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REAL OPTIONS FROM RFID ADOPTION: THE ROLE OF INSTITUTIONS AND MANAGERIAL MINDFULNESS

Les options réelles de l'adoption de la RFID : le rôle de l'attention portée par les institutions et les dirigeants

Completed Research Paper

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Abstract

Widely hailed as the next generation auto-identification technology, RFID has captured the imaginations of organizations across different industry sectors. Accordingly, organizational managers are faced with the important but difficult task of evaluating RFID in the context of their organization and deciding upon its adoption. This research uses the real options perspective to understand how managers' recognition of the real options from the adoption of RFID affects their adoption decision-making. Conceptualizing the recognition of real options as a sense-making exercise by managers, we investigate the roles played by the institution in which the organization operates, and managers' own mindfulness in recognizing these options. Using responses collected from 110 managers responsible for RFID adoption in their organizations, we demonstrate that managers recognize and value the presence of real options, and it affects their intention to adopt RFID. Both institutional factors and managerial mindfulness are found important in recognizing the real options.

Keywords: RFID, Real Options, IT Adoption, Institutional Theory, Mindfulness

Résumé

Nous recourons à un raisonnement par les options réelles pour étudier comment leur reconnaissance par les managers affecte leur décision d'adopter la RFID. En conceptualisant la reconnaissance des options réelles comme un exercice de création de sens par les managers, nous utilisons une méthode de recherche par enquête pour examiner le rôle joué par l'institution dans laquelle opère l'organisation, et l'attention du manager dans la reconnaissance de ces options.

Introduction

Information technology (IT) innovation is generally believed to impart strategic and competitive benefits to the adopting organization (Brynjolfsson and Hitt 1996; Kohli and Devaraj 2003; Mukhopadhyay et al. 1995). However, it also involves significant resource commitments on behalf of the organization, and chances of failing to successfully implement the technology or to appropriate business value from it are often quite high (Melville et al. 2004). Thus, organizational decision-makers are faced with a complex decision-making scenario of deciding to adopt a technology that is relatively new and uncertain in terms of expected outcomes, but calls for large resource investments, or embrace the risk of becoming saddled with outdated technology, and losing the flexibility to deploy new IT capability based on market requirements.

To explain organizational engagement with IT innovations and their adoption, previous research has examined the role of different technological, organizational and environmental factors (classified under the TOE framework), and used different theoretical perspectives to hypothesize relationships between these factors and diffusion and adoption of IT in organizations. For example diffusion of innovations theory (Rogers 2003) has been used to predict the influence of different technological factors on IT adoption, and the institutional theory (DiMaggio and Powell 1983) has been used to predict how different institutional factors affect adoption behavior (e.g., Teo et al. 2003). The role of organizational factors (viz. top management support) in influencing IT adoption has also been investigated.

In spite of the focus on technological, organizational and environmental factors, researchers have acknowledged that whether, when and how to innovate with IT is a complex and crucial question faced by managers in almost all organizations and also acknowledged the role of managerial sense-making in organization engagement with an IT innovation (Swanson and Ramiller 1997; 2004). However, most of this research stops short of outlining the underlying decision-making process which organizational decision-makers go through in order to arrive at a decision related to the adoption of a given IT innovation. Therefore, little is known of how a manager's understanding of factors external to his organization, the technology and his own organizational context influences the decision process leading to IT adoption. This research uses real options perspective to understand the decision-making process that managers go through in the adoption of radio frequency identification (RFID) technology. We investigate the role played by the recognition of the real options in determining managers' intention to adopt RFID. Since real options are not generic, but depend on context specific factors, the role of institutions in making sense of these real options, and decision-makers' cognitive abilities in recognizing these real options are examined.

Real options theory is a useful framework for evaluating investment decisions under uncertainty (Dixit and Pindyck 1994; Trigeorgis 2001; Amram and Kulatilaka 1999). Compared to traditional techniques for evaluating investment decisions in organizations (such as net present value and discounted cash flow analysis), the real options approach recognizes the value of managerial flexibility in structuring and timing investment decisions in the face of uncertain conditions, varying levels of risks at different stages of an investment project and irreversible investments. Therefore, this approach is deemed suitable for application to the investigation of IT innovation adoption decisions, more specifically when the technology is relatively new and uncertain in terms of its likely outcomes; and managers have the flexibility of timing the adoption decision depending on factors such as prevailing market conditions and availability of information (Benaroch and Kauffman 1999; 2000; Fichman 2004b).

RFID technology satisfies many of the requirements for applying the real options thinking. Organizational decision makers may intuitively realize the strategic potential from investing in RFID even if initial returns look unfavorable. They are likely to appreciate the current uncertainty pertaining to the technology and the way it is going to evolve over time, thus making it prudent to wait for more information to arrive before investing in the technology. Further, they might also realize that while investing in RFID is somewhat irreversible, they have the flexibility of structuring the investment project in small incremental steps. The recognition of these real options is likely to influence

organizational decision-makers intention to adopt by influencing the sense-making and justification process that managers go through when evaluating RFID adoption.

Theoretical Background

Real Option Analysis

Real options analysis is a method to evaluate investment decisions under conditions of high uncertainty, irreversibility of costs and relatively high managerial flexibility in structuring the investment (Dixit and Pindyck 1994). A real option is a limited commitment investment in physical and human assets that provides the opportunity to respond to future contingent events should the payoff look attractive (Kogut and Kulatilaka 2001; McGrath and MacMillan 2000). The notion of real options is derived from financial investment options, however, they are less liquid and the option value is contingent on firm-specific factors, as the real value of an investment to one firm differs a lot from its value to another firm.

The different real options identified in prior research are *growth option*– the future growth opportunities that can be realized from an initial investment, *deferral option* – the option to wait and delay an investment till more information arrives, *learning option* – the option to learn and gather information and reduce uncertainty through an initial investment, the *option to stage* – the choice of breaking up an investment into incremental conditional steps where each step is carried out after the successful completion of prior steps, *option to change scale* – the flexibility to respond by altering the capacity, *option to switch* – put the initial investment into an application different from what it was initially intended for, and *option to abandon* – the option to discontinue a project (Brach 2003; Kogut and Kulatilaka 1994; Fichman et al. 2005; Tiwana et al. 2006; Tiwana et al. 2007).

Real options analysis has been used to evaluate investments in real estate, natural resources, capital budgeting decisions, research and development projects, etc. When using real options analysis, researchers typically identify scenarios that are amenable to the real options analysis, and then analyze whether the given investment situation satisfies the prescriptions of real options analyses. For example, McGrath and Nerkar (2004) analyze a sample of pharmaceutical firms to show that their R&D investments are consistent with the logic of real options reasoning. In another example, Benaroch and Kauffman (2000) analyzed the scenario of a bank's investment in point-of-sale debit card network and found that the deferral option was significant. In reality, the bank's actions also reflected the recognition of the deferral option, thus validating the real options reasoning.

