Radio Frequency Identification (RFID) Adoption in the South African Retail Sector: an Investigation of Perceptions Held by Members of the Retail Sector Regarding the Adoption Constraints

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Abstract: Radio Frequency Identification (RFID) technology is a method of identifying unique items using radio waves that communicate between RFID tags and readers without line-of-sight readability. Application areas include person identification, logistics, pharmaceutical, access control, security guard monitoring and asset management. One of the areas where RFID promises excellent potential is in the retail industry for the tracking of goods and products throughout the supply chain. There are concerns around numerous RFID adoption barriers. Decision makers in the South African retail sector seem to be adopting a wait-and-see approach. In an attempt to identify and explore these barriers, a literature review was conducted identifying 29 unique barriers to RFID adoption. A survey instrument, informed by these barriers, was constructed and administered to members of the retail sector in South Africa. The research reveals that the South African retail sector is aware of the benefits in adopting RFID technology, however, they have identified numerous adoption barriers that will need mitigation before they will commit to adopting RFID. The research confirms six main categories with several adoption barriers in each, needing to be addressed. The main categories include, RFID skills shortage, a lack of standardization, high costs of RFID devices, the difficulty of integrating with current legacy systems and a lack of familiarity with RFID systems.

Keywords: RFID, diffusion of innovation, adoption barriers, business case, supply chain management

1. Introduction

RFID is a generic term for technologies that use radio waves to automatically identify individual items Sandip (2005:2). Although there are implementation variations, RFID makes use of a microchip with an in-built radio transmitter. The radio transmitter and the microchip together are called the RFID tag. Two types of tag exist; a remotely powered passive tag and a self powered active tag (Sweeney, 2005:20). RFID is gaining acceptance as it moves from being expensive and experimental to increasingly affordable and practically implementable. RFID technology is being applied in retail, supply chains, logistics, and other areas. At present, businesses are focused on using RFID to streamline data collection and data consistency; for example, tracking products through the manufacturing cycle and then locating them at warehouses and retailers. Using RFID, each product can be identified by physical location, manufacturing history and distribution path (Borriello, 2005). As RFID technology improves, so does the application of RFID broaden in scope. Nonetheless, problems associated with the implementation of RFID persist. These include cost variation, the lack of business case study, reader and tag collision, RFID privacy and security issues, radio frequency interference and lack of standards. Given the aforementioned RFID concerns, it is not surprising to find members of the South African retail sector with varying perceptions regarding the usability of RFID technology. This study was initiated to try and understand these perceptions so that a model describing RFID implementation barriers could be constructed.

2. RFID adoption; a brief review of the literature

While the implementation of RFID in the retail sector is a recent innovation and a departure from traditional barcode technology, RFID technology per se is not a new concept and according to Bhuptani *et al.*, (2005: 25), can be traced back to World War II, when the British military needed to find a way to identify whether an approaching aircraft was friend or foe. There are numerous benefits to adopting RFID in the retail sector such as tracking and tracing goods and the containers that hold them, even in harsh environments, since RFID tags do not wear out and do not require line-of-sight to function (Sandip, 2005: 52). RFID can uniquely identify products, cases, and other items, which increases productivity and saves on labour costs in comparison to barcode technology (Sandip, 2005: 115; Lee *et al.*, 2005). RFID virtually eliminates the need to have people locate items and manually scan barcodes. Unfortunately, as with most technology, RFID also has its limitations too. As

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mentioned, RFID tags and transponders transfer information via radio waves. These radio waves can be subject to interference, mainly from metal and liquid products, especially when merchandise is packaged in metal cans or containers (Sandip, 2005: 60). These potential sources of interference must be recognised and accounted for during system planning. Unlike barcodes, it is quite possible for a bad or damaged tag at the item level within a batch of goods to go undetected when passing through the reader (Sandip, 2005: 60). RFID systems consist of more than just the tag. There are several components which introduce integration complexity (Finkenzeller 2003, Sandip 2005 and Shepard 2004). These components include:

- A programmable RFID tag or transponder for storing data (exception: read-only tags).
- An antenna to facilitate the reading and writing of data on the tag. In the case of a passive tag, the antenna assists in powering the tag.
- A reader that encodes or decodes the data in the tag's integrated circuitry. In the case of passive RFID systems, the reader also supplies power to the tag.
- Software components that are required to communicate between the application and the hardware, such as tags and readers. These components include RFID system software, middleware and host applications.

