Factors affecting Pig Farmers' Adoption of the HACCP System

Gu-Hyun Jung · Kyeong Ah Ahn · Han-Eul Kim · Hye Bin Jo · Young-Chan Choe

Abstract The goal of this study is to determine, based on survey results, the underlying factors that affect the intention of the farmers who have not adopted the Hazard Analysis and Critical Control Points (HACCP) system for the rearing phase of pig production to adopt this system in the future. The research model for this study was con structed based on strategic contingency theory, the theory of the diffusion of innovation, and the technology acceptance model (TAM). Using structural equation modeling with partial least squares (PLS), this study analyzes the effects of the intensity of competition, the environmental uncertainty, the innovativeness and self-efficacy of the individual farmers, and the impact of the credibility of the Agricultural Technology Service Center (ATSC), which acts as the principal agent of technology dissemination and as a leader of change, on the perceived usefulness of technology and the farmers' intention to adopt the system.

The results of the analysis are as follows. First, with regard to the underlying factors affecting the intention to adopt the new system, the intensity of competition within the industry and the institutional credibility of the ATSC were inferred to underlie the perceived usefulness. Second, institutional credibility has a positive impact on the perceived usefulness of the system, and the perceived usefulness, in turn, has a positive impact on the intention to adopt. The perceived ease of use also has a positive impact on the intention to adopt. Because the factor that has the biggest impact on the intention of a farm to adopt is the credibility of the ATSC, it is crucial for extension organizations, such as the ATSC, to make greater efforts to promote the expansion of the HACCP system. Because farmers feel that the implementation of the HACCP system is an instrumental strategy for coping with the high intensity of competition within the industry, they attempt to gain a competitive edge through the production of safe livestock products.

Keywords HACCP, strategic contingency theory, diffusion of innovation, technology acceptance model, innovativeness, self-efficacy

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1 Introduction

As food safety accidents become more frequent, concerns about livestock diseases, the excessive use of antibiotics, and the safety of imported livestock products are increasing (Lee, 2007). Consumers are demanding the assured hygiene of final livestock products and the safety of the products through all phases of food production from the farm to the table, and they are willing to pay for this assurance

(Cho & Song, 2007; Yoon, 2008). The Korean government is attempting to secure the safety of livestock products by implementing measures such as environmentally friendly livestock products, record tracing systems, and HACCP systems.

In particular, HACCP (Hazard Analysis and Critical Control Points) is a preventive food safety management system aimed at averting hazards. This system builds consumers' trust in food by preventing, eliminating, or reducing to permissible levels the biological, chemical, and physical elements of hazard. The system is implemented across the board in areas of the food production process, such as rearing, slaughter, and processing; in the rearing phase, the system is applied to livestock species, such as cows, pigs, and chickens. The HACCP system was first introduced to the rearing phase of pig farming in 2006, and the government has been providing consultancy for the farms and promoting the acceptance of the system with implementations such as the environment-friendly and safe livestock direct payment system. The concept of HACCP has also been adopted globally for international trade, according to the provisions of the WTO/SPS regarding the standards for sanitation and food hygiene, and it is becoming a prerequisite for importing pork (Kim & Lee, 2010).

However, as of 2011, only 560 pig farms in Korea have been HACCP-certified out of a total number of approximately 7,200, i.e., only 7.1%. The adoption of the HACCP system at the rearing stage depends on the farmer, but considering the growing awareness among consumers and that the farm is the point of departure for safe livestock products, HACCP adoption should be encouraged.

Because the adoption of the HACCP system requires additional cost and effort from the farmers with regard to the necessary equipment and facilities, record management, and disease prevention, the farmers expect corresponding increases in productivity and profitability. The results of a survey of adopting farms revealed improvements in farm performance, as the standardization of the specifications of management and the reduced costs of medications resulting from disease prevention caused the productivity to increase (Cho, 2008). With the adoption of the HACCP system, the livestock mortality rate has decreased, and the number of pigs marketed per sow per year (MSY) has grown as the managerial mentality and the standards of sanitation improve; the system has been particularly effective for small-scale farms, for which pragmatic difficulties exist in the introduction of systematic management techniques (Nam, Cho, Kim, Kim, Lim et al., 2008). Studies have recommended improvements in the elements impeding the adoption of the HACCP system, such as the inconvenience of dealing with the bureaucracy; the selection of the consulting firm, costs, and related education; and the provision of government support and subsidization of the investment costs.