IT projects are found to possess characteristics that make them amenable to real options analysis. For instance, investments in IT are often characterized by high uncertainty (such as uncertainty regarding the future of the technology under consideration, uncertainty regarding technical details and uncertainty regarding the business and market conditions). According to the options theory, real options are more valuable under conditions of greater uncertainty, since uncertainty raises the value of managerial flexibility provided by the real options. Therefore, the real options perspective becomes applicable for analyzing IT investment scenarios with a high level of uncertainty.

In IS research, real options theory has been used for evaluating IS project continuance and escalation, IT innovation adoption decisions, and managing risks in IT investment projects (Kambil et al. 1993; Benaroch and Kauffman 1999; 2000; Taudes et al. 2000; Fichman 2004b; Tiwana et al. 2006). In addition to growth option, the different real options that are often associated with IT investments are the option to change scale of operations, the option to abandon, the option to defer an investment, the option to switch, the option to learn, and the option to stage the investment. For instance, while Taudes et al. (2000) investigated growth option conferred upon an organization by its initial investment in a SAP R/3 project, Benaroch and Kauffman (2000) investigated the deferral option in implementing a point-of-sale debit card network. Fichman (2004b) modeled the early adoption of IT platform as a real growth option and identified the determinants of option value of the project based on IS innovation literature. Tiwana et al. (2006) showed that the recognition of the different real options from an IS project could predict managers' intention to escalate and continue with the project under conditions of high uncertainty.

In the case of IT adoption, managers may have to decide between keeping their options open by deferring the adoption or securing a stake in the technology by deciding to adopt. Therefore both growth options and deferral options will influence the decision to adopt RFID. From the real options perspective, investment in RFID can be viewed as a real option, which confers upon the organization, a right, but not the obligation to make further investments, should the initial results look attractive. To decide on making the initial investment, managers are

likely to also consider the value of other options that are embedded in the adoption decision, such as the option to learn from the initial project and the value of this learning for future use and exploitation of the technology, or, the option to stage the investment in small incremental steps i.e., the staging option (Brach 2003; Trigeorgis 2001).

An investment has different value for different organizations depending on the contextual factors within which the investment is made. Thus, using real options analysis to evaluate IT investments is considered difficult because the real options that an organization can recognize from the adoption of an technology is not generic for all organizations, but vary depending on characteristics that are unique to the adopting organization and also the decision-maker responsible for evaluating the IT. For example, RFID technology can have different implications for different organizations based on the prevailing business conditions that the organization operates in, and the effect of external factors such as competitors, trading partners, governmental regulations, etc. It has been shown that institutions play an important role in the adoption of IT innovations (e.g., King et al. 1994; Teo et al. 2003). Institutions can also play a somewhat indirect role by helping in making sense of the innovation and perceptions regarding its legitimacy, desirability, etc. (Swanson and Ramiller 1997). The role of institutions is particularly pronounced when an IT innovation is in its early stages of diffusion because of the associated uncertainty and lack of sufficient information or understanding regarding the technology. Under such circumstances, managers are likely to take cues from the external environment, such as actions of other organizations that have direct or indirect influence over the actions of their organization. Therefore, institutions are likely to affect the recognition of real options from RFID, especially when the value of the option comes from a promise of strategic and competitive benefits that can be obtained from the technology.

Previous research has indicated that managerial cognition plays an important role in strategic decision-making (e.g., Schwenk 1988). Therefore, in addition to the inherent characteristics of the technology, such as the uncertainty associated with its development and evolution, and the role of institutions, the cognitive characteristics of the manager who is responsible for RFID adoption within the organization are likely to affect the recognition of real options from the adoption of RFID. Managerial mindfulness (which can be defined as the cognitive ability or capability of the manager) in innovating with IT refers to the act of making contextually nuanced decisions based on factors that are relevant to their organization (Swanson and Ramiller 2004). Mindful managers are likely to consider the implications of RFID on their organization based on their own organizational facts and specifics. Accordingly, they will be in a better position to appreciate and recognize the different real options that the adoption of RFID will provide to their organization. Therefore, we discuss the role of managerial mindfulness in the recognition of real options from RFID adoption.

An Overview on RFID

RFID is a wireless tracking technology that uses radio frequency communication to automatically identify, track and manage objects, people or animals. Objects to be sensed are tagged with electronic radio frequency tags, and tag readers are used to read the data contained in the tags. The type of tag used and the data stored in the tag varies from application to application. The information stored in the tags can range from static identification numbers to user written data to tag sensory data.

The June 2003 Wal-Mart mandate to its suppliers to start using RIFD tags by January 2005 was a major instigating factor causing a sudden leap in the industry and public interest in RFID technology (Curtin et al. 2007). Consequently, many companies are now engaged in implementing pilot projects on RFID to understand the potential of this technology and evaluate the business case for adopting RFID. RFID dramatically increases the potential for organizations to collect data about any tagable entity, and has implications for supply chain management, human resources management, customer relationship management across different industry sectors such as in transportation and logistics, healthcare, aerospace, manufacturing and retail consumer goods industry. In spite of its manifold applications, and promising future applications, issues such as high cost of tags, technical uncertainties over possible configuration for tags and tag-readers, differences in available frequency bandwidths, social concerns regarding loss of privacy and security, etc. are some of the factors that result in uncertainty over the future destiny of the technology and its outcomes. While on one hand these issues are deterring the widespread diffusion and adoption of RFID, on the other hand, these are also the factors that make the decision to adopt RFID amenable to real options analysis.

Role of Institutions

Modern day organizations operate in complex dynamic environments and have business relationships with multiple external parties. Under such circumstances, their decisions and actions are often determined by a consideration towards factors external to their own organization such as market dynamics, regulatory institutions, and, the actions of dominant industry players, and trade and industry associations (DiMaggio and Powell 1983). This has been found to hold true in the context of IT adoption as well, both for technologies that are adopted within the organization or technologies that span organizational boundaries (Teo et al. 2003). Coercive, mimetic and normative forces (DiMaggio and Powell 1983) are the three different mechanisms through which institutions regulate and influence the actions of organizations. Accordingly, institutional influences and regulations (King et al. 1994) are likely to increase the strategic and competitive value of the adoption project, because RFID can not only be applied to functions and processes within the organization, but can also facilitate inter-organizational IS linkages. In addition, RFID is currently still evolving in terms of technology related issues, the cost of the technology, and issues related to integration with other information systems. Under such circumstances, the actions of other potential adopters, trading partners or those of regulatory bodies are likely to play an important role in determining how managers perceive the value of the technology based on its current and future prospects (Swanson and Ramiller 1997).

