RADIO FREQUENCY IDENTIFICATION (RFID) ADOPTION STRATEGY FOR STRATEGIC SUPPLY CHAIN

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ABSTRACT

The on-going trend of applications and implications of Radio Frequency Identification (RFID) technology, and the increasing external pressures on industries operating in the global market is no doubt making RFID adoption unavoidable. This is driving many manufacturers and businesses into "immature" RFID adoption with low records of success. Whilst most existing technology adoption readiness models can help an organisation evaluate its technology adoption readiness, there is no existing model to analyse and resolve the identified barriers in RFID adoption. This paper therefore, investigates the specific RFID adoption issues confronting industries operating in the global supply chain, discusses and develops an RFID Adoption Strategy framework for successful RFID-enabled business. The paper also offers a strategic approach to timely delivery of a successful RFID adoption under global supply chain external pressures.

Key words: RFID, Supply Chain, Performance Improvement.

1. INTRODUCTION

In recent years, the manufacturing cost of RFID tag had decreased due to economic scale of production that followed the exponential growth in demand and interest in application of RFID technology (Smith, et al., 2009) thus bringing down the cost of an RFID tag from about $1.00 in the late 1990s to the current $0.03 (Li, et al., 2006; rfidrange, 2011). The perceived usefulness and capability of RFID technology has also increased external pressures such as government legislative regulations and mandate from top level supply chain partners for RFID compliance within a limited period of time or before inter-business transactions; this almost driving many manufacturers and businesses into "immature" RFID adoption with low records of success (Li, et al., 2006).

The impact and influence of RFID innovation on business processes and the external pressures would however continue as far as the bargaining power of buyers over suppliers (or vice-visa) holds (Lee and Qualls, 2010) (reference to Porter's five forces model), the weight of legislative regulations for compliance increases, and the need to gain and sustain competitive advantage remains a key strategy for business performances (Schmitt, et al, 2010). This invariably will radicalise the market, increase the competitiveness, and in due course run off unprepared businesses out of the game. However, many researchers have posited that the key performance indicators for a successful RFID adoption in strategic supply chain are improved business performance, customer satisfaction, return on investment (ROI), and delivery of the innovation within the imposed time limit. Thus, the hypothetical question is:

- How should a business improve performance, increase customer satisfaction, and return on investment (ROI) by adopting RFID technology within a short time frame?

In response, the study investigate and analyse potential barriers other than tag cost that inhibit the wider successful adoption of RFID technology and proposes adoption strategy framework for a time performance delivery of a successful RFID-enabled business.

The Methodology: First, a survey instrument was developed based on deduced hypotheses from a literature review, distributed to Manufacturing, and Oil and Gas industries in two geographical

locations, and the respondents' results were analysed and tested for the hypotheses. Second, an iterative problem solving methodology was used to analyse and evaluate possible solutions to the hypothetical question and the tested hypotheses. Based on the results, this research developed an RFID Adoption Strategy framework.

2. ISSUES WITH RFID ADOPTION

2.1 Lack of Knowledge

Like many other new innovations, there are associated challenges that hinder the wider adoption of RFID. For example; according to Essex, (2011), cost and system design issues have slowed RFID's use on individual products. In his research, Vijayaraman, (2006), said despite the trials by some early adopters such as Gillette and Tesco, the ROI for items level tagging still remain a major issue for many companies. Deavours, (2006), states that lack of knowledge to make decision and explicit knowledge of the implications of RFID technology is a barrier to its adoption. It implies that:

H1: Lack of Knowledge has a negative and significant relationship with RFID adoption

2.2 Standardisation Issues

Lack of clear benefits (Thiesse, *et al.*, 2011), and lack of mature and proven standard of interoperability among organisations, communication and information technologies of RFID are other challenges that are noted to hinder RFID adoption (Vijayaraman, 2006; Schmitt, *et al.*, 2007, 2010; Thiesse, *et al.*, 2011). Schmitt, *et al*. (2010), argues that one reason for standardisation problem is the lack of agreement for a single RFID standard most especially in respect of data standard and unique identifier such as the Electronic Product Code (EPC). Thus:

H2: Standardisation has a positive and significant relationship with RFID adoption
H3: Level of knowledge has a positive and significant relationship with Standardisation
H6: Organisation goals and objectives have a positive and significant relationship with RFID adoption

2.3 Privacy and Security Issues

Privacy and security is another concern that is hampering its adoption (Vijayaraman, 2006; Schmitt, *et al.*, 2010). This is a great issue when it comes to its application in healthcare for example; where RFID application to monitor medications for diabetes patients requires the insertion of an object into the body (Ton, *et al.*, 2005). Customer perception of privacy for tagging all items is another raising issue.

