6	7
20.	Initial investment in RFID will be high	1	2	3	4	5	6	7
21.	Organisations have high investment in existing systems	1	2	3	4	5	6	7
22.	The costs (time and money) of training in RFID technology will be high	1	2	3	4	5	6	7
23.	The costs of integrating RFID with other information systems will be high	1	2	3	4	5	6	7
24.	The costs of supporting RFID technology will be high for organisations	1	2	3	4	5	6	7

Part E.
Organisational Factors Impacting RFID Adoption

The questions in part E relate <u>to your perspectives about organisational variables that impact on RFID adoption *within the retail supply chain.*</u>

13. With respect to EPCGlobal's RFID network please address the following statements in relation to **top management support** <u>within the retail supply chain.</u> Please circle the appropriate number for each statement.

	Organisational factors *Top Management Support*	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
19.	Top management provides strong and involved leadership when it comes to information technology	1	2	3	4	5	6	7
20.	Top management would support the implementation of RFID technology	1	2	3	4	5	6	7
21.	Top management has a desire to portray their organisation as a leader in the use of information technology	1	2	3	4	5	6	7
22.	Top management is willing to take the risk (financial and organisational) involved in adopting RFID technology	1	2	3	4	5	6	7
23.	Top management has established clear goals and a clear picture of how RFID technology might help these goals	1	2	3	4	5	6	7
24.	Top management understands the potential opportunities from adopting RFID	1	2	3	4	5	6	7
25.	Top management is interested in RFID technology	1	2	3	4	5	6	7
26.	Top management understands the importance of RFID	1	2	3	4	5	6	7
27.	Top management considers RFID a potential strategic resource	1	2	3	4	5	6	7

14. With respect to EPCGlobal's RFID network please address the following statements in relation to **information technology investment** within the retail supply chain**.** Please circle the appropriate number for each statement.

	Organisational factors ***Information Technology (IT) investment***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
19.	IT departments have sufficient expertise to implement and integrate RFID technology	1	2	3	4	5	6	7
20.	Organisations will be able to adapt to the process and informational needs of RFID technology	1	2	3	4	5	6	7
21.	Organisations will be willing to train employees to implement and maintain RFID technology	1	2	3	4	5	6	7
22.	Organisations feel comfortable with the level of external support available for RFID technology	1	2	3	4	5	6	7
23.	Organisations often adopt IT as a component for an information based innovation	1	2	3	4	5	6	7
24.	Technology/solution vendors have an influence over organisation's information technology and communication (ICT) decisions	1	2	3	4	5	6	7
25.	IT departments are encouraged to learn about new technologies	1	2	3	4	5	6	7
26.	Organisations have a willingness to invest in IT relative to revenues	1	2	3	4	5	6	7
27.	IT departments closely follow trends in new technologies	1	2	3	4	5	6	7

Part F.
External Environmental Factors Impacting RFID Adoption

The questions in part F relate to your perspectives about external environmental variables that impact on RFID adoption within the retail supply chain.

15. With respect to EPCGlobal's RFID network please address the following statements in relation to security within the retail supply chain. Please circle the appropriate number for each statement.

	External Environmental factors ***Security***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
15.	Designing appropriate and dependable security and auditing processes for transmitting data will be critical to the success of RFID implementation	1	2	3	4	5	6	7
16.	Internet security is a major concern when deciding to adopt RFID based business-to-business transactions	1	2	3	4	5	6	7
17.	The nature of the business data regularly exchanged between trading partners requires a secured communication medium	1	2	3	4	5	6	7
18.	Data exchanged during the transaction when using RFID must be accurate.	1	2	3	4	5	6	7
19.	Data exchanged when using RFID must be restricted to legitimate users only.	1	2	3	4	5	6	7
20.	Organisations are aware of the importance of information technology security	1	2	3	4	5	6	7
21.	Information security compliance, enforcement and monitoring is essential for RFID success	1	2	3	4	5	6	7

16. With respect to EPCGlobal's RFID network, please answer the following questions in relation to RFID **industry forces** within the retail supply chain**.** Please circle the appropriate number for each statement.