Mindfulness

Mindfulness has been described as a cognitive ability or cognitive style (Sternberg 2000) that characterizes active information processing and is reflected by openness to novelty, alertness to distinction, sensitivity to different contexts, awareness of multiple perspectives, and orientation in the present (Langer 1989; 1997). Originally defined as an individual level characteristic, mindfulness was subsequently extended to the organization level (Weick 1995; Weick and Sutcliffe 2001) where it can be thought of as a desirable property or state that organizations should strive to achieve, since it is likely to make them more adept in managing the unexpected.

It has been proposed that mindfulness can be used to analyze organizational engagement with innovations (e.g., Fichman 2004a; Fiol and O'Connor 2003; Swanson and Ramiller 2004), because innovations incorporate concepts of newness or novelty, and IT innovations that are adopted in organizations are often characterized by new and complex technical knowledge and process changes, resulting in unexpected or uncertain outcomes. When engaging with an IT innovation, mindfulness pertains to attending to the innovation with a contextually differentiated reasoning based on the organization's own facts and specifics (Swanson and Ramiller 2004). Therefore, mindfulness is likely to have implication in RFID adoption, because the decision of evaluating RFID underlines an organization's attempt to make sense of an uncertain scenario that can result in unexpected outcomes.

In organizational adoption of innovations, mindfulness has been considered as both an organization-level property (Swanson and Ramiller 2004), and an individual decision-maker characteristic (Fiol and O'Connor 2003). Since managers are responsible for fostering mindfulness in their organization, it has been suggested that organizational mindfulness is a consequence of the mindfulness of its managers and decision-makers (Swanson and Ramiller 2004). Therefore, this study investigates the role of managerial mindfulness in the adoption of RFID.

Research Model and Hypotheses

RFID is gaining popularity as the next generation auto-identification technology with the potential to collect vast amounts of data and endow efficiencies across the value chain of different industries. At the same time, there are significant uncertainties associated with the development of the technology. These two characteristics make the adoption of RFID technology a suitable context for applying the real options theory.

Previous applications of real options analysis in IS research is primarily based on quantitative analysis of IT investment options using financial option pricing models such as the Cox-Rubenstein model or the Black-Scholes model, and estimating the model parameters (Benaroch and Kauffman 1999; 2000; Taudes et al. 2000). However, uncertain opportunities are often difficult to quantify since the actual value of an investment is idiosyncratic, and depends on organization-specific factors such as the configuration of competencies and resources already belonging to the firm and the market in which the firm operates. Quantification of real options under such circumstances can call for too many assumptions and simplifications to be of informational purposes as there is limited information regarding the model parameters (McGrath and MacMillan 2000; Fichman 2004b). However, this can be overcome

by managers applying real options reasoning to recognize the value of the different options that the adoption of the technology provides, even if they are not able to quantify the value. In fact, past research has already shown that managers intuitively rely on real options reasoning to justify their decisions regarding different IT projects such as a willingness to escalate and continue with the project even when the net present value of the project is not favorable (Tiwana et al. 2006). IT managers took actions and/or gave rationales consistent with options thinking even when real options reasoning was not used formally for project assessment (Fichman et al. 2005)

In RFID adoption, employing the real options framework as an intuitive and analytical tool can help managers in reconciling conflicting assumptions and expectations within the organization in order to arrive at better adoption decision-making. This study identifies the real options that managers are likely to recognize from RFID technology and how recognition of these real options influence their intention to adopt the technology. The role of institutions and managerial mindfulness in recognizing these real options is discussed.

Options Realized from RFID

IT projects create different real options depending on the context in which they are carried out. For instance a decision to outsource IT operations confers the option to change scale, and the option to switch, while adoption of a technology such as RFID can confer growth options or deferral options, depending on the organization's prevailing conditions. The option to stage is available when a technology can be implemented in a series of small incremental steps. Learning options are conferred upon the organization, when there is significant value in learning or gaining knowledge from the adoption of an IT innovation. Even for the same technology, different options are likely to be used to evaluate the technology at different phases in the adoption and implementation process. For example, while growth option, deferral option or the option to learn are likely to be more important in the pre-adoption phases, the option to abandon, the option to change scale and the option to switch use are more relevant when an organization is considering salvaging a situation that has not worked out as planned, and therefore, these options are likely to be more valuable after the adoption decision has been made, and there are periodic evaluations of the status of the implementation project. Also, prior survey results have shown that managers are less appreciative of options that only serve to curtail losses such as the abandonment option (Busby and Pitts 1997; Tiwana et al. 2006). Therefore, although seven different types of real options have been identified in literature, it is unlikely that all the options will influence managerial decision-making for every IT adoption project.

Accordingly, when considering RFID adoption as an investment project, managers are likely to appreciate the options that have positive or optimistic connotations. Therefore, growth option, which enhances the value of the adoption project by opening up possibilities of future add-on projects, learning option, which derives value from the opportunities of learning and gaining knowledge from the adoption of RFID, and the option to stage – which gets value from the realization that investment in the technology can be carried out in incremental steps, rather than having to outlay a large amount of resources in order to carry out the adoption project are identified as the three real options that are likely to be appreciated in considering RFID adoption. These options will positively affect managers' intention to adopt by increasing the potential value of the initial investment.

When evaluating RFID adoption, managers are still in the process of deciding on the timing of the adoption project, therefore, they are likely to appreciate the value of deferral option, since prevailing internal and external conditions may suggest that there is more value in deferring or delaying the investment in RFID. Therefore, recognition of the deferral option will have a negative impact on the intention to adopt RFID. The option to change scale, the option to switch use or the option to abandon are likely to be less important in the pre-adoption phase for RFID technology, but increase in value once the technology has been put into place and periodic evaluation and assessment of the overall implementation and adoption project is being carried out. Therefore, growth, learning, staging and deferral options are the four different real options that are assessed in this study in the context of RFID adoption.

Growth Options

Software growth options embedded in an information system is defined as the possibility to introduce new IS functions after the base system has been installed (Taudes 1998). Information systems that are easily adaptable to changing business scenarios with the possibility of implementing add-on functions to the base system is considered to be of higher value to the organization because of the growth options that can be realized from them. Investments in IT platforms such as an ERP application or in IT infrastructure are viewed as positioning investment because they open up opportunities for further investment (growth options) in other information systems (Taudes et al. 2000).