However, from the farmer's perspective, it is difficult to suppose that the HACCP system would be adopted based solely on the expectation of improved productivity because some elements are directly related to the profits of the farm, such as the increased import of livestock products, the spread of diseases, and the increase in the feed prices, and because a market differentiated from that of the customary livestock products does not exist. To facilitate the adoption of the HACCP system by a larger number of farms, it is necessary to demonstrate the economic effects of the improved productivity and to review various factors that affect the adoption of an innovative system.

Based on the strategic contingencies theory, this study will assume that the behavior of adopting an innovative technology is a strategy and will review whether the adopting agent's environmental awareness is a factor that affects the intention to adopt (Miller, 1991). Furthermore, based on the theory of the diffusion of innovation (Rogers, 1995) and the technology acceptance model (TAM) (Davis, 1989), this study will review whether individual characteristics, the credibility of the agricultural extension organizations as stimulators of innovation, and the usefulness and ease of use of the HACCP system affect the intentions of farmers to adopt innovative technologies.

2 Literature Review and theory

2.1 The Current State of the Implementation of the HACCP System at the Pig Rearing Stage and Related Studies

With the growing demand of consumers for the production of safe livestock products and for the availability of transparent information and an objective certification system, securing stability has been a major task for every nation that is attempting to garner a competitive edge with regard to livestock products (Kim & Lee, 2010). The HACCP system is designed to preclude the biological, chemical, and physical elements of hazards that are harmful for the consumer's health and to immediately rectify problematic aspects. The critical control of this system can characteristically operate on all of the processes throughout rearing, slaughter, processing, packaging, distribution, and sales.

South Korea laid the foundation for the introduction of the HACCP system through a December 1997 amendment of the law on the processing and handling of livestock

products, and the HACCP standards for livestock products were announced in August 1998. Livestock farms began to implement the system in 2006, and the number of compliant farms is increasing yearly.

Table 1 The History of the HACCP System for Livestock Products

Time	Title	Major Events
December 1997	Establishment of legislation on the processing and handling of livestock products, paving the way for HACCP	- Introduction of HACCP and SSOP into sites of livestock production
August 1998	Announcement of the establishment of HACCP for livestock products	- Slaughterhouses: Implementation of annual duties between July 1, 2000 and June 30, 2003 - Rendering works: Voluntary implementation by interested companies
September 2002	Announcement of the amendment of HACCP for livestock products	- Rendering works: expansion of applicable items (9 items → 13 items) - Existing items: ham, sausage, packaged meat, milk products, fermented milk products, processed cheese, natural cheese, butter - Added items: spiced meat, ground meat products, low-fat milk products, ice cream
July 2003	Announcement of the amendment of HACCP for livestock products	- Establishment of regulationsfor colon bacillus and salmonella testing as a post control at slaughterhouses - Transfer of HACCP post control services to cities and provinces.
January 2004	Announcement of the amendment of HACCP for livestock products	- Expansion of HACCP-implemented sites - Existing sites: slaughterhouses, rendering works - Added sites: meat-packaging plants, milk-collecting plants, livestock products storage, livestock product transportation companies, livestock products sales businesses
January 2005	Announcement of the amendment of HACCP for livestock products	- HACCP certification of feed factories - Commissioningof the right to notify regarding the livestock products HACCP to the director of the National Veterinary Research and Quarantine Service
March 2006	Announcement of the amendment of HACCP for livestock products	- Establishment of the English form issuing credentials - Added items: Rib products, Dry-stored meat, egg products (whole egg liquid, egg yolk liquid, egg white liquid)
March 2006	Amendment of the law regarding the processing and handling oflivestock products	- Introduction of HACCP at the livestock-rearing stage - Laying the foundation for the appointment of the livestock products HACCP agency
September 2006	Foundation of the Korea Livestock Products HACCP Accreditation Service	- Foundation of the Korea Livestock Products HACCP Accreditation Service, which wasincorporated based on Section 9.2 of the law on processing and handling livestock products - Ministry of Agriculture and Forestry: commissioned by the Korea Livestock Products HACCP Accreditation Service as the agency overseeing HACCP (October)
November 2006	Announcement of the amendment of HACCP for livestock products	- Added industries: meat sales, livestock-rearing phase (pig) - Added items: heat-processed egg products, powdered milk (skim milk, whole milk)
Data: National Veterinary Research and Quarantine Service website (www.nyrqs.go.kr), Lee (2007)		

The first pig farm implemented the HACCP system in November 2006, and as of the end of 2011, 560 of 7,900 pig farms have implemented the system, i.e., 7.1% of the total. The implementation of HACCP during the rearing phase of pig production still relies on the voluntary participation of farms, and although the number of adopting farms is rising, the adoption should be promoted further in consideration of the growing consumer awareness of safety issues and the competitiveness of Korean livestock products.