	External Environmental factors ***Industry Forces***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
15.	Organisations are planning to adopt RFID technology in their facilities	1	2	3	4	5	6	7
16.	Organisations will be at a competitive disadvantage if they do not implement RFID technology	1	2	3	4	5	6	7
17.	Organisations react to what their competitors are doing in terms of information and communication technology (ICT)	1	2	3	4	5	6	7
18.	Organisations will lose to their competitors if they do not adopt RFID technologies	1	2	3	4	5	6	7
19.	It is a strategic necessity to use RFID technologies to compete in the market place	1	2	3	4	5	6	7
20.	An industry move to utilize RFID interorganizational communications would put pressure on other organisations to do the same	1	2	3	4	5	6	7
21.	The pressure to adopt RFID placed on organisations by their competitors is high	1	2	3	4	5	6	7

17. With respect to EPCGlobal's RFID network, please address the following statements in relation to RFID **privacy** within the retail supply chain. Please circle the appropriate number for each statement.

	External Environmental factors ***Consumer Privacy***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
15.	It is unlikely that someone will use RFID to steal my personal information	1	2	3	4	5	6	7
16.	It is unlikely that my privacy will be violated as a result of RFID	1	2	3	4	5	6	7
17.	Minimal harm would be done if someone broke into RFID databases containing my private personal information	1	2	3	4	5	6	7
18.	Minimal harm would be done if an organization that employs RFID abused my information	1	2	3	4	5	6	7
19.	Minimal harm would be done if consumers' personal information is stolen because of RFID	1	2	3	4	5	6	7
20.	If given the choice between a RFID product and a non-RFID product, I would choose the product that was tagged with RFID.	1	2	3	4	5	6	7
21.	Organisations must inform shoppers fully about the collection of consumer purchasing and profile information via RFID tags and how collected information will be used	1	2	3	4	5	6	7

Part G.
Organisational Readiness Factors Impacting RFID Adoption Intention

The questions in part G relate to your perspectives about organisational readiness variables that impact on RFID adoption within the retail supply chain.

18. With respect to EPCGlobal's RFID network, please address the following statements in relation to **organisational readiness.** Please circle the appropriate number for each statement.

	Organisational Readiness *(with regards organisations operating within retail supply chains)*	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
19.	Organisations have access to financial resources to pay for implementation expenses	1	2	3	4	5	6	7
20.	Organisations have access to financial resources to pay for enhancement and ongoing expenses	1	2	3	4	5	6	7
21.	Organisations have access to the required technological resources for implementing RFID technology	1	2	3	4	5	6	7
22.	Organisations have access to the required technological resources for maintaining RFID technology	1	2	3	4	5	6	7
23.	Organisations are culturally ready to implement RFID technology	1	2	3	4	5	6	7
24.	Organisations places importance in accessing information about emerging technologies	1	2	3	4	5	6	7
25.	Organisations have systems in place to facilitate changes that may occur as the result of adopting RFID	1	2	3	4	5	6	7
26.	Organisations have been involved in similar information technology projects	1	2	3	4	5	6	7
27.	Organisations are not intimidated by technology	1	2	3	4	5	6	7

Part H.
Retail Supply Chain Performance

The following questions in Part H relate to your perspectives about the potential impact of RFID on retail supply chain performance.

19. With respect to EPCGlobal's RFID network, please address the following statements in relation to the impact of RFID on retail **supply chain performance**. Please circle the appropriate number for each statement.

	Retail Supply Chain Performance ***RFID will provide…***	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
35.	Higher shipping and receiving productivity	1	2	3	4	5	6	7
36.	Increased order accuracy	1	2	3	4	5	6	7
37.	Better returns processing	1	2	3	4	5	6	7
38.	Improved materials receipts accuracy	1	2	3	4	5	6	7
39.	Better inventory management	1	2	3	4	5	6	7
40.	Better receiving labour productivity	1	2	3	4	5	6	7
41.	Better asset use through tracking of vehicles	1	2	3	4	5	6	7
42.	Better reusable container control	1	2	3	4	5	6	7
43.	Visibility of high-value assets	1	2	3	4	5	6	7
44.	Improved recall management	1	2	3	4	5	6	7
45.	Improved tracking and traceability of inventory	1	2	3	4	5	6	7
46.	Better expiration date management	1	2	3	4	5	6	7
47.	Improvements in shrink	1	2	3	4	5	6	7
48.	Reduction in inventory and working capital	1	2	3	4	5	6	7
49.	Improved revenue through reduction in out-of-stocks	1	2	3	4	5	6	7
50.	Reduced expediting costs	1	2	3	4	5	6	7
51.	Higher product availability	1	2	3	4	5	6	7