Adoption of RFID technology can be considered as the source of future growth options for the organization because by adopting RFID the organization comes to possess the option of integrating the RFID system with its existing supply chain management system or inventory systems. Innovative marketing initiatives can be designed and executed by building on and adding features to the basic RFID system. RFID confers upon the adopting organization options for implementing a wide array of novel IS functions when they are called for. Other than the immediate benefits derived from the system in terms of operational efficiencies, growth options derived from the adoption of RFID technology contributes to the overall value of the technology. Thus, recognition of the growth options from RFID technology will positively influence a manager's intention to adopt the technology.

H1: Recognition of growth options derived from RFID will positively influence the intention to adopt RFID.

Learning Options

When faced with the option to invest in a new technology with uncertain benefits, there is a strong incentive for an organization to adopt some form of active information gathering (McCardle 1985). For instance preliminary market survey to judge the economical and technical feasibility of a product before it has been launched or development of a small prototype in the case on many IT projects can be viewed as an investment to gather information and reduce uncertainty before undertaking the actual project. Initial adoption of a technology may also be viewed as a positioning investment to gain first hand information and learning. The value of this learning is likely to be much more in the case of technologies that are shrouded in significant uncertainty regarding outcomes (Brach 2003). The knowledge gained enhances managers' flexibility on the deployment and execution of the project and increases the likelihood of success. Therefore, investment in an IT can provide an organization with valuable learning options.

Many organizations have already started pilot tests using RFID to gain insight regarding the technology. From a real options perspective, the adoption of RFID can be viewed as an investment to acquire the learning option, which derives value from the fact that it can help the organization in better decision-making, and improve the probability of success when the organization uses the technology for more advanced applications. Thus recognizing the learning options in the adoption of RFID technology will positively influence the intention to adopt the technology.

H2: Recognition of learning options derived from RFID will positively influence the intention to adopt RFID.

Staging Options

Information technology projects are often executed as a series of small projects which are of a more manageable magnitude. For instance, ERP implementation projects are usually carried out in incremental phases, with each successive phase starting after the completion of the previous phase. The option to stage is embedded in an IT adoption project when managers have the flexibility of deciding when and how to execute each incremental step. Staging IT projects derives value from the fact that organizations can manage their risk by cutting down the downward potential while retaining the investment option for favorable scenarios. This is possible because they have the option of timing the subsequent projects or even forgoing them depending on the situation.

RFID technology has a wide range of applications and can be used to facilitate B2B activities, intra-organizational operations, and several B2C activities. Organizations have the flexibility of deploying different applications as small individual projects. Some of these small projects may have dependencies requiring the successful completion of the previous project. For example, to be able to use the data captured by the RFID system for inventory management, the organization should have first installed the infrastructure for RFID technology, i.e., the tags to identify different objects and the tag readers. Similarly, in order to be able to use RFID for B2C marketing, the pre-requisite is to first tag individual items that are being sold. Thus, the adoption of RFID gives organizations the flexibility to sequence the implementation project, which in turn makes the initial adoption of RFID technology more attractive. Thus, recognition of the option to stage will positively influence the intention to adopt RFID technology.

H3: Recognition of the staging option derived from RFID will positively influence the intention to adopt RFID.

Deferral Options

When faced with the decision of adopting an information technology, organizations have the alternative of delaying the adoption in order to wait and see how the technology develops with time. The option to defer or delay derives

value from the fact that uncertainty gets reduced by the availability of more information as time progresses (Brach 2003). In IT adoption projects, the recognition of deferral option indicates that managers may be wary about the adoption based on facts and specifics pertaining to their own context or external environmental conditions, and consequently decide to forestall the IT project (Swanson and Ramiller 2004). Research has used real options analysis to show that based on situational information there was more value in deferring the deployment of point of sale debit services by a shared electronic banking network firm (Benaroch and Kauffman 2000).

In the case of RFID, the technology is evolving, standards are being finalized, and implementation and integration related issues are yet to be resolved. For example, currently RFID tags are incompatible with some metals, fluids; and frequency related issues often prevent their use in materials like aircraft parts. Given these characteristics, organizational decision makers might realize that there is value in deferring RFID adoption. Since the recognition of the deferral options implies that organizations are likely to wait for more information to be available and uncertainties to be reduced, it will negatively influence the intention to adopt RFID technology.

H4: Recognition of the deferral option derived from RFID will negatively influence the intention to adopt RFID.

Factors Determining the Recognition of Options

When considering the adoption of RFID technology, there are several factors that a manager is going to take into account in the decision-making process. As discussed, institutions are likely to play a significant role in shaping the perceptions of the decision-maker and the value that he recognizes from the adoption of RFID. In order to understand the role of institutions in the recognition of real options, we distinguish between institutional influences and institutional regulations. This distinction between influences and regulations is derived from the three elements of institutional structure – regulative, normative and cognitive elements which differ in terms of the mechanism through which the institutional forces act, indicators of their effects, and their basis for legitimacy (Scott 1995). The regulative pillar underlines coercive forces that are legally sanctioned, and are indicated by rules, laws and sanctions. The normative and cognitive pillars on the other hand result in normative and mimetic institutional forces that are morally governed and culturally supported. Normative and cognitive institutional effects are indicated by certifications, accreditations, prevalence and isomorphism (DiMaggio and Powell 1983; Scott 1995).

In RFID adoption, the regulative institutional pillar will result in institutional regulations – such as rules, sanctions and directives on the adopting organization from various institutional bodies such as regulatory government agencies, dominant trading partners (suppliers and customers) and industry and trade associations, etc. Regulations can be in the form of mandates from a dominant supplier or customer to adopt the technology (such as the Walmart mandate to its suppliers to adopt RFID), rules governing the RFID adoption, and standards set up by the government. Institutional influences will arise from the normative and cognitive pillars of the institution. Institutional influences will be in the form of normative and mimetic pressures on the organizations based on the actions of other members of the institution, such as trend setting organizations, competitors, and trade and industry association. Institutional influences exert persuasive control over the practices, rules and beliefs of those under the institution's sway (Kimberly 1979).

In order to be able to recognize the growth options from the investment, managers should be able to make sense of the technology by observing the effect or implication of the technology on other similar organizations that have already adopted. Actions from industry and trade associations that promote RFID will also influence the views and beliefs of the decision-maker that RFID adoption will give rise to the scope of future opportunities to be realized from the technology. Therefore, institutional influences will be positively associated with the recognition of growth options from RFID adoption.

H5: Institutional influence will be positively associated with the recognition of growth option from RFID.

Institutional regulations that legitimize RFID adoption and make it mandatory for the organization will result in the decision-maker realizing that the option to wait and watch does not exist, as there is a direct pressure on the organization to adopt. Therefore institutional regulations are likely to have a negative effect on the recognition of the deferral option. On the other hand, it is unlikely that the mere presence of regulations mandating RFID adoption results in the recognition of growth options.

H6: Institutional regulations will be negatively associated with the recognition of deferral option from RFID.