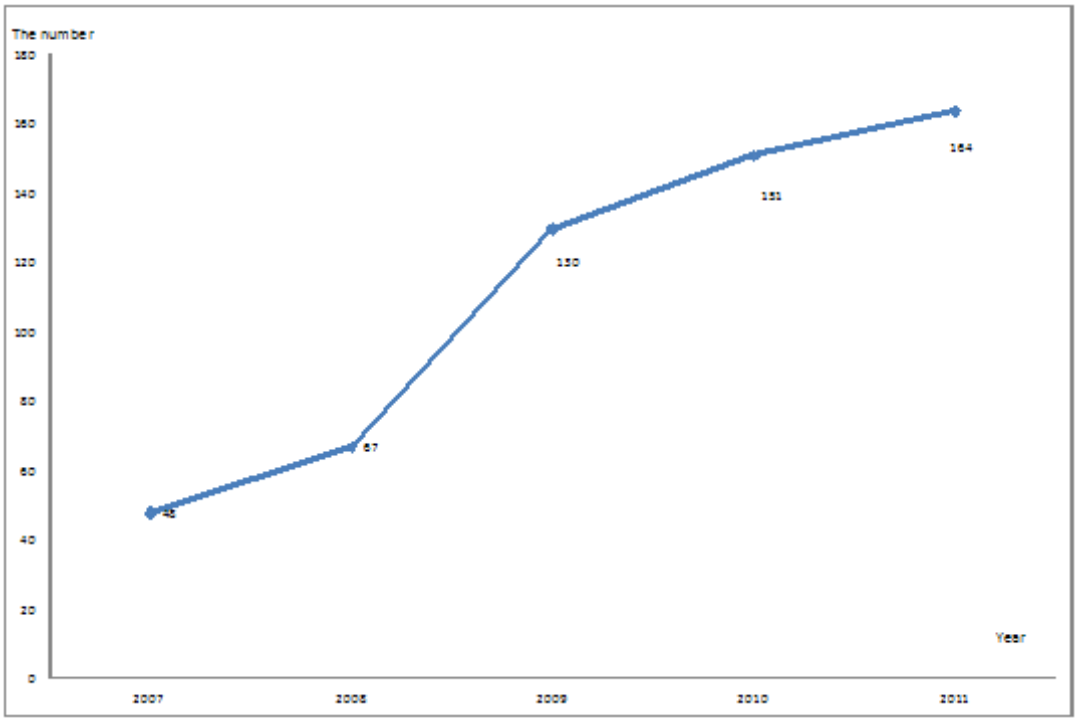

Fig. 1 Farms Adopting the HACCP System during the Rearing Phase of Pig Production, by Year

There has also been an effort to promote the adoption of HACCP at the government level; a plan has been established to create a production base of HACCP livestock products in approximately 120 municipalities with an investment of 10.6 billion Won by the year 2015, with 40% of all domestic livestock products being produced by these facilities. A HACCP food chain will be established that will apply HACCP principles to all of the processes from rearing livestock to slaughter, processing, and distribution. The managing costs of the farms are to be met by enforcing the direct payment system for the production of environmentally friendly and safe livestock products, which will generate 60 million Won over three years, with a maximum of 20 million Won per year.

Studies related to the HACCP system have been conducted in various fields in response to the demand by consumers and political pressure. Most studies on the pig-rearing phase have focused on performance improvement to facilitate a mandate for implementation at the farm level.

Cho & Kang (2009) verified that the adoption of the HACCP system enhances the sanitation activities (preventive measures at the entry of nominee pigs, execution of all-in all-out, showers upon entering and exiting the pigsty, the income level of the pig farm, the vaccination level, the quarantine level of ill pigs, and the quarantine level at entry), leading to increased productivity (the survival rate at birth, the MSY, the number of pigs weaned per sow per year (PSY), the cycle rate of the sows, the mortality rates of fattening and non-fattening pigs, and the mortality rates of litters) and profit. Nam, Cho, Kim, Kim, Lim et al. (2008) also conducted a comparative study of the productivity before and after the adoption of the HACCP system and found that the delivery rate increased by 3.73% and the PSY increased by 0.28 head. The yearly cycle rate of the sows increased by 0.04 cycles relative to the rate before the adoption of HACCP, and the survival rate increased by 4.55%.