H7: RFID technical skills has a positive and significant relationship with RFID adoption

2.4 Adoption Theory and Motivation

The theory of adoption and diffusion of innovations (Rogers, 1995) have been strongly supported as appropriate and used by many researchers to describe factors that affect the decision to adopt or to reject the adoption of new innovations (Sahin, 2006; Thiesse, *et al.*, 2011; Zhu, *et al.*, 2006). Rogers, (2003) in his theory explained diffusion as the process by which an innovation is communicated through certain channels over time among the members of a social system. In this case the process of influence and information flow hampers the spread of technological innovation. Firms which are strategically positioned within information and communication network or closely connected to leading and innovative organisations by socioeconomic status or education therefore tends to learn about such innovation and adopt it earlier than firms outside the border of the communication networks. Thus,

H4: Supply Chain Collaboration has a positive and significant relationship with the level of knowledge of RFID
H5: Strategic Partnership with RFID consultant has a positive and significant relationship with level of knowledge of RFID

3. CONCEPTUAL MODEL PROPOSITION

Drawing from Rogers (2003) technology adoption and diffusion theory model, the researchers conceptualised the RFID adoption process in a socio-economic and collaborative supply chain environment in order to investigate and capture the interaction between *Conditional Decision factors* and *Unconditional Decision factors* for RFID adoption. This is achieved by organising the factors that were found to be influential in prior RFID adoption together in one model. The conditional factors include the Persuasion criteria and Knowledge decisive factors. The unconditional decision factors are the external factors which include: Mandate from top supply chain partners, legislative regulation compliance, and competitive advantage (See Figure 1).

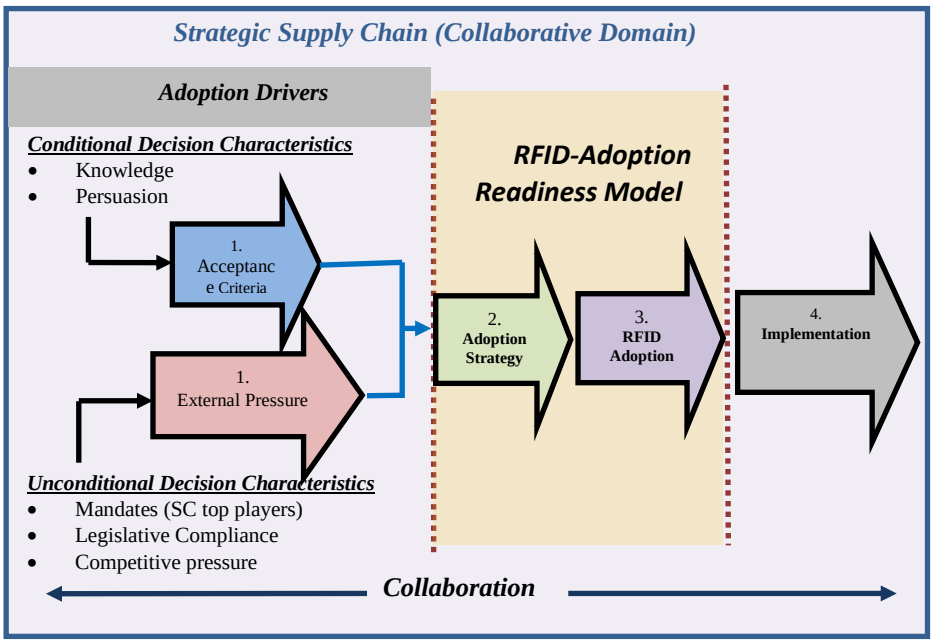

Figure 1 A revised four Stages framework for RFID Technology adoption process

3.1 Acceptance Criteria (AC)

In this frame work, Acceptance criteria for RFID technology adoption is a function of the Level of Knowledge of RFID technology (K), and the Level of Persuasion developed towards RFID technology (P). These two functions may have negative or positive influence on the decision to adopt RFID technology hence they are grouped under "Conditional Decision Criteria". AC = $f(K, P)$

3.2 External Pressures (EP)

The external pressure that drives the adoption of RFID technology encapsulates several forces within the competitive environment and surroundings. These include the need to comply with the Mandate from the top supply chain partners (M), the need to be compliant with the Legislative regulations (L), and the level of need to be competitively positioned due to the advent of RFID technology in the industry (C). These functions are grouped under "Unconditional Decision Characteristics" of RFID adoption. EP = $f(M, L, C)$

3.3 Adoption Strategy under Finite Time

The decision for adoption is conceptualised under a strategic supply chain and under two perspectives:

The level of obligation is high to comply with customers or suppliers mandates within a short time frame.