Organizational mindfulness is characterized by contextually differentiated reasoning (Swanson and Ramiller 2004). When faced with the decision to adopt an innovation, greater mindfulness aids in an expanded environmental scanning for information and context relevant interpretations of the available information leading to more discriminating decisions. Mindful individuals will have higher awareness regarding the technological developments in RFID and are pre-disposed towards carefully thinking through and analyzing all the related information that is available to them. Therefore, they are likely to be in a better position to recognize the different opportunities for growth that the adoption of the technology provides their organization with. Being aware of different perspectives and taking into account the facts and specifics of their own organizations will make decision-makers realize whether the timing is right for the adoption of RFID in their organization or whether there is more value in waiting for new information to reduce the uncertainty associated with the technology. Thus, decision-maker mindfulness is likely to have a positive influence in the recognition of real options from RFID technology.

Mindfulness among organizational decision-makers can also help in resisting bandwagon behavior. For innovations that have a favorable image based on the perception that it is a tried recipe for success (Spender 1989; Weick 1995), greater mindfulness among decision-makers might make them recognize that there is more value in deferring the adoption decision if their own organizational context calls for a "wait and see" approach rather than immediate adoption. On the other hand, for innovations that have an unfavorable image resulting in its rejection by most organizations, mindfulness can result in the decision-maker recognizing the future business opportunities generated by its adoption, in spite of the popular negative perception regarding the innovation. Therefore, mindfulness is positively associated with the recognition of growth option and the recognition of deferral option.

H7: Managerial mindfulness will be positively associated with the recognition of growth option from RFID.

H8: Managerial mindfulness will be positively associated with the recognition of deferral option from RFID.

Mindful decision-makers will have higher awareness regarding the technical details of RFID, and be able to contextualize their understanding of the technology to the requirements of their organization. They will be in a better position to appreciate what the technology affords in term of flexibility in structuring the adoption process. Therefore, decision-maker mindfulness will be positively associated with the recognition of staging option. Mindfulness in decision-makers will make them assign more value to any information or knowledge regarding RFID technology that not only informs their decision-making, but also help in giving a better understanding regarding the technology and how to go about implementing and applying it to their own organizational context. Therefore, mindfulness will make decision-makers recognize more value in the option to learn from RFID adoption. Figure 1 illustrates our basic research model and hypothesis.

H9: Managerial mindfulness will be positively associated with the recognition of learning option from RFID.

H10: Managerial mindfulness will be positively associated with the recognition of staging option from RFID.

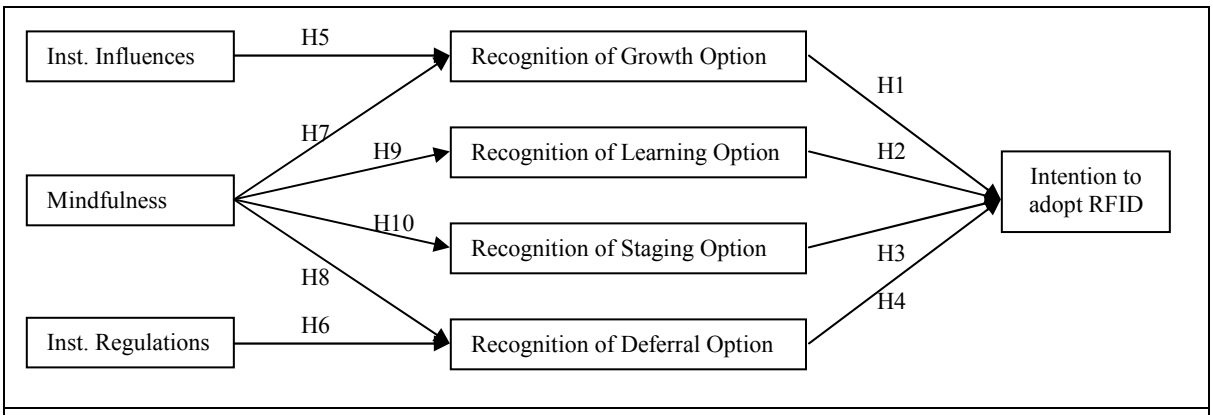

Figure 1. Research Model

Research Methodology

A questionnaire survey research methodology was chosen for this research because of the generalizability of results (Dooley 2001). The survey was carried out over a six month period in late 2007. The sample of our research comes

from Singapore based manufacturing and logistics firms. Manufacturing and logistics are two industry sectors where RFID has a very high potential for providing operational and strategic efficiencies. The unit of analysis is at the individual decision maker/ manager level within the organization.

Operationalization of Constructs

Wherever possible, we used instruments from previous studies to measure the constructs as this enhances validity (Stone 1978). Where no suitable instruments could be found, we developed new questions based on a review of the related literature. IS faculty members from a large Singapore based university were asked to assess the initial face and content validity of the measurement items and their feedback was used to refine the items. Following this, two rounds of questionnaire sorting exercise (labeled and unlabeled) was carried out based on Moore and Benbasat (1991). Four graduate students participated in each sorting exercise. For the unlabeled sorting exercise, the labels that the sorters came up with closely corresponded with the actual construct names and on the average more than 80 percent of the items were correctly sorted into their intended constructs. After refining the measurement items based on the results of the unlabeled sorting exercise, the labeled sorting exercise – in which the sorters were provided with the name and definition of each construct – resulted in an average of 94% of the items getting correctly sorted into their intended constructs, thus indicating a high level of face and content validity. All constructs except for institutional influence were measured on a seven-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree", ("Very Low" to "Very High" for institutional influence). Table 1 gives a brief description of the constructs, and the items measuring them.