In small-scale farms, the productivity was greatly improved by the adoption of the system. Kim, Cho, Pyo, Kwak & Nam (2009) conducted a study on the relationship

between the adoption of the HACCP system and the productivity at small-scale farm with less than 2,000 head. The MSY increased by approximately 2 head, which was statistically significant, and the remaining parameters, including the number of sows, delivery rate, total number of births, number of pigs starting lactation, number of pigs weaned, age at weaning, cycle rate of sows, fattening rate after weaning, production cost per marketed pig, feed cost per marketed pig, and PSY were not significantly affected. It was predicted that the adoption of the system by a small-scale farm would have a positive impact on its productivity. Nam, Kwak, Pyo, Hwang, Kim et al. (2008) classified pig farms as small-scale for herd sizes less than 2,000 head, medium-scale for herd sizes between 2,001 and 5,000, and large-scale for herd sizes greater than or equal to 5,001 and concluded that, among "the factors affecting the productivity of a small-scale farm (turnover rate of sows, cycle rates of sows, average number of surviving litters, PSY, age at weaning, rate of fattening after weaning, and MSY), the cycle rates of the sows, the average number of surviving litters, the rate of fattening after weaning, and the MSY were higher than those of a large-scale farm." Given the difficulties of implementing systematic management techniques on a small-scale farm, the implementation of the HACCP system was able to systematize the management system, thereby positively affecting the growth in productivity.

2.2 Strategic Contingency Theory

An organization can perform at a desired level when it closely analyzes various external elements, such as market characteristics and competition, and constructs an appropriate strategy based on its internal resources. The theories that an organization can employ for selecting a strategy include the "resource-based view, which identifies the factors that determine competitive superiority based on the internal managerial resources and internal capacities, and the strategic contingencies theory, which puts the emphasis on the fit with the external environment" (Choo, Yu & Limb, 2009).

According to the strategic contingencies theory, the type of strategy differs according to the degree of the environmental uncertainty, and the differentiation strategy is suitable when the situation is dynamic and difficult to predict, whereas the cost-leadership strategy can generate greater accomplishment in a stable environment (Miller, 1988; Miller, 1991). Additionally, from an organizational design perspective, when a large amount of uncertainty is present in the environment, it is better to employ a strategy that explores new options (Burton, Obel & DeSanctis, 2006). The strategic contingencies theory emphasizes more aggressive choices with regard to the deterministic environment, structure, and achievements that are suggested by the structural contingency theory. Organizational decision-making is a strategic problem that includes the value systems of the individuals involved rather than an adjustment to the environment, and the strategic choice includes the decision maker's cognitive choice (Child, 1972).

With regard to the acceptance of innovative technologies, environmental uncertainty and the intensity of competition within the industry could play a role. Environmental uncertainty indicates the degree to which the elements of the external environment are dynamic and unpredictable (Lee, Miller, Woo & Son, 1993). Duncan (1972) found that, as the environmental uncertainty grows higher, more elaborate organizational structures and systems are needed, the input of resources for the work is increased, and the intention of the company to change the organizational structure and to adopt innovative technologies is increased. According to Damanpour (1991), this effect occurs because the environmental uncertainty stimulates innovation within the organization, and the organization will try to escape the conventional mold and answer the demand for change as a way of increasing its value. As the competition within the industry grows intense, the profitability of the industry as a whole decreases, which negatively affects the accomplishments of the organization and ultimately leads to the modification of the strategy (Porter, 1985). As the direction of the strategy becomes challenging and aggressive, each competitor acquires additional intention to adopt innovative technologies.

2.3 Diffusion of Innovation

Innovation is "defined as any idea, practice, or material artifact perceived to be new by the relevant unit of adoption" (Zaltman & Chesler, 1973), and the diffusion of innovation is "defined as the means by which an innovation is communicated through certain channels and adopted by a social system, such as an individual, a group or another unit of adoption over time, expanding the number of adopters" (Rogers, 1995).