10.6 Appendix F: Details of the Mail-Out Position Descriptions

Specific Position Titles the envelopes were addressed to (where no person was identified)	
Suppliers	
2B Systems Coordinator	Administrator Appointed
Advisor	Analyst
Analyst Programmer	ANZ Imported Supply Planner
Applications Support Manager	Assistant Administration Officer
Assistant Brand Manager	Assistant Category Manager - Bakery
Assistant Circulation Manager	Australasian Packaging Development Director
B2B E-Commerce Manager	Barcode Implementation Manager
Barcode Project Coordinator	Business Analyst
Business Analyst - IT (Aust/Asia)	Business Application Team Leader
Business Co-ordinator	Business Development
Business Improvement Manager	Business Intelligence Analyst
Business Manager	Business Manager - Operations
Business Operations Manager	Business Systems Administrator (Trade)
Business Systems Analyst	Business Systems and Logistics
Business Systems Manager	Business Systems Manager - Supply Chain
Customer Supply Chain Manager	Customer Support Manager
Demand & Flow Manager	Demand & Supply Manager
Demand Coordinator	EANnet Consultant
eBusiness Collaboration Manager	e-Business Integration Manager
e-Business Manager	e-Business Supply Chain Manager
eCommerce - Systems Assistant	eCommerce Manager
e-Commerce Manager	ECR & Data Integrity Manager
ECR Manager	EDI Manager
EDI Person	EDP Manager
Electronic Trading Manager	Engineering & Operations Manager
Engineering Manager	e-Systems Support Manager
e-Trading Senior Analyst Programmer	General Manager – E Data Administration
General Manager - Information Technology	General Manager - IT
General Manager - Logistics	General Manager - Logistics & Technical
General Manager - Supply & Distribution	General Manager - Supply Chain
General Manager - Supply Chain & RFID Solutions	General Manager IT Systems
Group IT Manager	Group Logistics Development Manager
Group Logistics Manager	Group Logistics Operations Manager
Group Managing Director	Group Operations Marketing Manager
Information Officer	Information Services Manager
Information System Manager	Information Systems Analyst
Information Systems Manager	Information Technician
Information Technology Co-ordinator	Information Technology Manager
Infrastructure Manager	Innovation & Renovation Development Technologist
IT & Operations Manager	IT & Systems Controller
IT Account manager	IT Advisor
IT Analyst-Programmer	IT Assistant
IT Business Analyst	IT Co ordinator
IT Consultant	IT Development Manager
IT Director	IT Manager
IT Officer	IT Operations Manager
IT Portfolio Manager	IT Program Manager
IT Project Leader	IT Support
IT System Manager	IT Systems Manager
IT Systems Manager - Marketing	IT Technical Manager
Joint Managing Director	Logistics & Distribution Manager
Logistics & Procurement Manager	Logistics & Trading Manager
Logistics Analyst	Logistics Assistant
Logistics Controller	Logistics Co-ordinator
Logistics Director	Logistics Manager
Logistics Manager C/Service & Operations	Logistics Officer
Logistics Operations Manager	Logistics Packaging Manager
Logistics Special Projects Manager	Logistics Supervisor
Manager - IT	Manager - IT Operations
Manager - Logistics Operations	Manager - Operations
Manager - Supply Chain	Manager - Technical / Production
Manager - Technology Development	Managing Director
Manufacturing & Logistics Manager	Merchandise Logistics Manager
National IT Mgr	National Logistics Manager
National Manager	National Supply Chain Manager
Operation Manager	Operational Manager