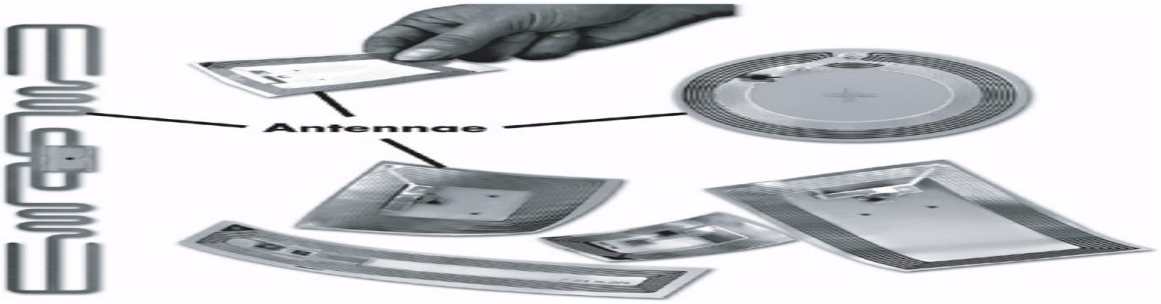

Figure 1: Typical passive RFID tags with antennae highlighted (Bhuptani *et al.*, 2005: 47)

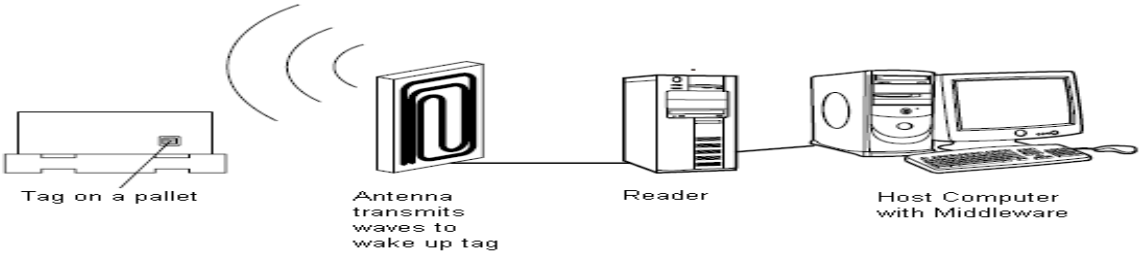

Figure 2: Illustrates the various building blocks which constitute an RFID system (Sweeney, 2005: 78)

One of the major factors restricting the development of RFID technology is the disunity of RFID standards (IDTechEx 2004). Clearly, organisations do not want to back a particular RFID standard which may be superseded by another. Currently, the two major standards are International Standards Organization (ISO) and EPCglobal (previously known as Auto-ID). Given the obvious benefits to implementing RFID as well as some impediments as mentioned above, currently, two of the world's largest retailers; Wal-Mart and Metro in America have committed to adopting RFID technology within their supply chains. (Bhuptani *et al.*, 2005: 31; Shepard, 2004:144). Wal-Mart in particular mandated that their top 100 suppliers use RFID tags on all product deliveries by 2005 (Wal-Mart, 2005). Despite some delay, the process was successfully accomplished and development is ongoing (Wal-Mart, 2006). At present in South Africa, some retailers such as Pick 'n Pay, Shoprite and Woolworths are aware of RFID and in some cases investigating the technology. There is some reluctance, possibly best described as a look and see approach to adopting RFID technology. In an attempt to understand what could be influencing the uptake of RFID technology within the South African retail sector, a survey was conducted using a purpose built instrument informed via a detailed literature review. The literature review included diffusion of innovation theory; the fundamental theory that explains how a new idea or innovation is spread within a social system, which consists of individuals, informal groups, organisations and subsystems (Rogers, 2003). For reasons of brevity, these theories are merely listed below. They include:

- Adoption of information technology innovation theory (Moore and Benbasat, 1991)

- Theory of reasoned action (Fishbein and Ajzen, 1975)
- Social cognitive theory (Bandura, 1977; Bandura, 1986)
- Technology acceptance model (Venkatesh, Morris, Davis and Davis, 2003)
- Theory of planned behaviour (Ajzen, 1991)
- Model of personal computer utilization (Thompson, Higgins and Howell, 1991)

These theories can be grouped under individual-level and organisational-level technology adoption, each theory addressing particular adoption constraints with a view to understanding how individuals, organisations as well as groups may perceive the viability of adopting a particular innovation. Put together, individual-level technology adoption and organisational-level technology adoption (adoption of IT innovation theory and the diffusion of innovation model), represent a wealth of knowledge regarding the innovation adoption process. These theories provide evidence that a variety of factors influence whether potential adopters and consumers will accept or reject new technology within a social system (Baskerville and Pries-Heje, 2001). Following on from the investigation into diffusion of innovation theory, the literature review investigated adoption barriers. The authors and their respective concerns are listed in table 1 and 2 respectively.