Rogers (1995) created a classification of five adopter groups based on the time taken to adopt a non-continuous innovative product and suggested the Technology Adoption Life Cycle model. "Innovators" are largely not interested in the convenience that the innovative products provide and tend to try to acquire new technologies sooner because they have a deeper understanding of technologies

than the average person. “Early adopters” have a tendency to be more advanced regarding innovation and to prioritize economic gains and strategic values. Most of the members of this category pursue high-risk and high-reward opportunities. Innovators and early adopters exceed other individuals in terms of their adventurous spirit, leadership, and understanding of complex technologies. “Early majority adopters” are not particularly interested in the technologies themselves but rather focus on the practical aspects. These adopters pursue improvements in productivity that result from progressive change and sustainable competitive advantage rather than revolutionary changes. “Late majority adopters” are a conservative group that mostly avoids risks and is sensitive to price. “Laggards” are the group that takes a negative view of new technologies or innovative products. The members of this group innately dislike technology, avoid risks, and are doubtful.

A study by Rogers (1995) about the factors that affect the speed of the diffusion of innovation reported that five factors, including the characteristics of the perceived innovation, the type of innovation determination, the characteristics of the social system, the competence of the leader of the change, and the path of communication, had the largest impact on the speed of diffusion.

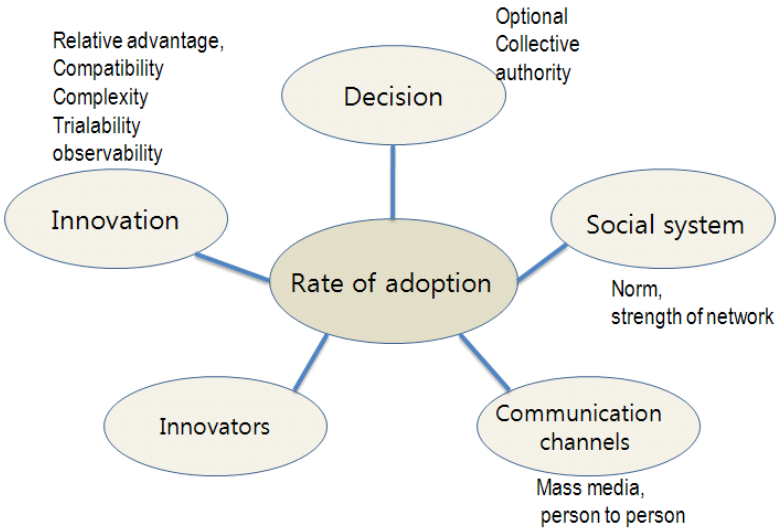

Fig. 2 Factors that Affect the Speed of Diffusion (Rogers, 1995)

The perceived characteristics of innovation, in turn, have five properties, including relative advantage, compatibility, complexity, observability, and trialability, and these properties affect the pattern and rate of adoption. The types of innovation determination are optional, collective, and authoritative. Mass media are effective for the dissemination of innovations in the early phase, as they usually inform the potential adopters of the innovation directly and rapidly, whereas the interpersonal channel produces the dissemination of innovations only after a certain period of time, as the dissemination is performed by each individual (Rogers, 1995).

For the adoption of the pig-rearing phase HACCP system to advance beyond the early adopters and proceed to the early majority, the role of the ATSC and the Rural Development Administration (RDA) as innovators and stimulators of innovation is crucial. The RDA and the ATSC are currently making efforts to expand the farm-level HACCP implementation and promote early adoption by developing and distributing the management standards model, the management manual, and electronic data processing, and it is necessary to determine whether their credibility can be a prerequisite for the adoption.

2.4 Innovativeness and Self-efficacy of the Individual

Individual innovativeness is a concept that has been used by numerous studies related to the adoption of innovative technologies. Based on a behavioral study of consumers, Midgley & Dowling (1978) explain the innovativeness of an individual, which is defined as the tendency to adopt innovative goods or services without the influence of oth-

ers, as an inherent attribute of the individual, and Miller (1983) views the innovativeness as a disposition at the organization level to make audacious decisions while taking risks to achieve goals; as such, the concept of innovativeness has been used in various ways in diverse academic fields.

Additionally, Agarwal & Prasad (1998) defined the innovativeness of an individual as the willingness of the individual to try new technologies, whereas Calantone, Cavusgil & Zhao (2002) defined the innovativeness as the ability to adjust rapidly to novelties, relative to competitors. Agarwal & Karahanna (2000) found that the individual innovativeness is an important factor in the adoption of innovative technologies and influences the perceived usefulness and ease of use of TAM.

