A stage-based model for RFID assimilation processes by supply chain participants in China

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ABSTRACT

RFID technology is an emerging technology that attracts attention of supply chain participants. However, most Chinese supply chain participants just adopt this new innovation without making further steps to fully utilize its benefits. Extant IS research on this technology also only focuses on factors that will impact its organizational adoption. Assimilation theories suggest that most information technologies exhibit an "assimilation gap" which means the widespread usage tends to lag behind their adoption. But a technology can only achieve its greatest benefits through full-scale deeper diffusion into the organization's daily operations besides physical adoption. Drawing upon TOE framework, we use a stage-based model to investigate factors that influence the assimilation of RFID into an organization. Moreover, we investigate these factors' changing effect across different assimilation stages in the Chinese context which is addressed little in the previous literature.

Keywords (Required):

Innovation diffusion, assimilation, RFID technology, TOE framework, stage-based model

1 INTRODUCTION

In recent years, RFID has emerged as a new technology to increase operations efficiency in warehouse management and inventory monitoring. Compared with traditional bar code, RFID can identify tagged products without line of sight and track the status of products when they are received or shipped away from the warehouse in real-time. Therefore, product inventory status can be captured with less labor force and increase inventory management efficiency.

The benefits resulting from this technology innovation may be curtailed if it cannot be widely adopted (Zhu, Kraemer, Gurbaxani, & Xu, 2006). Adoption is just one part of an innovation assimilation process, which cannot ensure wide-scale assimilation. Only through wide-scale assimilation of RFID can its benefits be realized. As indicated by Chatterjee et al. (2002b), many firms have failed to achieve deep usage beyond initial adoption. Most recent IS research on RFID focus on a single stage such as one-shot adoption decisions. According to the literature review of Fichman (1999)and Zhu et al. (2006), the post adoption stages of assimilation are especially worthy of a focused study.

This research will fill the research gaps and investigate various factors' changing effects on each stage of assimilation processes. As indicated by Fichman (1999), it is necessary since the same factors may have "differential effects," depending on the stages of assimilation. Similar to the definition of e-business assimilation by Zhu et al. (2006), RFID assimilation is defined as a series of stages from a firm's initial evaluation of this technology at the pre-adoption stage (initiation), to its formal adoption, and finally to its full-scale deployment at the post-adoption stage in which RFID becomes an integral part of the value chain activities (routinization).

Further, it is also important to identify antecedents that influence RFID assimilation. According to Roger's innovation diffusion theory, some of technology characteristics which will influence innovation diffusion are relative advantage, complexity, and compatibility. Beyond technology perspective, Chatterjee et al. (2002b) identified organizational enablers including management support and cross-department coordination. Moreover, influences from the environment could also affect RFID assimilation (Teo, K.K.Wei, & Benbasat, 2003). However, there is a lack of literature which integrates these different factors into a single research framework. Thus, we develop an integrated model to investigate different contextual factors' effect.

Motivated by the above theoretical gaps, we propose an integrative model to address the following questions: (1) which factors (including technological, organizational, and environmental factors) would impact RFID assimilation? (2) How do these different factors impact each assimilation stage? An integrative theoretical model combining the innovation diffusion theory, institutional theory, and stage-based model will be built to investigate these problems. Our research model will be tested through data collected from supply chain participants in China which have already adopted RFID technology in different stages.

Structural equation modeling will be used to test each factor's importance across three assimilation stages.

2 THEORY OF INNOVATION ASSIMILATION AND STAGE-BASED MODEL

2.1 THE STAGES OF INNOVATION ASSIMILATION

Innovation assimilation is a dynamic and complex process, which means a multi-stage analysis is necessary to better understand the assimilation processes. In this section, extant stage-based models and their corresponding tasks are introduced.

In order to describe the phenomenon of a system implementing organizational innovation, Lewin (1952) propose a three-stage change model including unfreezing, moving, and refreezing. Meyer and Goes (1988) categorized assimilation into three primary stages: knowledge-awareness stage, evaluation-choice stage, and adoption-implementation stage with each of these primary stages having three sub-stages. Cooper and Zmud (1990) identify that assimilation can be viewed as a six-stage process from initial adoption to a complete infusion. Premkumar et al. (1994) investigate the diffusion of EDI in three stages: adaptation, internal diffusion, and external diffusion.