Table 1: Authors referred to in the literature review as referenced in table 2.

A: Montgomery (2006)	K: Eckfeldt (2005)
B: Aberdeen Group (2005)	L: Commonwealth of Australia (2006)
C: Swanton (2005)	M: Leong, NG and Cole (2006)
D: VDC (2006)	N: Asif and Mandviwalla (2005)
E: ATK and KSA (2004)	O: Michael and McCathie (2005)
F: Davison and Smith (2005)	P: Huber, Michael and McCathie (2007)
G: Wu, Nystrom, Lin and Yu (2006)	Q: Angeles (2005)
H: Seymour, Lambert-Porter and Willuweit (2007)	R: Juels (2006)
I: Cooke (2005)	S: Staake, Thiesse and Fleisch (2005)
J: Walker (2004)	

Table 2: Summary of barriers to RFID adoption (1/3)

Barriers to RFID adoption (categories)	**Authors and Research Group**																		
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**
Authentication challenges																		X	X
Awaiting next generation of offerings				X															
Consumer privacy concerns					X	X													
Current technology in place is satisfactory/existing technologies will work faster and better			X	X		X													
Customers and suppliers won't use it	X							X											
Health challenges											X	X							
High cost of hardware/infrastructure		X	X	X	X		X	X											
High cost of software, integration, service, and support			X	X			X	X											
High cost of tags	X	X			X	X	X	X											
High degree of business process change required					X	X		X											
Implementation challenges													X	X	X				
Integration challenges							X									X	X		

Table 2: Summary of barriers to RFID adoption (2/3)

Barriers to RFID adoption (categories)	Authors and Research Group																	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Lack of awareness	X			X															
Lack of application requirements/Not applicable or relevant				X				X											
Lack of business case or unconvinced business case	X					X													
Lack of customer demands			X					X											
Lack of senior management support						X		X											
Lack of skilled personnel								X	X	X									
Lack of standards	X	X	X	X	X	X	X	X											
Need to fix data synchronisation first						X													
No compelling value proposition		X						X											
No identifiable business need						X													
Not suitable for product assortment						X													
Poor tag read rates/tag reader accuracy		X			X		X	X											

Table 2: Summary of barriers to RFID adoption (3/3)

Barriers to RFID adoption (categories)	Authors and Research Group																		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Products not optimal to RFID			X																
Security					X			X											
The data would swamp business						X													
Unclear on benefits of RFID				X				X											
Unclear ROI	X		X	X			X												

3. Methodology

A quantitative research methodology was used for the study. A custom survey instrument consisting of 37 questions based on the research hypotheses was developed and piloted. The Wilcoxon Signed Rank test was chosen as an appropriate statistical tool for Likert scale type data used in the survey. Finally, issues of reliability and validity concerning data collection and analysis for the study were considered and addressed.

The questionnaire was distributed via the Internet using an open source survey system called “PHP Easy Survey Package”.

Only one respondent from each retail organisation was permitted to answer the questionnaire. This is because several organisations own more than one major retailer in South Africa. It was believed that major strategic IT decisions such as whether or not to adopt RFID would be made at the parent company level. As an example, Massmart Holdings owns Game®, Dion®, Makro®, Builders Warehouse®, Builders Express®, Jumbo®, Shield® and Trade Department®. Therefore, it was considered preferable to ask the CIO of Massmart Holdings to participate in the survey, rather than IT managers or IT personnel at the retail branch level.

The final list consisted of 39 retailers who were approached telephonically and asked to complete the online survey. 33 completed surveys were collected.

4. Findings and discussion

RFID technology faces many challenges. Some are systematic, and others are as a result of negative perceptions. In order to implement RFID systems successfully, we need to understand some of the key barriers that hinder RFID adoption. Table 3 provides a summary of the technological constraints.