Table 1. Operationalization of Constructs

Construct	Definition	Measurement Items
Recognition of Growth Options	Recognition of the value of future IT-related business and strategic opportunities from current adoption of RFID	RFID Adoption – *is a necessary foundation for future IT capabilities* (Tiwana et al. 2006); *gives us the possibility of implementing add-on applications later*; *opens up the possibility of designing new IS products and services around the RFID technology* (self-developed)
Recognition of Learning Options	Recognition of the opportunities to learn and get a better understanding of RFID from its current adoption	RFID adoption – *allows us to gain important knowledge related to the technology*; *enables us to accumulate valuable know-how for future use*; *keeps us abreast with the latest developments in RFID* (self-developed)
Recognition of Staging Options	Recognition of the option or to carry out RFID implementation in incremental steps	RFID adoption – *can be incrementally funded through investment in stages* (Tiwana et al. 2006); *can be carried out in a series of incremental steps*; *can be done through a step-wise execution of the adoption project* (self-developed)
Recognition of Deferral Options	Recognition of the value in delaying adoption of RFID based on prevailing conditions	In our firm – *RFID adoption can be deferred to some future period*; *there is more sense in not adopting RFID at the present*; *it is preferable to wait and see before deciding to adopt RFID* (self-developed)
Institutional Influences	Normative and mimetic pressures to adopt based on the actions of the other members of the institution	Extent of adoption of RFID by our competitors; Extent of adoption of RFID by our trading partners; Extent of promotion of RFID by industry, trade or professional bodies; Extent to which IDA and other professional bodies facilitate RFID knowledge and information sharing (Teo et al. 2003)
Institutional Regulations	Rules, sanctions and directives from other members of the institution guiding the actions of the organization.	Our trading partners (suppliers / customers) mandate RFID adoption; Government regulations make RFID adoption necessary; Suppliers of RFID offer subsidies/discounts to facilitate RFID adoption; Standardization or RFID bandwidth in Singapore make RFID adoption easy (self-developed)
Mindfulness in RFID Adoption	Attending to RFID with reasoning grounded in one's own organizational facts and specifics	When considering RFID adoption – *I take into account our firm's preparedness for the changes involved*; *my decision is based on reasoning grounded on our firm's own facts and specifics*; *I usually get new information from multiple sources for decision making*; *I am aware that there are multiple implications of RFID for our firm* (self-developed)
Intention to Adopt	The behavioral intention to adopt RFID	I am seriously contemplating RFID adoption in a year's time; It is critical for my firm to adopt RFID in a year's time; I am likely to adopt RFID in my firm in a year's time (Teo et al. 2003)

Survey Administration

Survey forms were mailed to top executives (CEO, CIO, Managing Director, etc.) of a list of firms obtained from the Singapore 1000 database. The survey questionnaire was accompanied with a cover letter with a brief description of the research project, and the recipient was requested to fill up the survey, or pass it on to a decision-maker within the organization who played a more important role in RFID adoption. The questionnaire contained a brief description of the RFID technology and some indicatory uses of the RFID technology. A copy of the completed research report with findings was promised as an incentive to the respondents. The completed survey forms were returned to the authors in envelopes with pre-paid postage. A total of 724 forms were sent, and we received 159 responses, thus giving a response rate of 22%. Out of the 159 responses received, 144 were found to be usable. Of these 144 responses, 34 responses came from managers whose organizations had already adopted and were using RFID and the remaining 110 were from non-adopters and are analyzed in this study.

Out of the 110 responses, 62 respondents were from the manufacturing sector, while 36 were from the logistics, the remaining 12 respondents had not specified their industries. The respondents were primarily from top-level senior executives within the organization, 74% of them having more than 10 years of overall experience and held job titles such as CIO, COO, Vice-President, Executive Director, General Manager and Senior Manager. In terms of educational qualifications, 36% of the respondents held post-graduate or above degrees, while 54% were graduates, the remaining had high school education or diplomas.

Data Analysis and Results

Partial least squares (PLS) was used to perform the data analysis using the software SmartPLS Version 2.01. PLS has enjoyed increasing popularity in recent years because its ability to model latent constructs under conditions of non-normality and in small to medium-sized samples (Chin 1998b). It allows researchers to specify the relationships among the conceptual factors of interest and the measures underlying each construct, resulting in a simultaneous analysis of the measurement model (i.e., how well the measures relate to each construct) and the structural model (i.e., whether the hypothesized relationships at the theoretical level are empirically true). Using the two-stage approach, we first examined the measurement model, and then the structural model.

Measurement Model

Internal consistency, convergent validity, and discriminant validity are assessed to validate the instrument (Gefen and Straub 2005). Internal consistency was examined using composite reliability, which in PLS relies on the actual loading to calculate the factor scores and Cronbach's alpha. In PLS, composite reliability relies on actual loadings to compute the factor scores and is a better indicator of internal consistency than Cronbach's alpha (Ranganathan et al. 2004). As shown in Table 2, the composite reliability for the constructs in the model were all above the suggested threshold of 0.7 (Chin 1998a; Chin 1998b; Straub 1989), thus supporting the reliability of the measures.

Convergent validity indicates the extent to which the items of a scale that are theoretically related are also related in reality. Convergent validity measures the correlation among item measures of a given construct using different methods of measurement. Table 2 presents information about the factor loadings of the measures of our research model. All items have significant path loadings at the 0.001 level. The average variance extracted (AVE) values are 0.604 or higher, above the recommended value of 0.50 (Fornell and Larcker 1981). Therefore, the convergent validity of the scales are acceptable.

There are two ways of assessing discriminant validity in PLS. The AVEs for each construct should be greater than the square of the correlations among the constructs, indicating that more variance is shared between the construct and its measurement items that with another construct represented by a different set of measurement items. In Table 3, the diagonal elements, which are the square roots of the AVE, are all higher than the correlations between the constructs. Another check of discriminant validity is to examine the factor loadings and cross loadings, which are shown in Table 4. Constructs get higher loadings from their corresponding items than from other items, and items

[1] Ringle, C. M., Wende, S. and Will, A. (2005): SmartPLS 2.0, www.smartpls.de.

load on their corresponding constructs higher than on other constructs, thus showing good discriminant validity (Chin 1998b). Overall there is high reliability, and convergent and discriminant validity.

Table 2. Psychometric Properties of Measurement Model

Construct	Item	Factor Loadings	Composite Reliability	AVE
Growth Option	GroOpt1 GroOpt2 GroOpt3	0.939 0.941 0.929	0.955	0.877
Learning Option	LrnOpt1 LrnOpt2 LrnOpt3	0.963 0.965 0.927	0.967	0.906
Staging Option	StgOpt1 StgOpt2 StgOpt3	0.938 0.929 0.949	0.957	0.882
Deferral Option	DefOpt1 DefOpt2 DefOpt3	0.868 0.890 0.869	0.908	0.767
Inst. Influences	InstInf1 InstInf2 InstInf3 InstInf4	0.914 0.891 0.945 0.899	0.952	0.833
Inst. Regulations	InstReg1 InstReg2 InstReg3 InstReg4	0.732 0.843 0.840 0.833	0.886	0.662
Mindfulness	Minful1 Mindful2 Mindful3 Mindful4	0.820 0.891 0.847 0.769	0.898	0.604
Intention to Adopt	AdpIntent1 AdpIntent2 AdpIntent3	0.946 0.917 0.906	0.945	0.852