Wu and Chuang (2010) investigate diffusion of electronic supply chain management from a multi-stage perspective: adoption, implementation and assimilation. They classify the diffusion stage into three categories: (1) adoption classified for initiation, comprehension, earliness of adoption and adoption; (2) implementation classified for adaptation, acceptance and implementation; (3) assimilation is classified for routinization, infusion and assimilation. Antecedents which can influence each assimilation stages are investigated as well as financial and non-financial firm performance.

Zhu et al. (2006) conduct a study on the assimilation process of e-business and investigate the assimilation from three stages perspective: initiation, adoption, and routinization based on the TOE framework. Comparison studies between developed countries and developing countries suggest that technology readiness strongly influence assimilation process in developed countries while technology integration has a significant effect on developing countries' assimilation.

At initiation stage, organizations are aware of the new technology and evaluate whether the technology can solve the organization's problems. As indicated by Zhu et al. (2006), firms at this stage evaluate how the potential benefits of the innovation can improve a firm's value chain activities. Organizational problems are also identified.

Following initiation is adoption which involves allocating necessary resources to obtain the technology and prepare for redesigning business processes. The degree of fit between innovation and organization's tasks and problems determines the adoption of this technology.

However, adoption does not always result in widespread usage. Fichman and Kemer (1999) suggest that there is an assimilation gap between adoption and widespread routinization. Adaptation/acceptance stage is the stage at which organization begins to learn and adapt to the innovation by trying it out and then their feedbacks are collected. At this stage, innovations are transferred for regular use and the organization's governance systems are adjusted to account for the IT application.

At the routinization and infusion stage, innovation has already been widely used as an integral part in a firm's value chain activities in a more comprehensive and integrated manner. This stage is usually regarded as a significant dimension of IS success. After introducing various stage-based models, we will analyze their strengths and weaknesses in the following part based on which we propose our own research models.

In Table 2.1, we summarize various stage-based models from existing literature. In Table 2.2, we illustrate assimilation stages and tasks involved in each stage.

Table 2.1 Summary of the stage-based models

Model	**Name of stage**	**Literature**
Two-stage model	Adoption (activities of knowledge acquisition, persuasion and learning, and adoption decision) Implementation (preparations of organizational changes, processes, and technologies necessary for innovation deployment)	Rogers (2012) Rogers(L.Fries, M.Turri, C.Bello, & f.Smith, 2010)
Three-stage model	unfreezing, moving and refreezing knowledge-awareness stage, evaluation-choice stage, and adoption-implementation stage adaptation, internal diffusion, and external diffusion adoption, implementation, assimilation initiation, adoption, routinization adoption, implementation, assimilation	Lewin (1952) Meyer & Goes (1988) Premkumar et al. (1994) Ranganathan et al. (2004) Zhu et al.(2006) Wu and Chuang (2010)
Six-stage model	Initiation, adoption, adaptation, acceptance,	Kwon and Zmud (1990)

	routinization, infusion	

Table 2.2 Different assimilation stages and tasks involved in each stage

Stage	**Definitions**	**Tasks involved in each stage**
Initiation	Decision makers are aware of this innovation and make formal evaluation and trial through vendor organizations.	Evaluate how the potential technology can bring benefits to an organization.
Adoption	Decision makers make the adoption or non-adoption decision according to their potential cost benefits analysis of RFID.	Allocating necessary resources to adopt RFID and prepare for redesigning business processes.
Routinization	Innovation has already been widely used as an integral part of a firm's value chain activities.	Integrate RFID with other enterprise systems such as ERP, MRP, CRM, etc.

2.2 Antecedents of innovation assimilation

In the previous section, we find that the most innovation-related research employs the TOE framework to investigate influencing factors that can impact innovation diffusion and assimilation. Related literatures include Furneaux and Wade's (2011) investigation of discontinuance intention of information systems. Wang et al. (2010) investigate determinants of RFID adoption in the manufacturing industry in Taiwan drawing upon the TOE framework. Kuan and Chau (2001) employ the TOE framework to investigate EDI adoption in small businesses. Hong and Zhu (2001) investigate six variables drawing upon the TOE framework to successful differentiate non-adopters from adopters of e-commerce. Zhu et al. ((2006a), (2006b)) explore how factors within the TOE framework influence the e-business assimilation at the organizational level.

As indicated by Wang (2010), TOE framework has many consistent empirical supports, so it can help analyze and consider suitable factors for understanding the innovation-adoption decision. We think TOE framework is a powerful tool to explain the assimilation processes, and thus we use it to explain RFID assimilation processes in our research.