4.1 Technological constraints

Table 3: Technological constraints

Area of Constraints	Hypothesis Set	Factor Analysis of Perceived RFID Barriers	Statistical Result: is or is not a barrier
Technological	1	Lack of technological usefulness and advantageousness	No
	2	Lack of a business case	No
	3	Lack of global standards	Yes
	4	Not suitable for product assortment	No
	5	Poor tag reader accuracy and rates	Yes
	6	Large amount of data would swamp the business	No
	7	Complexity of technology	No

81.8% of respondents believe RFID technology would provide additional value if deployed within the retail sector. 60.6% believe there is a convincing business case for RFID adoption in the retail sector. 66.6% of respondents believe that a lack of global standards is a hurdle for RFID adoption. 69.7% believe RFID technology is suitable for product assortment. 39.4% agree that poor reader accuracy is a barrier to RFID adoption while 44% were neutral and only 18% disagreed with this statement. 33.4% of respondents agree that poor RFID read rate is a barrier to RFID adoption while 54.5% were neutral and 12.1% disagree with that statement. 72.7% believe an RFID system does not generate too much data and 75.7% of respondents believe RFID systems are not too complex for users.

Discussion: All but two of the technological constraints were not considered as barriers to RFID adoption. The majority of SA retailers do, however, consider poor tag reader accuracy and tag read rates as a drawback of the technology. This barrier will have a direct impact on product detection, and as a result, retailers are concerned that the problem could cause direct financial losses due to inaccurate data. Hence poor tag reader accuracy and read rates are a barrier to RFID adoption in the SA retail sector.

There is also concern over the lack of global standards for RFID adoption. Unfortunately, there is no agreement amongst retailers on which standard to adopt in South Africa. There is furthermore a lack of regulation or guidance from the government on which standards should be followed when implementing RFID technology in South Africa. Uncertainty about the future direction of RFID standards is without doubt a factor causing retailers to hold back on the adoption in South Africa. Lack of global standards is seen as a barrier to RFID adoption.

4.2 Costs and Return on Investment (ROI)

Table 4: Cost and ROI Constraints

Area of Constraints	Hypothesis Set	Factor Analysis of Perceived RFID Barriers	Statistical Result: is or is not a barrier
Cost and ROI	8	The high cost of hardware and infrastructure	Yes
	9	The high cost of software, integration, service, and support	Yes
	10	The high cost of tags	Yes
	11	Unclear ROI	Yes

A total of 75.7% of respondents believe the high cost of RFID hardware and infrastructure is a barrier and 72.7% believe the high cost of RFID software, integration, service and support is a barrier. 72.7% believe the high cost of RFID tags to be a barrier and 69.7% believe uncertainty in return on investment is a barrier.

Discussion: Cost and ROI are considered key determinants as to whether or not to adopt RFID technology. Currently, the high prices of RFID components including hardware, software and tags

make it hard to see an immediate return on investment. As a result, retailers will not rush in without first researching the best RFID strategy suitable for their requirements. Certainly, most SA retailers view RFID adoption from a business standpoint, not just a technological one; thus, examining the cost and return on investment is critical for adopting RFID technology.

4.3 Privacy and security constraints

Table 5: Privacy and security constraints

Area of Constraints	Hypothesis Set	Factor Analysis of Perceived RFID Barriers	Statistical Result: is or is not a barrier
Privacy and Security	12	Customer privacy concerns	Neutral
	13	Security concerns	Neutral

39.4% of respondents believe consumer privacy is a concern, however, 36.4% of respondents disagree with this statement, and 24.2% neither agree nor disagree. 30.3% of respondents believe RFID security is a concern, however, 30.3% of respondents disagree with this statement, and 39.4% neither agree nor disagree.

Discussion: It is interesting that privacy and security issues remain neutral. Customer privacy concerns are mostly raised by privacy advocates abroad who do not have a major influence in South Africa. It is believed that the majority of customers in South Africa are not currently aware of the next generation of identification technology, such as RFID, let alone the privacy implications this may have on their lives. As a result of this lack of awareness, retailers are not under pressure to address this potential privacy concern. As general public awareness increases, South African retailers, like their counterparts in other countries will have to give this factor more attention. Hence, customer privacy should be a factor to consider in RFID adoption.