Operations Manage	Operations Manager
Operations Officer	Planning & Development Manager
Planning & Fulfillment Manager	Planning & Inventory Controller
Planning & Logistics Manager	Planning & Purchasing Manager
Planning and Supply Chain Manager	Plant Manager
Plant Operation Manager	Process & Project Development Manager
Procurement & Operations Manager	Procurement Coordinator
Procurement Co-ordinator	Procurement Manager
Procurement Officer	Product & Marketing Manager
Product Design Assistant	Product Development Co-ordinator
Product Development Manager	Product Manager
Product Manager - FMCG Baby Div.	Product Manager - InkJet
Product Manager - Retail	Production & Logistics Coordinator
Production & Stock Co-ordinator	Production Analyst
Production Logistics Co-ordinator	Production Logistics Manager
Supply Chain Analyst	Supply Chain Co-ordinator
Supply Chain Development Manager	Supply Chain Director
Supply Chain Manager	Supply Chain Manager - Australasia
Supply Chain Team Leader	Supply Excellence Manager
Supply Manager	Supply Chain Manager
System Administrator	System Analyst
Systems Analyst	Systems Development Manager
Systems Engineer	Systems Manager
Technical & Sales Representative	Technical Director
Technical Quality Officer	Technical Services Manager
Trade Co-ordinator	Trade Marketing Analyst
Transport & Inventory Manager	Transport & Logistics Manager
Retailer	
Business Systems Manager	eCommerce Manager
Information System Manager	IT Consultant
IT Manager	IT Officer
IT Support	Logistics & Distribution Manager
Logistics Manager	Manager - Supply Chain
Managing Director	Merchandise Logistics Manager
Supply Chain Manager	Supply Manager
Systems Development Manager	Technical Director
*** Less retailers in the database meant there was a smaller range of job titles for retailers.**	
Technology Providers (These all had the person's name with one exception)	
Account Executive	Account Manager
Branch Manager	Business and technical Manager
Business Development Manager	Business Unit Manager
CEO	Chief General
Country Manager Australia & New Zealand	Director
Director Authentication	Director BDM
Director Sales	Director Consulting
Executive Director	General Manager
Manager - Business Development	Manager - Supply Chain
Manager FM Systems support	Manager Strategic Alliance
Managing Director	Market and Business Development Manager
Marketing Director	Marketing Manager
Marketing Specialist	National Sales & Marketing Manager
National Sales and Marketing Manager	National Sales Manager
Principal Consultant	Product manager
Sales & Marketing Manager	Sales and Marketing Manager
Sales Assistant	Sales Director
Sales executive	Sales manager
Sales Manager RF	Senior design Engineer
Strategic Marketing Co-ordinator	Supply Chain Manager
Systems Engineer	Technical Sales Specialist

10.7 Appendix G: Reliability Indices and Factor Loadings using PLS-SEM Model

	retail SC performance	Adoption intentions	Organisational readiness	Technology compatibility	Technology complexity	Technology standards	Technology rel advantage	Organisational top mgt support	Organisational IT investment	Ext environment security	Ext environment consumer privacy	Ext environment industry forces	Economic costs Hw/Sw	Economic cost investment	Economic cost tags	Construct reliability	Composite reliability	AVE
RSCP1	0.725	0.136	0.269	0.207	-0.057	0.207	0.471	0.379	0.229	0.138	0.235	0.209	-0.041	0.012	-0.069	0.952	0.956	0.564
RSCP2	0.675	0.084	0.147	0.153	-0.045	0.140	0.464	0.308	0.071	0.031	0.046	0.218	0.006	-0.136	0.049			
RSCP3	0.826	0.154	0.263	0.297	0.011	0.170	0.547	0.356	0.241	0.130	0.181	0.237	-0.054	-0.044	-0.091			
RSCP4	0.822	0.161	0.249	0.354	0.020	0.174	0.548	0.386	0.297	0.124	0.214	0.331	-0.047	-0.054	0.011			
RSCP5	0.825	0.209	0.224	0.327	-0.088	0.198	0.564	0.389	0.282	0.109	0.327	0.210	-0.051	-0.041	-0.031			
RSCP6	0.761	0.205	0.231	0.215	-0.021	0.104	0.377	0.274	0.209	-0.003	0.224	0.184	-0.059	-0.043	-0.096			
RSCP7	0.778	0.295	0.323	0.301	-0.082	0.274	0.483	0.370	0.308	0.062	0.224	0.224	-0.051	-0.087	-0.070			
RSCP8	0.780	0.259	0.318	0.275	-0.149	0.277	0.461	0.422	0.262	0.165	0.236	0.251	0.011	0.019	-0.093			
RSCP9	0.766	0.203	0.215	0.203	-0.123	0.222	0.344	0.244	0.193	0.090	0.285	0.148	-0.028	-0.010	-0.054			
RSCP10	0.789	0.281	0.234	0.346	-0.135	0.214	0.352	0.263	0.215	0.142	0.237	0.172	-0.029	-0.013	0.038			
RSCP11	0.835	0.346	0.256	0.330	-0.168	0.188	0.480	0.341	0.284	0.185	0.248	0.264	-0.129	-0.098	-0.085			
RSCP12	0.690	0.318	0.280	0.321	-0.165	0.211	0.382	0.293	0.290	0.235	0.125	0.187	-0.105	0.037	0.095			
RSCP13	0.727	0.111	0.114	0.113	0.030	0.074	0.333	0.324	0.187	0.147	0.102	0.282	-0.084	-0.131	-0.046			
RSCP14	0.617	0.051	0.108	0.169	-0.010	0.110	0.371	0.354	0.133	0.177	0.021	0.163	-0.087	-0.117	0.051			
RSCP15	0.734	0.155	0.196	0.184	-0.024	0.212	0.445	0.339	0.210	0.105	0.025	0.260	-0.003	-0.036	0.126			
RSCP16	0.689	0.107	0.098	0.142	0.050	0.031	0.390	0.272	0.131	0.134	-0.011	0.293	0.000	-0.113	-0.033			
RSCP17	0.679	0.133	0.180	0.199	-0.047	0.106	0.379	0.325	0.215	0.168	0.069	0.321	-0.053	-0.125	-0.080			