Table 3. Correlations between Constructs

	Deferral Option	Growth Option	Inst. Influence	Inst. Reg-ulation	Intention to Adopt	Learning Option	Mindful-ness	Staging Option
Deferral Option	**0.875**							
Growth Option	-0.382	**0.936**						
Inst. Influence	-0.188	0.344	**0.912**					
Inst. Regulation	-0.255	0.226	0.593	**0.813**				
Intention to Adopt	-0.544	0.527	0.317	0.308	**0.923**			
Learning Option	-0.306	0.686	0.331	0.397	0.418	**0.951**		
Mindfulness	0.106	0.161	0.089	0.041	0.117	0.197	**0.777**	
Staging Option	-0.264	0.555	0.291	0.281	0.358	0.481	0.207	**0.939**

Note: Diagonal elements are the square roots of the average variance extracted (AVE)

Structural Model

Figure 2 shows the path analysis results. The model explains 42% of the variance in the intention to adopt RFID technology. Tests of significance were performed using the bootstrap resampling procedure. As hypothesized, recognition of growth option has a significant positive relationship with the intention to adopt, while recognition of deferral option has a significant negative relationship with the intention to adopt. However, the recognition of learning and staging option do not have any significant effect. Therefore, hypotheses 1 and 4 are supported, while 2 and 3 are not. For the determinants of the options, institutional influences are significantly associated with the

recognition of growth option, while institutional regulations have a significant negative relationship with the recognition of deferral option. Mindfulness has a significant positive relationship with the recognition of staging option and somewhat significant relationship with the recognition of learning options (at 10% level of significance), but no relationship with the recognitions of growth and deferral options. Therefore, hypotheses 5, 6, 9 and 10 are supported, while 7 and 8 are not.

Table 4. Factor Loadings and Cross-loadings

	Deferral Option	Growth Option	Inst. Influence	Inst. Regulation	Intention to Adopt	Learning Option	Mindfulness	Staging Option
AdoptIntent1	-0.544	0.446	0.245	0.286	**0.946**	0.367	0.113	0.279
AdoptIntent2	-0.451	0.573	0.268	0.249	**0.917**	0.467	0.137	0.395
AdoptIntent3	-0.514	0.434	0.370	0.319	**0.906**	0.318	0.070	0.313
DeferOpt1	**0.868**	-0.320	-0.143	-0.159	-0.517	-0.216	0.135	-0.170
DeferOpt2	**0.890**	-0.289	-0.182	-0.312	-0.452	-0.292	0.083	-0.265
DeferOpt3	**0.869**	-0.404	-0.169	-0.138	-0.457	-0.302	0.055	-0.264
GrowthOpt1	-0.354	**0.939**	0.355	0.239	0.512	0.626	0.123	0.502
GrowthOpt2	-0.370	**0.941**	0.313	0.180	0.499	0.636	0.152	0.514
GrowthOpt3	-0.349	**0.929**	0.295	0.214	0.466	0.668	0.178	0.546
InstInf1	-0.087	0.262	**0.914**	0.529	0.188	0.245	0.008	0.186
InstInf2	-0.062	0.187	**0.891**	0.583	0.235	0.252	-0.010	0.138
InstInf3	-0.187	0.337	**0.945**	0.563	0.328	0.344	0.068	0.285
InstInf4	-0.268	0.390	**0.899**	0.514	0.352	0.331	0.186	0.365
InstReg1	-0.113	0.116	0.435	**0.732**	0.259	0.242	0.018	0.239
InstReg2	-0.199	0.141	0.487	**0.843**	0.244	0.341	-0.061	0.257
InstReg3	-0.154	0.288	0.579	**0.840**	0.248	0.379	0.129	0.134
InstReg4	-0.248	0.189	0.455	**0.833**	0.260	0.319	0.058	0.265
LearnOpt1	-0.284	0.659	0.339	0.428	0.460	**0.963**	0.191	0.421
LearnOpt2	-0.300	0.696	0.327	0.358	0.384	**0.965**	0.168	0.477
LearnOpt3	-0.293	0.603	0.273	0.335	0.334	**0.927**	0.207	0.486
Mindful1	0.180	0.119	0.054	0.018	0.029	0.118	**0.820**	0.073
Mindful2	0.020	0.143	-0.009	0.003	0.135	0.222	**0.891**	0.162
Mindful3	0.087	0.132	0.122	0.088	0.104	0.201	**0.847**	0.221
Mindful4	0.091	0.138	0.124	0.015	0.103	0.095	**0.769**	0.207
StageOpt1	-0.266	0.491	0.302	0.342	0.389	0.451	0.202	**0.936**
StageOpt2	-0.223	0.533	0.211	0.172	0.291	0.431	0.167	**0.930**
StageOpt3	-0.250	0.546	0.295	0.253	0.315	0.472	0.211	**0.951**

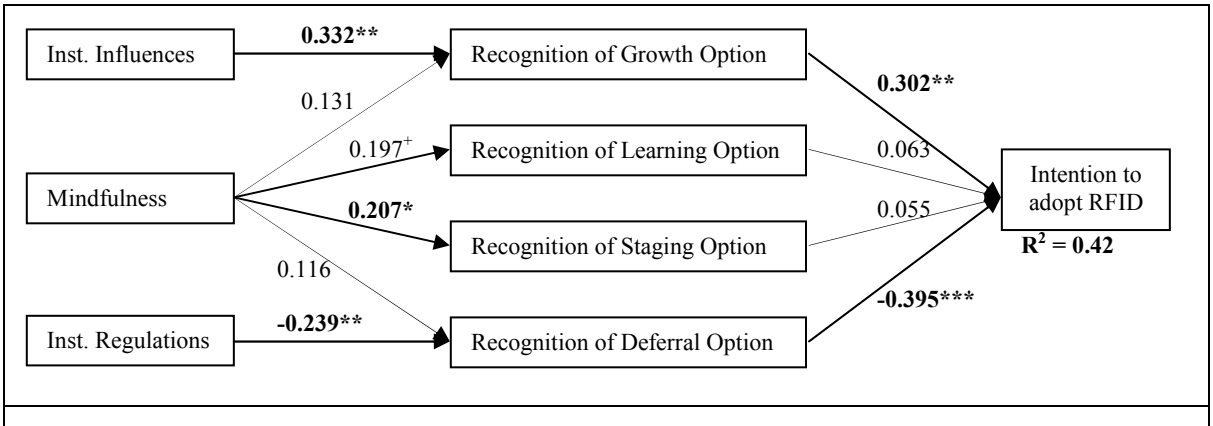

Figure 2. Results of Hypotheses Testing

+p<0.1; *p<0.05; ** p<0.01; *** p <0.001

Discussion and Implications

The primary finding of this study is that the recognition of real options from the adoption of RFID influences managers' intention to adopt the technology. As hypothesized, the recognition of growth options increases manager's willingness to adopt RFID, while the recognition of deferral option decreases the willingness to adopt RFID. However, the recognitions of staging and learning options are found to be insignificant in determining the intention to adopt RFID. The significant roles of growth and deferral options in the intention to adopt RFID suggest that managers recognize and implicitly value the real options in the technology.