Self-efficacy, which is based on social cognitive theory, is defined as a self-belief in the ability to produce a designated level of performance (Bandura, 1977). In other words, self-efficacy can be viewed as confidence in a certain situation; self-confidence allows employees to believe that they can moderate and control certain situations at work, and this increased confidence has the effect of reducing the perceived stress (Schaubroeck, Lam & Xie, 2000). Because self-efficacy has a dynamic structure that particularly reacts to new situations and information, it has been studied extensively in the fields related to the use of innovative technologies or the adjustment to new duties (Gist & Mitchell, 1992; Igbaria, Guimaraes & Davis, 1995; Hayashi, Chen, Ryan & Wu, 2004).

Because the most common size for pig herds in Korea is 1,000~2,000 head, which accounts for 46.5% of the total number of herds, and most farms are run in a single-site management form by a family (including husband and wife) and 1~2 employees, individual attributes have the potential to be an influential factor in the adoption of innovative technologies. Among these individual attributes, the effects of innovativeness and self-efficacy need to be reviewed.

2.5 Technology Acceptance Model (TAM)

The TAM is a model that Davis (1985) used to explain and predict whether an individual would adopt information technologies and was based on the theory of rational behavior. Whereas the theory of rational behavior described a general theory of human behavior, the TAM is acknowledged to be a theoretical and empirical model that is related to the behavior of the users of a certain system (Davis, 1989; Venkatesh & Davis, 1996).

The TAM is a model that was suggested by Davis (1989) to explain and predict an individual's behavior in the field of information technology and was based on the Theory of Rational Action (TRA) of Ajzen & Fishbein (1980), which employed the relationship of subjective norms-attitudes-intent to study the motives of behaviors.

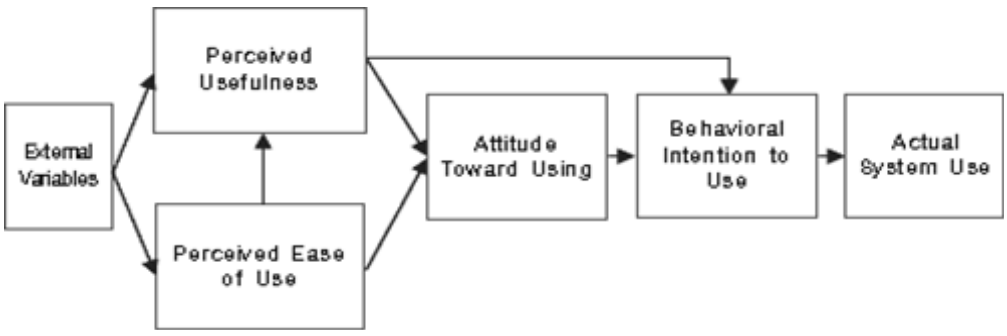

Fig. 3 Early Model of Technology Adoption (Davis, 1989)

Davis (1989) views the perceived usefulness and the perceived ease of use as important factors that affect the actions of users that intend to use technology through expectancy theory, behavioral decision theory, self-efficacy theory, and the theory of the diffusion of innovation; these two concepts are addressed by many studies because they are not only easy to apply to diverse situations involving the use of information technology but also able to produce practical results (Taylor & Todd, 1995).

Venkatesh & Davis (2000) also suggested a simplified model that excludes the concept of attitude adopted from TRA from the major concepts of TAM, and this model is used as a core concept for technology adoption in many studies that do not necessitate a defined approach to the

attitude. Moreover, by establishing the important concepts of the perceived usefulness and ease of use in the technology adoption process, the TAM played an important role in studies on the cognitive process of the human behavior. Thus, it is possible to review whether the perceived usefulness and ease of use of the pig-rearing phase HACCP as a management system for hazard control affect farmers' intentions to adopt the system.

3 Research Model and Hypotheses

3.1 The Operant Definitions of the Research Model and the Variables

Based on the expanded version of the TAM suggested by Davis (1989), this study established a research model that employs perceived usefulness, perceived ease of use, and intention to adopt HACCP as the main dependent variables. Several variables that may affect the perceived usefulness and ease of use of HACCP were identified through preliminary studies and used as underlying factors. The intensity of competition and the environmental uncertainty were set as environmental factors, institutional credibility was set as an institutional factor, and finally, the innovativeness of the individual was included in the research model as an individual factor. A structural analysis of the effects of these factors with the perceived usefulness and the perceived ease of use as the mediator was attempted.