ADI	0.295	1.000	0.350	0.407	-0.286	0.153	0.242	0.196	0.398	0.199	0.063	0.172	-0.084	-0.048	0.027			
OR1	0.090	0.193	0.786	0.390	-0.386	0.341	0.149	0.271	0.522	0.223	0.135	0.031	-0.304	-0.260	-0.120			
OR2	0.120	0.219	0.797	0.351	-0.384	0.348	0.139	0.263	0.562	0.282	0.135	0.071	-0.285	-0.186	-0.032			
OR3	0.252	0.318	0.822	0.477	-0.360	0.322	0.234	0.272	0.585	0.250	0.222	0.216	-0.231	-0.156	-0.058			
OR4	0.183	0.254	0.798	0.489	-0.402	0.323	0.173	0.231	0.543	0.181	0.259	0.190	-0.248	-0.173	-0.088			
OR5	0.323	0.295	0.638	0.425	-0.303	0.287	0.360	0.447	0.519	0.143	0.070	0.315	-0.135	-0.129	-0.182			
OR6	0.393	0.220	0.666	0.403	-0.175	0.289	0.250	0.391	0.566	0.167	0.237	0.158	-0.224	-0.121	-0.107			
OR7	0.293	0.221	0.736	0.413	-0.233	0.219	0.320	0.429	0.523	0.067	0.198	0.219	-0.220	-0.101	-0.055			
OR8	0.257	0.389	0.678	0.402	-0.327	0.262	0.281	0.306	0.408	0.317	0.215	0.171	-0.078	-0.054	0.080			
OR9	0.156	0.167	0.567	0.311	-0.207	0.174	0.138	0.310	0.508	0.206	0.322	0.056	-0.142	-0.098	-0.075			
TFCm1	0.343	0.425	0.470	0.841	-0.211	0.108	0.322	0.390	0.394	0.155	0.072	0.260	-0.208	-0.104	-0.084	0.73	0.798	0.343
TFCm2	0.339	0.376	0.523	0.820	-0.341	0.153	0.291	0.385	0.422	0.233	0.034	0.220	-0.179	-0.112	-0.075			
TFCm3	-0.002	0.180	0.320	0.619	-0.222	0.116	0.067	0.165	0.348	0.074	0.087	0.030	-0.205	-0.128	-0.189			
TFCm4	0.121	0.201	0.300	0.558	-0.211	0.283	0.192	0.114	0.308	0.187	-0.079	0.060	-0.139	-0.145	-0.042			
TFCm5	0.222	0.186	0.110	0.379	-0.060	0.356	0.388	0.272	0.215	0.063	-0.029	0.187	-0.055	-0.164	-0.020			
TFCm6	0.280	0.155	0.242	0.517	-0.113	0.137	0.435	0.377	0.256	0.204	0.133	0.375	-0.039	-0.097	-0.089			
TFCm7	0.276	0.244	0.398	0.732	-0.363	0.181	0.316	0.361	0.376	0.262	-0.031	0.111	-0.093	-0.039	-0.219			
TFCm8	0.100	0.100	0.179	0.186	-0.208	0.231	0.034	0.055	0.151	0.133	0.143	0.100	-0.098	-0.078	0.220			
TFCm9	0.042	0.035	0.105	0.184	-0.058	0.148	0.063	-0.014	0.067	0.126	0.234	-0.066	-0.158	0.068	0.191			
TFCx1	-0.046	-0.144	-0.222	-0.350	0.617	-0.004	-0.119	-0.246	-0.279	-0.104	-0.045	-0.010	0.048	0.123	0.222	0.867	0.894	0.552
TFCx2	-0.085	-0.282	-0.370	-0.292	0.871	-0.087	-0.093	-0.115	-0.363	-0.062	-0.105	0.075	0.249	0.113	0.163			
TFCx3	-0.083	-0.196	-0.357	-0.266	0.782	-0.097	-0.086	-0.075	-0.309	0.029	-0.120	-0.089	0.199	0.115	0.091			
TFCx4	-0.061	-0.235	-0.411	-0.313	0.813	-0.254	-0.096	-0.111	-0.379	0.003	-0.125	0.053	0.195	0.135	0.068			
TFCx5	-0.034	-0.150	-0.244	-0.226	0.789	-0.065	-0.087	-0.118	-0.242	-0.055	0.004	0.025	0.222	0.181	0.133			
TFCx6	-0.170	-0.275	-0.358	-0.275	0.746	-0.126	-0.137	-0.178	-0.258	0.040	-0.116	-0.059	0.203	0.200	0.007			
TFCx7	-0.085	-0.161	-0.064	-0.310	0.524	0.052	-0.108	-0.195	-0.091	0.099	-0.035	-0.006	0.168	0.194	0.303			