The insignificant effects of staging and learning options could be because of the difference in importance that managers assign to the different options. Tiwana et al. (2006) suggested that managers assign more importance to strategic options (such as the growth option) than to operational options (such as staging, switch use, change scale, etc.). Growth option is considered a strategic option because it provides the opportunity for appropriating business value through the creation of additional assets from the adoption of the initial base system. For instance, initial investment into RFID will provide the organization with the possibility of implementing business processes and functions that build on the base RFID system. Similar to growth option, the deferral option can also be considered a strategic option because decision-makers may realize strategic value in deferring or delaying the adoption decision based on the organization's own business and IT strategies, the technological conditions and the prevailing environmental conditions. On the other hand, both staging and learning options are likely to be viewed as operating options because they will also have an effect on the operational success of the RFID adoption project by giving managers the flexibility of scheduling the adoption project, or making use of the knowledge gained from the initial investment into RFID.

Over time, organizational engagement of IT innovations has evolved such that current day organizations are more concerned with the expectation of strategic or competitive benefits that an IT innovation provides rather than the operational efficiencies that can be realized from the adoption of the innovation. This can explain why strategic options are significant in adoption decision-making while the operational options are not. Managers are more likely for make their decision to adopt RFID based on the strategic value or competitiveness that RFID affords. Therefore, the options that have strategic implications pertaining to the adoption of RFID are likely to be assigned higher importance. The operational options (learning and staging) on the other hand do not seem to influence the adoption decision because the value of these options are likely to be perceived as less strategic, and more for internal efficiency generating, and for the success of the adoption/ implementation project. We believe that managers will attribute more importance to these options once the decision to adopt RFID has been made, and they are more concerned with successfully executing the adoption project and implementing RFID.

The findings regarding the determinants of option value underline the above reasoning on the relative importance of the different options in adoption decision making. As predicted, institutional influences were significant in the recognition of the growth options, however managerial mindfulness was insignificant. This finding suggests that in the presence of strong institutional forces, managers anchor their perceptions and beliefs regarding the value of growth option from the adoption of RFID based on the actions of the institutions (trading partners, competitors, regulatory bodies, etc.) within which they operate, rather than their own mindfulness. This can happen due to the strategic nature of the growth option, where managers are likely to feel that they will gain legitimacy and hence strategic advantages within their institutional environment from RFID adoption (DiMaggio and Powell 1983), even if their own contextually grounded reasoning may suggest otherwise. Similarly, institutional regulations have a significant negative association with the recognition of deferral option, because in the presence of rules, laws and sanctions that mandate or necessitate the RFID adoption, the option to delay RFID adoption will not be available to managers. Mindfulness was found to be insignificant in deferral option, because managers' own beliefs and perceptions regarding the value of deferring RFID adoption is overruled in the presence of institutional regulations.

Combining the findings regarding the relationship between the recognition of the strategic options (growth and deferral) and the decision to adopt, and the significant relationship between the two institutional effects (influences and regulations) and the recognition of options indicate that in the initial stages of adoption, organizational decision-makers are more inclined towards complying with the requirements of the external institutional environment in order to realize strategic benefits, especially in the presence of strong institutional influences and regulations. Therefore, compliance is viewed by them as a value-generating option form the adoption of RFID. Accordingly, it is possible to visualize compliance as a real option from the adoption of IT innovations in the presence of strong institutional pressures.

Mindfulness was found to be significantly associated with the recognition of staging option and somewhat associated with learning option. This suggests that managers who are prone to be more contextually grounded and differentiated decision-making, are likely to recognize the value from staging and learning options. These managers are able to see beyond the adoption and also understand the day-to-day implications of the RFID adoption project. However, since the option to stage and/or the option to learn are unlikely to result in strategic gains, they are not significant in the formation of the intention to adopt the technology.

Our findings regarding the effect of mindfulness on the recognition of different options can be explained using prior research on mindfulness in the organizational context. It has been suggested that mindfulness and its anti-thesis mindlessness are often complementary to each other (Levinthal and Rerup 2006) and organizations are likely to choose between mindfulness and mindlessness based on different innovations and during particular periods of their engagement with an IT innovation (Swanson and Ramiller 2004). Mindlessness is more likely in initial engagement with the technology, while mindfulness will be more observable during prolonged engagement with the technology. In our study all respondents are in the pre-adoption phase, and since strategic options are very important in the pre-adoption phase, these options are considered important by managers regardless of their mindfulness levels. In other words, the ramifications of mindfulness are ignored by managers in recognizing the options and that influence their RFID adoption decision. In contrast, operational options, that are likely to be valuable in the post-adoption phase, which is far in the future for organizations at the pre-adoption phase, are considered more important by managers with higher levels of mindfulness.

Limitations

The survey research methodology used to test the research model in this study allows for generalizability of results, however, the cross-sectional data collected through the survey only allows us to predict associations among the different constructs rather than the direction of causal relationship. Therefore, future research can aim in collecting longitudinal data in order to examine how the recognition of the different options change over time and the varying effects of mindfulness / mindlessness over the course of an organization's engagement with RFID. For instance, the findings for this study showed that for prospective adopters, growth and deferral options play an important role in the decision to adopt; however, learning option and the option to stage are not significant in the option to adopt. Longitudinal data or field studies may help in finding out if the importance of these options increases once the decision to adopt RFID has been made. Secondly, based on a sample size of 110 respondents, the research model was empirically tested and several significant results were obtained. A larger sample size would have allowed for more statistical power in predicting the relationships. Finally, the findings from this study can be corroborated and refined through the use of qualitative data in the form of one-to-one interviews with managers and decision-makers within organizations. While it is somewhat difficult to capture qualitative data simultaneously with a large-scale sample survey, future research can be targeted towards better understanding the recognition of real options form IT adoption by triangulating from the findings of both qualitative and quantitative studies.

Conclusion

This study develops and tests a theoretical model that predicts how the recognition of the different real options from RFID affects the managerial intention to adopt RFID. This study corroborates the findings of previous research in innovation diffusion by showing that institutions play a significant role in predicting adoption behavior or the intention to adopt. By employing the real options perspective, we show that the recognition of different real options can mediate the effect of strong institutional forces on adoption decision-making. This study also investigates the role of managerial mindfulness in the recognition of the different real options from RFID technology. The findings of this research shed some light to the debate over whether mindfulness and mindlessness can co-exist in organizational engagement with innovations by showing that recognition of some options may be affected by managerial mindfulness, while others are not. Future research can be directed towards designing empirical studies to gain a better understanding on the role of real options and the complementary influences of mindfulness and mindlessness in organizational adoption of IT innovations.

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