With reference to the technological context, classic *DOI (diffusion of innovation)* theory proposed by Rogers (1995) identifies five innovation characteristics including: (1) relative advantage, which means "the degree to which an innovation is perceived as being better than the idea it supersedes". (2) compatibility, which is defined as "the degree to which an innovation is consistent with existing business processes, practices and value systems"; (3)

complexity, the degree to which an innovation is difficult to use; (4) observability, the degree to which the results of an innovation are visible to others; (5) trialability, the degree to which an innovation can be experimented with. Among these factors, the first three are the most frequently used to explain and predict innovation diffusions and therefore we include them as technological factors in our research framework and investigate their changing effects across different assimilation stages.

Organizational context refers to top management support, an organization's IT infrastructure, managerial capability which is important components for an organization. These factors could help explain why some organizations are more innovative while others are less prone to innovate. As indicated by Mishar et al. (2007), the diversified performance differences of innovation diffusion is due to the significant differences in the resources the firm possess, which include managerial knowledge, technology infrastructure, and prior experiences with IT. Some other literatures also suggest that the value firms obtain from IT is dependent on their skills to leverage it ((Mata, W.Fuerst, & J.Barney, 1995) (Bhardwaj, 2000). Firms which possess strong managerial capability and prior IT experiences can utilize IT more efficiently than their competitors. Therefore, we include managerial capability, IT infrastructure and absorptive capacity which is regarded as organizational resources as antecedents.

As indicated by Tornatzky and Fleischer (1990), *environmental context* is the area in which a firm conducts its business-the industry, competitors, and dealing with government. DiMaggio and Powell's institutional theory proposes that institutional environment provides rule-like social expectations and norms for appropriate organizational structures, operations, behaviors and practices. The firm's perceptions of these pressures affect its interpretation of the environment in general and innovation intentions in particular. Thus we investigate factors within the institutional pressure that will impact RFID assimilation processes. Institutional pressures are classified into three categories: coercive pressure, normative pressure and mimetic pressure.

Coercive pressure is defined as the pressure originating from political influences exerted by the powerful firms on which the focal firm depends (Paul & Powell, 1983). This pressure is mainly from dominant suppliers and customers because these dominant partners hold resources organizations need such as new business contracts or funding. Normative pressure refers to the perceived extent to which members of the dyadic relational channels have adopted the innovation and the extent to which the government and industry agencies promote the use of information technology. In our model, we use regulatory support as the normative pressure that will influence RFID's assimilation processes. Mimetic pressures are those which make an organization imitate others when the organizational technologies are poorly understood, goals are ambiguous, or the environment is uncertain. Since RFID standard is still uncertain and investment is irreversible which means the market of RFID is still uncertain. Companies will follow others which have successfully implemented this technology. Meanwhile, fierce competition will make companies imitate others which have already successfully adopted this technology into their enterprises. In our research, we include market uncertainty and competition intensity as the source of mimetic pressure.

3 RESEARCH MODEL AND HYPOTHESES

Predictions related to technological factors

Relative advantage

Drawing upon previous literature, relative advantage is a suitable predictor when evaluating the benefits of technology innovation. This is true because at early assimilation stages, the function of RFID technology will be evaluated to check whether it has relative advantage over traditional bar code systems.

As proposed by Tsai et al. (2005), the benefits of RFID includes: (1) increasing cost efficiency; (2) improving inventory replenishment; (3) consolidating market strategy; (4) and increasing product security (by increasing the accuracy of the information on the movement of physical goods). Thus, we posit that relative advantage of RFID plays more significant roles on early than on later assimilation stages.

However, the influence of relative advantage is not so significant on later assimilation stages since at this stage, the major task is to adjust current operations process to adapt RFID technology into their daily operations and make employees accept this technology. Thus, the influencde of relative advantage might not be so significant on this stage. Accordingly, we propose hypothesis as follows:

> ***H1: Relative advantage plays a more significant influence on early than on later assimilation stages of RFID technology.***

Complexity

Complexity is defined as "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers and Shoemaker, 1971, p.154). In the context of RFID, Wang et al. (Wang, et al., 2010) define complexity as immaturity of RFID technology, lack of common standards. The difficulty of integrating RFID with the existing enterprises' information systems and business processes is also included as one component of complexity. Thus, complexity of innovation should also be analyzed to make sure that organization has enough financial and human capital to overcome the difficulties during implementation.