There is need to comply with legislative regulations in order to carry out business within and globally. The External pressure therefore supersedes the decision made under acceptance criteria.

$$EP > AC \quad = \quad f(M, L, C) \; > f(K, P)$$

The Level of Persuasion (P) diminishes as external pressure increases, thus: $f(M, L, C) \; > f(K)$
Introducing a constant "S" (that is; the adoption strategy for successful adoption of RFID technology) to balance the equation: $f(M, L, C) \; = S\, f(K)$
This mathematical expression can be said to be valid in a global strategic supply chain where compliance to RFID adoption is unavoidable and the level of technical knowledge of RFID impedes or determines its adoption. The level of technical knowledge of RFID technology influences the successful achievement of organisation goals and objectives.

Therefore:
H14: Mandate has a positive and significant relationship with RFID adoption
H15: Legislative regulations has a positive and significant relationship with RFID adoption
H16: Competitiveness has a positive and significant relationship with RFID adoption
H8: Clear strategy for RFID adoption has a positive and significant relationship with ROI

Thus we can also support this with the hypothesis statements of H1-H13. See Table 5.1 for summary of the hypothesis statements and the problem-solving backgrounds.

4. EMPIRICAL FINDINGS

The following are identified concerns based on the analyses of the results of respondents for RFID adoption:

1. Lack of evidence or guarantee for Return On Investment (ROI)
2. Customer satisfaction / Improved Business Performance
3. Lack of adequate knowledge for adoption of RFID technology

It can also be inferred from the findings that:
H9: Clear RFID adoption strategy has a positive and significant relationship with Improve Performance
H10: Clear strategy RFID adoption has a positive and significant relationship with Timely delivery
H11: Collaboration has a positive and significant relationship with RFID adoption
H12: Proximity or Partnership with RFID consultants has a significant relationship with RFID adoption
H13: Top management commitment has a positive and significant relationship with RFID adoption

5. RFID ADOPTION STRATEGY

The iterative problem solving framework was used in analysing various stages and evaluating possible solution to the hypothetical question. The framework has been used by many researchers to solve business issues that inhibit achievement of strategic, operations, and financial goals (Khoshafian, 2007; Bartkus and Conlon, 2008; Jonasson, 2008). The first section is the determination of the problem with a simplified hypothetical statement. This is followed by the identification of issues deducted from the literature review and the empirical findings. The process is then simplified to the proposed RFID adoption strategy and readiness model.

5.1 Determining the Problem: Hypothesis

According to Bartkus and Conlon, (2008), a good hypothesis statement is a guess of the solution – not a fact – and the more thought-provoking, the better. They also argued further that it must also be specific to the situation, debatable, actionable, and relevant to future decision making. In the introduction the researchers determined the problem and simplified it with the statement below:

How should a business improve performance, increase customer satisfaction, and return on investment (ROI) by adopting RFID technology within a short time frame?

The next sections identified correlation between different issues and the business goals and objectives and concluded with a strategic solution.

5.2 Identifying Issues

From the literature review and the empirical findings we identified some specific issues relevant to RFID adoption. These issues are defined in the hypothesis H1 to H13
From the conceptualised RFID adoption process model in a socio-economic and collaborative supply chain environment (See figure 3.1) we introduced a relationship between the Mandate, Legislative regulations, Competitiveness, level of Knowledge and adoption Strategy: $\boldsymbol{f(M, L, C)} = S\boldsymbol{f(K)}$
By using a table of Hypothesis Statement and Problem-solving background, a clear outlook of the summary and the correlation with the hypothesis statements H1-H13 was simplified before disaggregating the problems into issues.

5.2.1 Disaggregating the Problem into Issues: Issue Tree

Issue Tree Tool was used to simplify the complexity of the problem solving background. This tool organises all possible solutions in a mutually exclusive and collectively exhaustive (MECE) way that shortens to possible strategies (See Figure 2).