A concern about security is somewhat related to privacy. It is about how to keep RFID information safe from hackers or intruders, rather than concentrating on securing customer information, hence, it is more focused internally in the business. It is believed that one of the main reasons SA retailers are not concerned about RFID security is that there are currently no major threats against RFID technology, particularly in South Africa. As RFID technology gains in popularity amongst individuals, retailers and in other marketplaces, security will become increasingly important, while individuals try to exploit this technology for their own benefits. As a result, security concerns will heighten over time.

4.4 Implementation constraints

Table 6: Implementation constraints

Area of Constraints	Hypothesis Set	Factor Analysis of Perceived RFID Barriers	Statistical Result: is or is not a barrier
Implementation	14	Compatibility and integration with other technology	Yes
	15	Implementation challenges	Yes
	16	The need to fix data synchronisation first	No
	17	RFID authentication challenges	Neutral

45.5% of respondents believe that the compatibility and integration of RFID technology with other technologies is a barrier. 69.7% believe that challenges relating to RFID implementation are a barrier. 54.5% believe that data synchronisation between RFID systems and other systems is a problem. 15.2% of respondents agree, 66.7% neither agree nor disagree and 18.2% disagree that a lack of authentication in RFID systems and tags is an adoption barrier.

Discussion: Implementation constraints are clearly potential barriers to wide-scale deployment. As indicated in table 6, two out of four implementation factors are considered barriers to RFID adoption by SA retailers. How retailers view the difficulty of implementing RFID is a critical aspect to be measured by retailers that intended to mandate RFID technology in their business. There is no evidence indicating whether or not RFID authentication challenges are a barrier to RFID adoption in the retail sector.

4.5 Privacy and security concerns

Table 7: Privacy and security constraints

Area of Constraints	Hypothesis Set	Factor Analysis of Perceived RFID Barriers	Statistical Result: is or is not a barrier
Privacy and Security	12	Customer privacy concerns	Neutral
	13	Security concerns	Neutral

39.4% of respondents believe consumer privacy is a concern, however, 36.4% of respondents disagree with this statement and 24.2% neither agree nor disagree. 30.3% believe RFID security is a concern, however, 30.3% disagree with this statement and 39.4% of respondents neither agree nor disagree.

Discussion: It is interesting that SA retailers are undecided whether or not privacy and security concerns pose a barrier to RFID adoption. This is contrary to the findings from the literature review, which indicate that most researchers and research organisations see privacy and security issues as a key barrier. As previously discussed, when consumers and retailers gain a greater awareness of RFID technology, and the install base increases, so will security risks increase as exploiters realise on the value of data contained within these systems. Hence, it is believed that customer privacy concerns and security concerns should not be discarded as barriers, and must be included in the framework.

4.6 Organisational constraints

Table 8: Organisational constraints

Area of Constraints	Hypothesis Set	Factor Analysis of Perceived RFID Barriers	Statistical Result: is or is not a barrier
Organisational	18	A high degree of business process change required	Yes
	19	Lack of awareness	Yes
	20	A lack of identifiable business needs	Neutral

57.5% of respondents believe that a high degree of business process change required is a barrier. 60.6% believe that a lack of awareness in RFID technology is a barrier. 48.5% believe that a lack of identifiable business needs is not a barrier for RFID technology. 15.2% of respondents neither agree nor disagree, 30.3% of respondents agree and 6.1% of respondents strongly disagree that a lack of identifiable business need is an organisational barrier.

Discussion: An examination of the impact of organisational constrains on RFID adoption revealed that a high degree of business process change and lack of awareness are barriers. It is also interesting to note that the answer to 'no identifiable business need' is neutral, which means that there is no evidence to determine whether this factor is or is not a barrier.

4.7 People constraints

Table 9: People constraints

Area of Constraints	Hypothesis Set	Factor Analysis of Perceived RFID Barriers	Statistical Result: is or is not a barrier
People	21	The unwillingness of the customer and supplier to use it	Yes
	22	Lack of senior management support	Neutral
	23	Lack of skilled personnel	Yes

69.7% of respondents believe that a lack of willingness to use RFID technology is a barrier. 39.5% believe a lack of senior management support is a barrier while 24.2% neither agree nor disagree and 36.4% disagree with this statement. 63.6% believe that a lack of skilled RFID personnel is a barrier.

Discussion: The customers' and suppliers' lack of willingness to use the technology is a general concern for RFID adoption, and most retailers believe that this is a major adoption impediment. The reason is that retailers alone would not gain maximum benefits from a closed RFID system, since the scope of application of a closed system is limited within a single organisation. There are a multitude of benefits to be derived by an organisation integrating RFID across the entire supply chain. These benefits would positively impact risk and costs while increasing efficiency and success. Hence, an unwillingness of the customer and supplier to use the technology is a barrier to RFID adoption.