The influence of complexity is even more significant on later assimilation stages since at this stage organizations need to reengineer existing working procedures and integrate it with other enterprise systems including warehouse management systems, ERP, MRP, etc. Thus, complexity plays more significant negative influence on later than on early assimilation stages. We predict the hypothesis as follows:

H2: Complexity plays more significant negative influence on later than on early assimilation stages.

Predictions Related to Organizational Factors

Besides technological context, factors in organizational context can also influence RFID assimilation processes. We include IT infrastructure, managerial capability as well as absorptive capacity into the organizational context and investigate their changing effects across different stages.

IT infrastructure

With reference to IT infrastructure, Grant (1991) classifies IT-based resources into three categories: (1) the tangible resource comprising the physical IT infrastructure components; (2) the human IT resources comprising the technical and managerial IT skills; (3) the intangible IT-enabled resources such as knowledge assets, customer orientation, and synergy.

According to resource-based theory, tangible resources enable firms to assimilate innovations more quickly and improve products (S.Bharadwaj, 2000). IT infrastructure provides a platform on which innovative IT applications can be launched faster. Therefore, tangible resources are relevant factors that might influence RFID assimilation processes.

Human resources include both technical IT skills and managerial skills. Since RFID assimilation process entails significant changes of the business processes and IT infrastructure, managerial capability plays an important role in coordinating activities related with process redesign. Technical IT skills become important in the analysis, design, and implementation of changed business processes. The flexibility of human IT resources to adapt to change might be a significant antecedent for successful RFDI implementation.

Previous literature suggests that customer orientation has a significant role on innovation assimilation, e.g. Internet assimilation in China (Chau, Lai, & Li, 2008). It might also be an important driver for RFID assimilation since it shortens lead time between the manufacturers to customers, increases the traceability of products which makes the products more visible. If a company is more customers-oriented, it will consider improving customers' satisfaction through introducing new technology.

Knowledge assets refer to the ability of firms to integrate, transfer, and apply knowledge (Matusik & Hill, 1998). It is also critical for RFID assimilation processes since if a firm has a strong capability to integrate and transfer new knowledge that will be easier for them to assimilation new innovations.

Synergy is defined as sharing of resources and capabilities across organizational divisions. A firm is more flexible and can react faster to market needs if it shares knowledge and information across its functional units. Since RFID technology enables information sharing across warehouse division, purchasing division and production division across a company, it provides a good way to share resources and information. Thus, we think synergy of intangible resources is also related with RFID assimilation and include it into our research model.

Based on above analysis, we can see that physical IT infrastructure, human IT resources, and synergy all have significant relationship with RFID assimilation. Therefore, we include IT infrastructure as an antecedent of RFID assimilation process.

According to Bharadwaj (2000), IT as a resource can generate competitive value only when it leverages or enables pre-existing resources and skills. The situation is the same for RFID technology implementation. RFID can achieve its greatest benefits only through integrating with other backend systems such as enterprise resource planning (ERP), customer relationship management (CRM), and decision support systems (DSS) and sharing data and information with them. Again, this does occur until later assimilation stages. Importantly, the adoption rate of these enterprises systems remain very low in China (XU, Zhang, & D.C.,

2005) which means information and data flow may stand alone and cannot be integrated with business processes. Thus, this is a particularly important innovation barrier in China.

Moreover, when adopting and routinizing RFID technology, companies might have many technical problems and have to overcome these knowledge barriers. Relying on consultants is not enough because few consultants understand the clients' business processes sufficiently and thus must work closely with their clients (S.Bharadwaj, 2000). Technical skills of inter-house staff are important for speeding up preparation and enhancing chances of success in implementation. However, current Chinese enterprises lack such kinds of internal staff who are experts in RFID deployment, which can further inhibit RFID's adoption and routinization.

These negative influences might not be significant in the early assimilation stages since at these stages, initiation and adoption do not require RFID's integration with other backend systems including ERP, CRM and DSS. However, the impact of IT infrastructure challenges is likely to be substantial on later assimilation stages because organizations need to integrate RFID systems with other enterprise systems and data generated from RFID systems need to be used by other systems. The negative influence of unique Chinese IT infrastructure challenges might be even more significant on later assimilation stages than on early assimilation stages. Consequently, we predict the hypothesis as follows:

H3: Current Chinese enterprises' IT infrastructure has more significant negative influence on later assimilation stages than on early assimilation stage of RFID technology.