TFSt1	0.155	0.175	0.330	0.141	-0.118	0.588	0.091	0.108	0.213	0.164	0.020	-0.058	-0.113	-0.026	0.031	0.802	0.851	0.398
TFSt2	0.263	0.177	0.175	0.098	0.004	0.607	0.322	0.175	0.176	0.179	-0.008	0.127	0.120	0.047	0.147			
TFSt3	0.177	0.144	0.260	0.139	-0.076	0.793	0.250	0.221	0.200	0.118	0.126	0.063	0.089	0.037	-0.008			
TFSt4	0.121	0.131	0.316	0.284	-0.169	0.813	0.205	0.204	0.253	0.251	0.094	0.123	-0.082	-0.017	-0.034			
TFSt5	0.250	0.111	0.236	0.311	-0.127	0.411	0.181	0.120	0.229	-0.024	0.227	0.191	-0.077	0.009	-0.177			
TFSt6	0.094	0.058	0.233	0.087	-0.164	0.683	0.139	0.106	0.299	-0.031	0.116	0.127	-0.028	0.013	0.147			
TFSt7	0.093	-0.011	0.212	0.191	-0.172	0.653	0.148	0.206	0.179	0.033	0.185	-0.036	0.023	0.040	0.099			
TFSt8	0.061	0.016	0.224	0.114	0.040	0.483	0.098	0.219	0.179	0.103	0.030	0.080	0.068	-0.020	-0.010			
TFSt9	0.264	-0.016	0.151	0.066	0.064	0.534	0.162	0.146	0.132	0.075	0.107	0.101	0.075	0.022	-0.083			
TFRA1	0.472	0.148	0.280	0.280	-0.074	0.236	0.796	0.442	0.265	0.124	0.112	0.210	-0.027	-0.067	0.011	0.917	0.932	0.633
TFRA2	0.507	0.171	0.181	0.314	-0.001	0.180	0.758	0.337	0.182	0.065	0.076	0.229	-0.086	-0.103	-0.083			
TFRA3	0.424	0.192	0.214	0.279	-0.011	0.125	0.801	0.403	0.200	0.180	-0.006	0.294	-0.119	-0.206	-0.012			
TFRA4	0.553	0.194	0.234	0.301	-0.104	0.296	0.756	0.421	0.301	0.164	0.217	0.289	-0.009	-0.043	-0.112			
TFRA5	0.537	0.150	0.205	0.317	-0.183	0.268	0.821	0.486	0.289	0.150	0.182	0.316	-0.001	-0.093	-0.066			
TFRA6	0.271	0.118	0.229	0.362	-0.080	0.215	0.738	0.398	0.301	0.114	-0.045	0.325	-0.218	-0.297	-0.105			
TFRA7	0.472	0.306	0.284	0.344	-0.201	0.234	0.852	0.463	0.353	0.147	0.029	0.403	-0.139	-0.238	-0.155			
TFRA8	0.441	0.229	0.303	0.311	-0.145	0.189	0.836	0.499	0.378	0.134	0.039	0.417	-0.105	-0.229	-0.123			
OFTM1	0.135	-0.035	0.185	0.055	0.038	0.122	0.096	0.522	0.319	0.031	0.307	0.009	0.028	0.061	0.069	0.889	0.909	0.531
OFTM2	0.335	0.195	0.320	0.365	-0.315	0.208	0.458	0.734	0.447	0.091	0.169	0.206	-0.110	-0.232	-0.251			
OFTM3	0.328	0.129	0.462	0.375	-0.091	0.248	0.354	0.782	0.505	0.217	0.176	0.249	0.019	-0.005	0.001			
OFTM4	0.280	0.175	0.412	0.461	-0.222	0.190	0.495	0.730	0.500	0.174	0.132	0.264	-0.084	-0.233	-0.143			
OFTM5	0.253	0.211	0.152	0.146	-0.015	0.126	0.470	0.637	0.258	0.037	0.085	0.350	0.043	-0.171	-0.091			
OFTM6	0.337	0.132	0.265	0.221	-0.126	0.233	0.319	0.716	0.394	0.138	0.211	0.199	-0.112	-0.203	-0.161			
OFTM7	0.428	0.145	0.248	0.364	-0.052	0.202	0.476	0.782	0.378	0.163	0.202	0.266	-0.009	-0.096	-0.087			
OFTM8	0.267	0.157	0.275	0.251	-0.113	0.171	0.254	0.736	0.389	0.168	0.171	0.175	0.004	-0.109	-0.077			
OFTM9	0.438	0.157	0.352	0.391	-0.116	0.182	0.591	0.868	0.513	0.202	0.240	0.366	-0.079	-0.159	-0.168			