Surprisingly the response from SA retailers on the issue of senior management support did not clearly indicate whether or not this factor is a barrier to RFID adoption. However, it is believed that a major drawback to wide-spread deployment of RFID systems is people's overall attitude towards the technology. A possible reason for this research outcome could lie in the nature of the targeted respondents, as most respondents, if not all, were IT professionals, who are more likely to understand and support RFID adoption than other senior management who do not have the same insight. Furthermore, a lack of awareness, as identified earlier, indicates that in general, retailers have insufficient knowledge about RFID, and as a result, would not support its adoption. Hence a lack of senior management support has not been discarded from the framework and is considered a barrier to RFID adoption.

RFID-knowledgeable personnel are hard to find. Many SA retailers, regardless of size, would discover they have no qualified RFID personnel. Without expert skills, retailers might end up spending too much time and money on an RFID project, possibly leading to its failure. Hence, SA retailers regard the lack of skilled personnel as a barrier to RFID adoption

4.8 Environment constraints

Table 10: Environment constraints

Area of Constraints	Hypothesis Set	Factor Analysis of Perceived RFID Barriers	Statistical Result: is or is not a barrier
Environment	24	Social influence	No
	25	The effect of radio emissions on personal health	No

48.5% of respondents believe that social issues surrounding RFID technology is not a barrier while 27.3% neither agree nor disagree and 24.2% agree with this statement. 69.7% of respondents believe that the impact of RFID technology on human health is not a barrier while 27.3% neither agree nor disagree and only 3% of respondents agree with this statement.

Discussion: Given the existing minimal install base of RFID in South Africa and the resultant lack of public knowledge and understanding of the technology, it is believed that environmental issues which include social influence as well as health concerns have not really been explored. There is evidence of these concerns in the international market. Within a South African context, these issues are not considered barriers to RFID adoption.

5. Summary

There are 16 barriers identified to be stumbling blocks to RFID adoption in the South African retail sector. These barriers are grouped according to areas of constraint and are illustrated in Table 11. in terms of an enhanced framework. The framework of RFID adoption barriers are sorted according to each category (area of constraints), rather than importance. This framework is an outline of the barriers impacting RFID adoption in the SA retail sector that need to be addressed.

Table 11: Enhanced framework of the barriers to RFID adoption in the South African retail sector (1/2)

Area of Constraints	RFID adoption Barriers
Technological	Lack of global standards
	Poor tag reader accuracy and rates
Cost and ROI	The high cost of hardware and infrastructure

	The high cost of software, integration, service, and support
	The high cost of tags
	Unclear ROI
Area of Constraints	RFID adoption Barriers
Privacy and Security	Customer privacy concerns
	Security concerns
Implementation	Compatibility and integration with other technology
	Implementation challenges
	RFID authentication challenges
Organisational	A high degree of business process change required
	Lack of awareness
People	The unwillingness of the customer and supplier to use it
	Lack of senior management support
	Lack of skilled personnel

6. Conclusion

The potential benefits to implementing RFID are acknowledged by most managers within the South African retail sector. RFID could become the preferred supply chain management technology in future retail systems, however, there are adoption barriers that represent major obstacles that must be identified, understood, and as far as possible, overcome, in order for South African retailers to consider adopting RFID technology. The RFID adoption barriers identified by means of a survey include:

- Lack of global standards
- Poor tag reader accuracy and rates
- The high cost of hardware and infrastructure
- The high cost of software, integration, service, and support
- The high cost of tags
- Unclear ROI
- Customer privacy concerns
- Security concerns
- Compatibility and integration with other technology
- Implementation challenges
- RFID authentication challenges
- A high degree of business process change required
- Lack of awareness
- The unwillingness of the customer and supplier to use it
- Lack of senior management support
- Lack of skilled personnel

As RFID technology is increasingly adopted within global markets by companies such as Wal-Mart, it is believed that many of the current adoption barriers will fall away. Costs will decrease through greater scales of economy resulting in improved ROI, technology will improve as equipment suppliers compete for market share and expertise will increase through wider implementation experiences. South African retailers have demonstrated an interest in RFID technology and as adoption barriers decrease, the decision to adopt RFID in the South Africa retail sector may well become increasingly compelling.

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