Managerial capability

Asif et al. (2005) suggest that the deployment of tags and readers by themselves cannot push companies ahead of their competitors. What is more important is how an organization uses the fine-grained and real-time data derived from RFID to change and improve its business processes that will determine the extent of strategic benefit the companies can obtain from RFID technology. RFID is a radical innovation that can significantly change the operational process of an organization, but doing so requires substantial managerial capability. Fichman (2004) likewise suggests that technologies which enable more radical improvement require substantial complementary changes to organizational structures, routines and policies. Accordingly, RFID involves some unique changes with reference to organizational and process adaptations (Chatterjee, et al.,2002a). Robert et al. (2003) note that not all firms can effectively manage adaptation since they lack managerial skills and know-how for change management. Thus, the effect of managerial capability which refers to managerial skills for managing organizational adaptation to accommodate RFID assimilation is worth investigating.

Organizational adaptations in RFID assimilation include making organization changes on structures and coordination mechanism (Chatterjee, et al., 2002a) and acquiring new expertise necessary to use the innovation (G.Fichman, 1999). Most literatures owe IT failure to management issues such as lack of synergy between business and IT skills, how to integrate the technology with the business strategy, skilled technical people and experienced, trained users. These literatures suggest that managerial obstacles can impede RFID initiation, adoption and routinization when organizations cannot make organizational changes, redesign business processes, and acquire new expertise. The influence of managerial capability is especially significant on later stages since at this stage, organizations need to make organizational changes to adapt the new innovation and infuse it into the company's daily operations.

As indicated by Bai and Hamilton (Alon & R.McIntyre, 2005), since Chinese economy has evolved from centrally-planned to market-oriented, there is a great shortage of management personnel who understand and master Western management skills in marketing, financial management, inventory control, human resources, and international business rules. Moreover, they lack know-how for change management, which makes it very difficult to make radical organizational changes and improvements. Most Chinese enterprises have not been engaging in in world markets for nearly as long as Western counterparts. It has only been until recently that Chinese managers have had access to advanced managerial education involving basic courses in market economics, change management, and business process improvement. This might inhibit the RFID assimilation process, especially in later stages. Therefore, we predict the hypothesis as follows:

H4: Current Chinese enterprise's managerial capability plays more significant negative influences on later assimilation stages than on early assimilation stages of RFID technology.

Absorptive capacity

As defined by Cohen and Levinthal (2006), an organization's *absorptive capacity* is represented by its ability to recognize the value of new, external information, absorb it, and apply it for commercial ends. They also point out that effective absorptive capacity can be determined by prior relevant knowledge and intensity of effort. Especially in an uncertain environment, absorptive capacity can affect expectations formation and enable a firm to predict more accurately the nature and commercial potential of technological advances. Because RFID is a radical innovation that is full of uncertainty, it requires absorptive capacity to recognize the value of it, absorb it and apply it to their operations.

Existing literature regard absorptive capacity as a knowledge base, especially the extent of prior knowledge the firm possess. (Lane, Salk, & Lyles, 2001). This is similar to *path dependency*, which is a firm's ability and incentive to adopt an innovation, which can be largely determined by its level of related experience with prior relevant technologies (Hassan & Chatterjee, 2006). Also indicated by Cohen and Levinthal (2006), such skills and knowledge are critical for successful adoption of new technology standards. Thus, firms which have prior experiences ***and knowledge*** with related technology such as EDI or barcode systems may have developed technical and managerial skills for deploying RFID technology compared with those firms without EDI or barcode experiences.

However, most Chinese enterprises lack absorptive capacity to absorb RFID technology and apply it for their application since most of these companies do not have ***related*** prior ***knowledge and*** experiences to use EDI or barcode before. Lack of previous ***relevant knowledge and*** experiences related with EDI or barcode technology will inhibit them to implement RFID technology. Therefore, we predict the following hypothesis:

H5: Current Chinese enterprises' absorptive capacity has negative influence on both early and later assimilation stages of RFID technology.

Predictions Related to Environmental Factors

Competition intensity

Competition intensity is "the degree that the company is affected by competitors in the market" (Zhu, et al., 2004). Porter (1980) suggest in his five-force competitive model that competitive pressure is an important external driver to initiate the deployment of IOS among trading partners.

According to Tsen (2001), China's economic reform towards a market economy promote more trade and encourage more foreign direct investment (FDI) to contribute economy growth since its economic reforms in 1979. As suggested by Fu (2008), China has become the second largest FDI recipient in the world which is after the United States and the largest host country among developing countries. These FDIs bring capital, knowledge and new managerial skills to China. However, they also attracted the most talent researchers and compete in the markets of innovation products that can threaten local firms, especially the SMEs. Their participation increases competition in the domestic markets which makes challenges to Chinese enterprises' technology and managerial capabilities. Therefore, we posit that competition intensity will influence Chinese enterprise' RFID assimilation process.