OFIT1	0.183	0.306	0.580	0.382	-0.327	0.174	0.074	0.298	0.673	0.285	0.110	0.159	-0.175	-0.162	-0.158	0.886	0.907	0.502
OFIT2	0.188	0.320	0.619	0.406	-0.444	0.303	0.270	0.382	0.845	0.362	0.132	0.198	-0.228	-0.206	-0.219			
OFIT2	0.188	0.320	0.619	0.406	-0.444	0.303	0.270	0.382	0.845	0.362	0.132	0.198	-0.228	-0.206	-0.219			
OFIT3	0.285	0.346	0.573	0.489	-0.470	0.366	0.343	0.496	0.750	0.333	0.211	0.254	-0.055	-0.156	-0.217			
OFIT4	0.305	0.295	0.313	0.352	-0.247	0.189	0.369	0.376	0.564	0.156	0.087	0.300	-0.083	-0.169	-0.282			
OFIT5	0.280	0.279	0.484	0.409	-0.170	0.238	0.334	0.479	0.707	0.256	0.153	0.288	-0.025	-0.026	-0.044			
OFIT6	0.155	0.136	0.230	0.132	-0.090	-0.026	0.300	0.277	0.417	0.070	-0.144	0.407	-0.144	-0.340	-0.138			
OFIT7	0.174	0.298	0.532	0.346	-0.265	0.271	0.186	0.385	0.719	0.163	0.066	0.178	-0.176	-0.137	-0.080			
OFIT8	0.168	0.201	0.469	0.294	-0.098	0.200	0.184	0.507	0.711	0.153	0.270	0.139	-0.028	0.062	-0.088			
OFIT9	0.367	0.275	0.551	0.362	-0.094	0.231	0.387	0.612	0.747	0.182	0.194	0.292	-0.080	-0.060	-0.139			
EES1	0.289	0.038	0.126	0.086	-0.046	0.121	0.138	0.260	0.066	-0.113	0.735	-0.037	0.172	0.237	0.254	0.551	0.894	0.551
EES2	0.038	-0.013	-0.019	-0.071	0.099	0.015	-0.019	0.120	-0.026	-0.208	0.567	-0.134	0.102	0.170	0.141			
EES3	0.263	0.045	0.334	0.078	-0.066	0.107	0.178	0.234	0.193	-0.076	0.858	-0.017	0.039	0.179	0.018			
EES4	-0.035	0.043	0.101	0.026	-0.241	0.065	-0.108	-0.013	0.130	0.061	0.619	0.027	-0.055	0.183	0.193			
EES5	0.099	0.008	0.024	-0.081	-0.134	0.070	-0.073	0.114	0.040	-0.020	0.752	-0.088	0.027	0.155	0.077			
EES6	0.142	0.075	0.199	0.057	-0.106	0.209	-0.064	0.195	0.164	0.040	0.777	-0.123	0.084	0.207	0.117			
EES7	0.220	0.033	0.088	-0.017	-0.023	0.058	0.119	0.235	0.100	-0.089	0.839	-0.040	0.088	0.208	0.134			
EECP1	0.093	0.151	0.270	0.288	-0.071	0.147	0.118	0.172	0.301	0.873	-0.115	0.280	-0.061	-0.021	0.081	0.725	0.778	0.369
EECP2	0.095	0.170	0.219	0.298	-0.062	0.132	0.128	0.182	0.297	0.869	-0.086	0.227	-0.045	0.008	0.077			
EECP3	-0.102	0.046	0.051	0.064	0.126	-0.041	0.014	-0.006	0.128	0.585	-0.230	0.186	-0.060	-0.097	-0.062			
EECP4	-0.078	0.063	0.061	0.088	0.139	-0.048	-0.030	-0.038	0.141	0.573	-0.198	0.119	-0.034	0.019	-0.060			
EECP5	0.096	0.031	0.096	-0.064	0.237	0.013	0.034	0.043	0.093	0.497	-0.085	0.043	-0.017	-0.028	-0.069			
EECP6	0.206	0.128	0.081	0.142	0.143	0.053	0.132	0.015	0.046	0.266	-0.010	0.074	0.031	0.005	0.023			
EECP7	0.248	0.139	0.170	0.067	-0.158	0.186	0.180	0.208	0.212	0.273	0.329	-0.123	0.017	0.159	0.033			
EEIF1	0.081	0.094	0.114	0.161	0.020	0.002	0.215	0.152	0.247	0.096	-0.096	0.690	0.047	-0.062	0.051	0.749	0.753	0.326