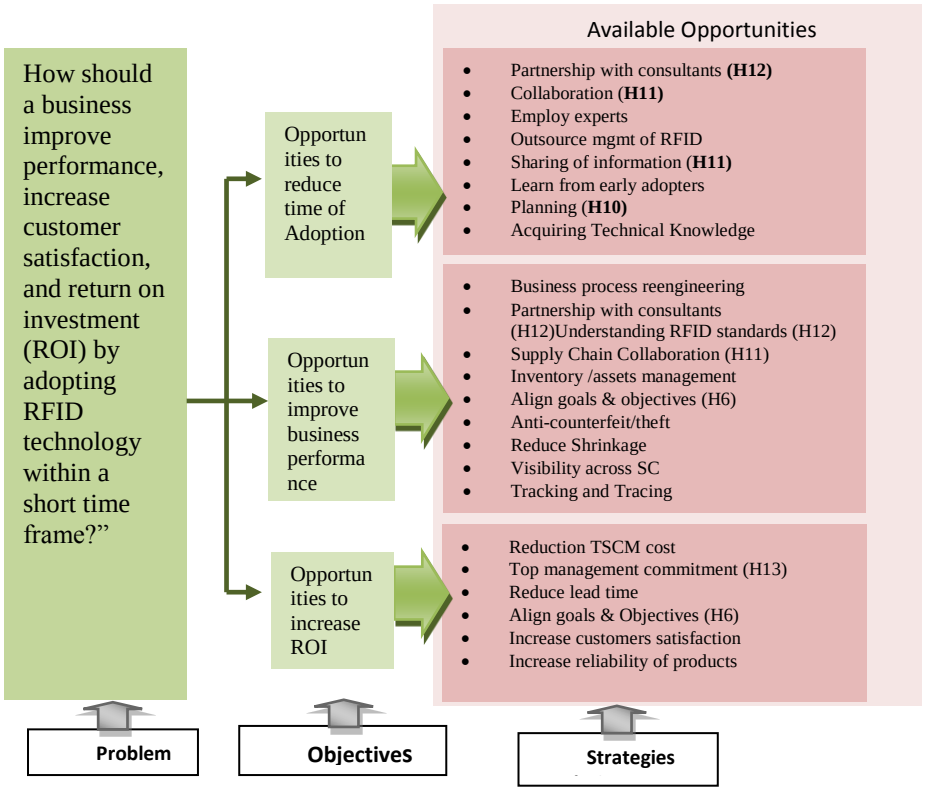

Figure 2 RFID Adoption Issue Tree showing various opportunities

5.3 RFID adoption Strategy and RFID Adoption Readiness Model

In order to simplify and gain more insight into the relationship between the hypothesis, Figure 3 further disintegrates the issue tree with relevant adoption strategies that were identified in the various opportunities available for achieving Improve Business Performance (IBP), Return on Investment (ROI), and Timely Delivery (TD).

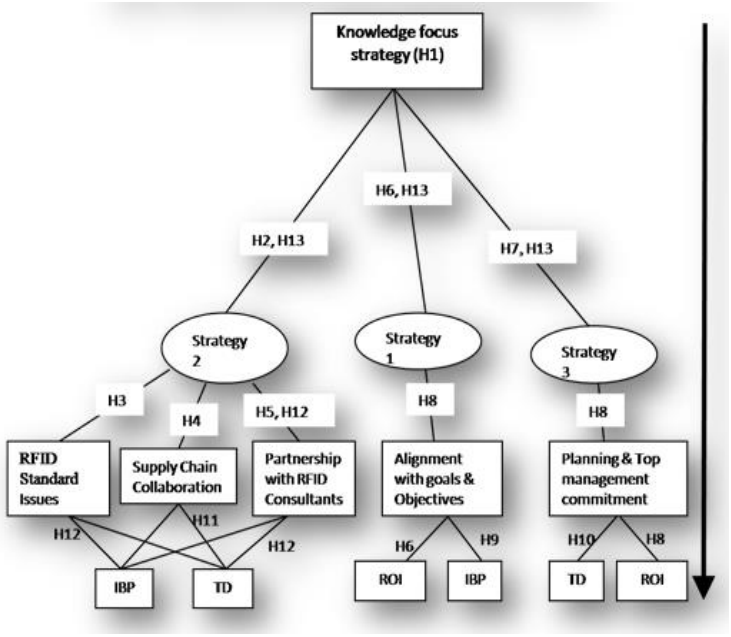

Figure 3- Relevant strategies for RFID adoption

A simplified RFID adoption readiness model is proposed (see Figure 4). The model incorporates the three strategies identified in the problem solving framework. By overlapping the three strategies in a pictorial form, the expected outcomes (ROI, IBP, & TD) connect the three strategies thus, implying they are dependents in achieving a successful RFID enabled business.