Its effect on RFID assimilation might also be different across different assimilation stages. At initiation and adoption stage, benefits derived from first movers' RFID adoption might arouse decision makers' awareness of this technology and make them consider adopting it. Compared with traditional bar code systems, RFID can track the status of products in real-time and thus improve the inventory visibility as well as asset management. These improved efficiencies are critical for companies to maintain their competitive advantage. Therefore, competition intensity is likely to drive companies to initiate and adopt RFID technology.

Nevertheless, competition intensity could have a reverse effect on later assimilation stages. According to Mata et al. (1995), complex technologies can only be routinized through a gradual and learning-by-using processes. Nonetheless, more competitive pressure would drive firms to leap rapidly from one technology to another rather than develop skills to routinize existing technologies. As mentioned before, the current Chinese competitive environment drives firms to leap from one technology to another which means they are less likely to undergo a gradual, careful and sustained learning by doing process to routinize RFID into their organization. Hence, we postulate that competition intensity has positive influence on early assimilation stage but negative influence on later assimilation stages. Accordingly, we predict the following hypothesis:

H6: Competition intensity has positive influence on early assimilation stage, but it has negative influence on later assimilation stage.

Regulatory support

Regulatory support is a critical factor influencing innovation diffusion (Zhu & Kraemer, 2005; Zhu, Kraemer, & Xu, 2006). Williamson (1983) suggest two ways which government could affect innovation diffusion. "One way is to take tax and other measures to increase or decrease payoff, the other way is to alter the climate in which they are received." (Williamson, 1983, p. 126). Zhu et al. (2006) investigate the assimilation of e-business and find that governments can encourage e-business legislation by supportive regulations and policies.

These issues are particularly important in China. Chau et al. (2008) investigate the assimilation process of Internet technologies in China and find that Chinese companies have the highest concern for the regulatory environment in which they and their business reside. In our research, since currently Chinese government is proposing the twelfth five-year plan and government plans to invest in R&D of the "Internet of Things" and cloud computing, and develop digital and virtual technologies. RFID technology is the key enabler of the Internet of Things. Regulatory support from the government can form an encouraging environment that will make decision makers aware of this technology and consider adopting it in their enterprises. The influence of supportive regulatory support is also significant on later assimilation stages. Therefore, we have hypothesis as follows:

H7: Current Chinese government's regulatory support is positively related with early and later assimilation stages of RFID.

Environmental Uncertainty

As indicated by previous literature, firms facing environmental uncertainty have greater incentives to adopt IOS (inter-organizational innovation) to improve information exchange and to reduce uncertainty between trading partners. Sharma (2000) also indicate that firms facing higher environmental uncertainty will sense more opportunities, are proactive and innovate more than other firms.

However, this situation might be different in China. As indicated by Chau et al.'s (2008) investigation of Internet assimilation status in China, market uncertainty has a negative influence on a firm's proactive and innovative strategies and behaviors. Since adopting RFID technology requires a lot of investment and whether benefits can be gained from these large investment costs is still a problem for most enterprises. Compared with bar code system, the cost of an RFID tag is still much higher which approximately ten times of that of bar code. The costs might still be a large hurdle for Chinese enterprises' RFID deployment. This problem is even more serious for the low-end product industry such as toys and clothes. Another cost incurred is the IT infrastructure. As Konsynski and Smith (2005) suggest, deployment and development is likely to add significant cost to the tight implementation of RFID technology. Moreover, the investment cost is irreversible due to the tight coupling between the technology and organization.

With reference to standards uncertainty, the Chinese government has decided not to use either EPC or UID, but instead to develop their own RFID standard. Additionally, two bureaucratic challenges further complicate the current standards problems (Lai & Hutchinson, 2005). The first one is that radio frequency assignment for RFID is not finalized. The second challenge is that it is not clear who is responsible for drafting the RFID standards. Currently, there are two organizations which have overlapping functions for developing RFID standards: one is the working group of electronic labeling set up by SAC (Standardization administration of China), the other is the ANCC (Article Numbering Center of China) which is the authority for product coding.