EEIF2	0.190	0.121	0.050	0.085	0.071	-0.060	0.331	0.236	0.124	0.091	-0.020	0.648	0.040	-0.114	-0.016			
EEIF3	0.282	0.140	0.165	0.146	0.006	0.188	0.201	0.247	0.253	0.214	0.135	0.597	0.099	0.033	-0.028			
EEIF4	0.163	0.046	-0.044	-0.024	0.128	0.007	0.291	0.194	0.031	0.043	0.146	0.370	-0.021	-0.193	0.004			
EEIF5	0.194	0.083	0.000	0.025	-0.034	-0.006	0.363	0.304	0.073	0.047	0.136	0.425	-0.013	-0.206	-0.054			
EEIF6	0.050	0.109	0.048	0.116	-0.106	0.061	0.021	0.056	0.089	0.125	0.116	0.268	-0.145	-0.029	0.031			
EEIF7	0.246	0.091	0.163	0.195	0.024	0.051	0.434	0.273	0.161	0.110	-0.164	0.796	-0.066	-0.214	-0.072			
EFChs1	0.002	-0.042	-0.173	-0.153	0.196	0.066	-0.120	-0.048	-0.168	-0.020	0.217	-0.058	0.835	0.810	0.286	0.710	0.642	0.490
EFChs2	-0.090	-0.008	-0.226	-0.177	0.208	0.019	-0.085	-0.097	-0.152	0.055	0.105	0.058	0.877	0.729	0.540			
EFChs3	0.029	0.143	0.143	0.090	-0.048	0.134	-0.005	-0.078	-0.010	0.175	0.238	-0.028	-0.057	0.406	0.374			
EFCi1	-0.105	-0.051	-0.174	-0.074	0.073	0.034	-0.203	-0.159	-0.134	-0.006	0.058	-0.076	0.645	0.834	0.275	0.769	0.886	0.684
EFCi2	-0.004	-0.016	-0.133	-0.037	0.151	0.094	-0.096	-0.138	-0.121	0.035	0.190	-0.066	0.582	0.868	0.392			
EFCi3	-0.027	-0.046	-0.175	-0.238	0.238	-0.079	-0.189	-0.138	-0.189	0.043	0.360	-0.111	0.510	0.777	0.612			
EFCt1	-0.049	0.029	-0.073	-0.113	0.160	0.007	-0.141	-0.166	-0.215	0.051	0.164	-0.039	0.398	0.616	0.971	0.847	0.754	0.622
EFCt2	-0.071	0.025	0.021	-0.054	0.151	-0.020	-0.198	-0.170	-0.131	0.025	0.187	-0.053	0.434	0.667	0.550			