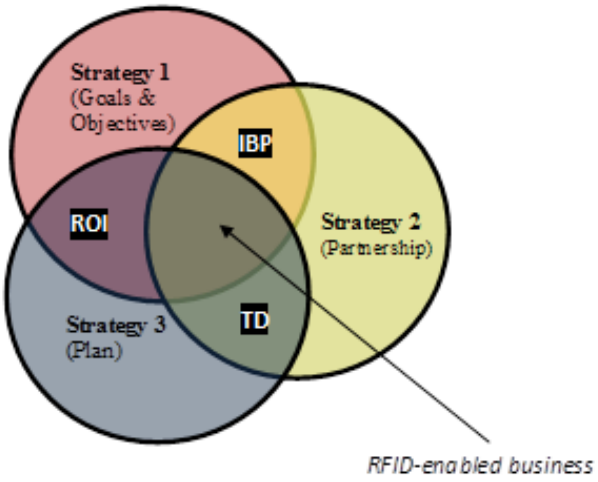

Figure 4- RFID adoption readiness model

Strategy 1

The strategy 1 has to do with aligning the issue of RFID adoption with the company goals and objectives such as financial benefits, customer satisfaction, improve business performance (IBP), efficiency, effectiveness and ROI (see H6). Have a clear plan on how to go about adopting RFID technology (see H8, H9, & H10); the existing technology readiness model could be advantageous to evaluate the resources of the company (Essex, 2011). The key strategy here is the top management commitment (H13) in undertaking the project.

Strategy 2
Strategy 2 identifies the business issues and challenges in meeting the external pressure demands. Issues such as lack of technical knowledge (H2), Training, RFID standard issues (H2), Resources requirements, Short time for compliance, and interference and attenuation issues, such as the use of RFID in the surroundings of liquids or metals are identified. To guarantee improve business performance and timely delivery, the model suggest collaboration with supply chain partners (H4 & H11) for sharing of information, resources and risk. The second strategy is to partner with RFID consultants (H5 & H12) to ensure valuable experience, expertise approach and commitment to business issues such as RFID standards and tag frequency selection. Early adopters have used this strategy to achieve business process reengineering that ensures improve business performance and timely delivery.

Strategy 3
The third strategy in this model is to ensure successful delivery of the project in order to guarantee ROI, and timely delivery. Change management techniques and different project management methodology (see H7 & H8) is deployed here to achieve the business case. The use of six sigma tools in achieving near-zero defects result is also advisable in this strategy. Planning and Top management commitments (H13) are identified as major strategy to achieve return on investment and timely delivery of the project.

6. CONCLUSION

In this study, we have explored the motivations and barriers to RFID technology adoption for a successful time performance target within a strategic supply chain. We have proposed adoption strategy framework that supports successful RFID-enabled business under increasing external pressures in a global supply chain. The RFID Adoption Strategy (RAS) has its focus on Return on Investment (ROI), Improved Business Performance (IBP), and Timely delivery (TD) of the adoption process.

The RFID Adoption Strategy model incorporates three dependent strategies identified in the problem solving framework. The first strategy analyses and aligns the identified issues of RFID adoption with the company goals and objectives such as financial benefits, customer satisfaction, improve business performance (IBP), efficiency, effectiveness and ROI. The key strategy here is the top management commitment in undertaking the project.

The second strategy identifies lack of knowledge and RFID technical skills as the main business issues and challenges in meeting the demands of external pressure within a limited time and maintaining improved business performance. This key strategy is to partner with RFID consultant and collaborate with other supply chain partners.

The third strategy ensures successful delivery of the project in order to guarantee ROI, and timely delivery. Change management techniques and different project management methodology are deployed here to achieve the business case. The use of six sigma tools in achieving near-zero defects result is also advisable in this strategy. Planning and Top management commitments are identified as major strategy to achieve return on investment and timely delivery of the project.

A further enquiry into early adopters' case study reports and the respondents' adoption strategy helped in the development of a RFID Adoption Strategy (RAS) for global businesses under external pressure. The model has been applied and validated in real industrial situations and the results are promising. Further work is underway to design and develop sector specific tool kits.

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