At early assimilation stage, uncertainty of standards might inhibit decision makers make purchase and adoption decision since they are not sure which RFID system they should purchase. At later assimilation stage, lack of harmonization between standards might increase the complexity of application or operation. Thus, standards uncertainty might negatively influence both early and later stages of RFID assimilation. Taking these factors into consideration, we have following hypothesis:

H8: Environmental uncertainty will negatively influence both early and later stages of RFID assimilation.

We depict our research framework in figure 1.

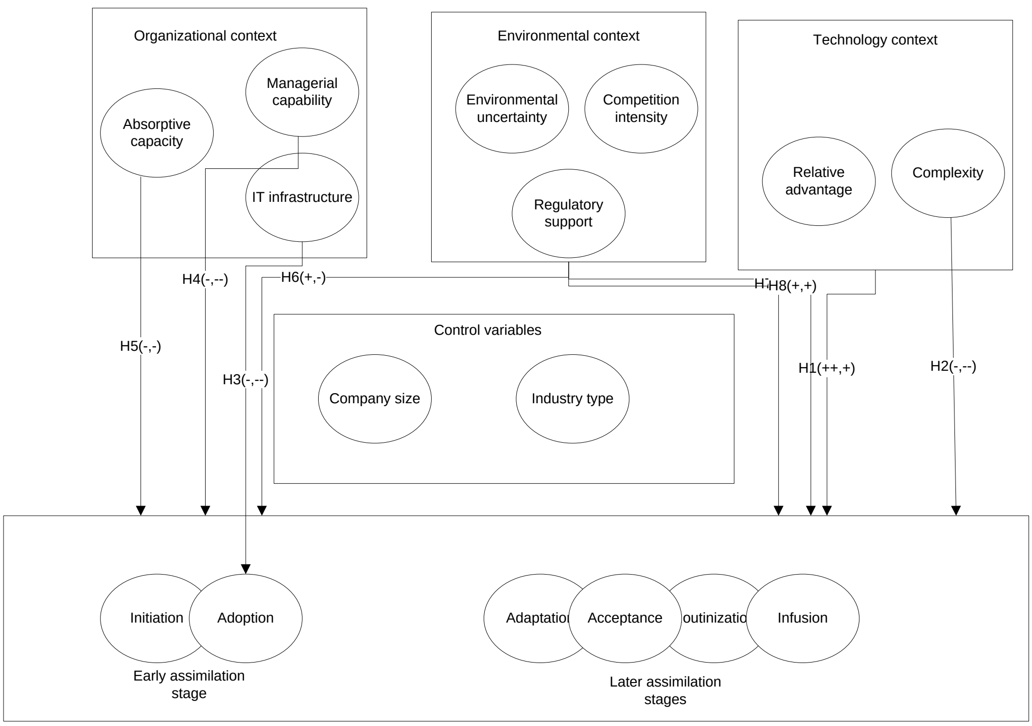

Fig.1 Research model

4 METHODOLOGY AND DATA ANALYSIS

4.1 Sample Frame

We will use questionnaire surveys to collect data from various supply chain participants including manufacturers, retailers and logistics providers. We collect data through two non-profit organizations: Gs 1 Hong Kong and LSCM centre (Hong Kong R&D Centre for logistics and supply chain management enabling technologies). They help us distribute the questionnaires to their member companies. IT managers or project managers who are familiar with the deployment process of RFID technology will be respondents for investigation and this can avoid response bias from a single informant.

Before surveying, we conduct three pilot interview studies to check if there are any content validity problems with our questionnaires. To reduce the common-method bias, we collect data through several different ways: online questionnaire surveys, paper questionnaires as well as telephone surveys.

4.2 Measures

Measurement items are developed based on a comprehensive review of the literature as well as expert opinions. Seven-point Likert scales ranging from "(1) strongly disagree" to (7) strongly agree" will be used for all items.

4.3 Data analysis

4.3.1 Measurement model

Partial least-squares (PLS) approach will be used to test the structural model. It assesses the relationships between the research constructs as well as the relationships between the constructs and their measurement items (Ranganathan, Dhaliwal, & Teo, 2004). It involves no assumptions about the population or scale of measurement. Its sample size requirement is either 10 times the largest measurement number within the same construct or 10 times the largest measurement number affecting the same construct. It is better suited when the focus is on the theory development, whereas LISREL is preferred for confirmatory testing of the fit of a theoretical model to observed data, thus requiring stronger theory than PLS (Barclay, Thompson, & Higgins, 1995). We use smart-PLS to evaluate the research model.

A two-step data analysis will be conducted to first assess the measurement model and then test the hypotheses by fitting the structural model. In the measurement model assessment, construct reliability, convergent validity, discriminant validity will be evaluated. Reliability measures the degree to which items are free from random error, and therefore yield consistent results. It is evaluated by Cronbach's α. If a construct has a composite reliability in excess of 0.70, it implies this construct has an acceptable level of reliability (Fornell and Larcker, 1981). Construct validity includes convergent validity and discriminant validity. According to Fornell and Larcker (1981), convergent validity for a construct is evaluated by three criteria: (1) item loadings (λ) larger than 0.70; (2) composite construct reliability larger than 0.80; (3) average variance extracted (AVE) larger than 0.50. Discriminant validity is the extent to which h different construct diverge from one another. It is assessed by the criterion that the square root of AVE for a construct should exceed its correlations with all of the other constructs, which indicates that items share more variance with their respective constructs than with other constructs.

4.3.2 Structural model

First, an exploratory analysis is conducted for empirically defining the diffusion stages. Based on the measurements of initiation, adoption and routinization, we classify the investigated firms into two categories: those who are in the early assimilation stage and later assimilation stage. A structural model will be built to examine the causal structure of the research framework. The evaluation of the structural model using PLS is conducted in the following two steps. First, the standardized path coefficient and statistical significance for the influence paths in the structural model is estimated. We will perform bootstrapping analysis with a large sample size to estimate path coefficients, statistical significance, and relevant parameters such as means, standard errors, item loadings and item weights, etc. Second, the coefficient of determination (R^2) for endogenous variables will be calculated to assess the predictive power of the structural model which is similar to that found in multiple regression analysis. We will perform three separate runs for each of the three stages based on the clusters of data to test which factors are important on each stages. After that the results of these three separate models will be integrated into one model for illustration.

5 CONCLUSION AND SUMMARY

Drawing upon innovation diffusion theory, TOE (task-organization-environment) framework and stage-based IT diffusion model, this research empirically investigates different factors' impact on different diffusion stages. This model extends the current state-of-the-art since most IOS research focus on one stage-adopts or not adopts which neglect the dynamic nature of RFID diffusions. However, our research capture this nature of RFID diffusion in an organization and it will provide some important findings for scholars and practitioners:

This study used a multi-stage diffusion approach and proposed a novel theoretical framework to explain RFID's diffusion processes within an organization. Previous research focused on technology implementation issues from a single decision view of adoption or acceptance which has often caused inconsistent findings. Subsequent research could be based on this foundation and investigate RFID's diffusion processes across various trading partners since it's an inter-organizational technology and only through collaborating with trading partners can its benefits be greatly achieved.

Second, the relationships between different external antecedents and different diffusion stages will guide organizations to diffuse RFID technology more efficiently. From technological perspective, when firms are planning to initiate RFID deployment, relative advantage of this technology may draw special attention of decision makers while complexity and compatibility may not play a significant role since at this stage decision makers haven't decided to whether adopt it or not. However, at adoption stage, large investment costs push decision makers to conduct cost/benefit analysis, comparing relative advantage with its large investment costs and consider the complexity of adoption and implementation and compatibility with other applications of the organization as well as the working procedures of the organization. At routinization stage, relative advantage and complexity may not become the major concern but compatibility may still play an important role since RFID technology needs to be integrated with other applications as well as the organization's working procedures to finish the organization's operations. From organizational perspective, organization size is positively related with initiation and adoption since larger organizations usually have more slack resources to invest in the high cost technology such as RFID. However, during the routinization stage, due to the entrenched structure and complex business processes and hierarchical decision making process, it is more difficult to reengineer the business processes. And therefore, organization size is negatively related with routinization stage. Since RFID's implementation involve unique changes with regard to organizational adaptations, organizations which lack managerial skills and know-how for change management will have some difficulties in RFID's initiation, adoption and routinization. Managers need to consider both advantages and disadvantages of their organization characteristics (e.g., size, managerial obstacles), during their RFID diffusion process and propose some solutions to deal with these challenges of each stage. From environmental perspective, mimetic and normative pressure may play significant effect on initiation stage and adoption stage, but its positive effect is not significant on the routinization stage. Coercive pressure has significant effect on adoption and diffusion stage with less significant effect on initiation stage. These results will give some guidance to organizations in different RFID implementation stages to overcome inhibitors associated with that stage and diffuse RFID technology more deeply and efficiently. Thus this research will provide many valuable implications for practitioners.

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