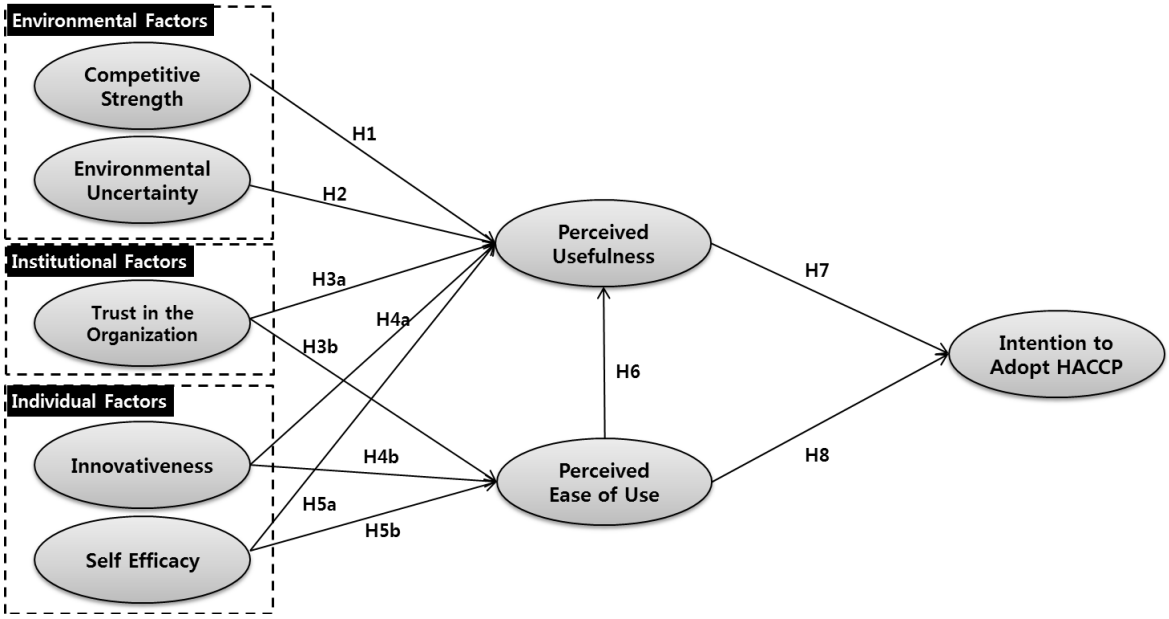

Fig. 4 Research Model

Table 2 shows the organization of the operant definitions, parameters of measurement, and related studies for the variables used in this research model. Eight types of latent variables were measured using 28 parameters of measurement.

Table 2 Operant Definitions and Parameters of Measurement for the Research Variables

Research Variable	Operant Definition	Parameters of Measurement	Related Study
Intensity of competition	The degree of intensification of the competition within the swine industry	Overall intensity of competition against other farms	Premkumar, Ramamurthy & Saunders (2003) Yao, Palmer & Dresner (2007)
		Pricing and quality pressure	
		Degree of intensification of competition in the swine industry	
Environmental uncertainty	The uncertainty felt by farms about the internal and external environment of the swine industry	Uncertainty about pig productivity	Freel (2005)
		Uncertainty about management profitability	
		Uncertainty about the swine industry	
Institutional credibility	Belief that the Agricultural Technology Service Center will act favorably based on the interactions in the past	Credibility of agricultural technologies at the Agricultural Technology Service Center	Gefen, Karahanna & Straub (2003)
		Appropriateness of the agricultural technologies promoted by the Agricultural Technology Service Center	
		Credibility of the level of technology at the Agricultural Technology Service Center	
		Attitudeof the technology instructors at the Agricultural Technology Service Center	
		Proactiveness of the technology instruction by the Agricultural Technology Service Center	
Individual innovativeness	Self-motivation to accept, understand and try new technologies sooner and of active use	Activeness in exploring new technologies	Agarwal & Prasad, (1998) Agarwal & Karahanna, (2000)
		Early adoption of new technologies	
		Risk-taking regarding new technologies	
		Comparative level of technology versus other farms	
Self-efficacy	Self-belief in the abilityto produce the desired level of performance	Level of understanding of technologies	Bandura (1977) Gist & Mitchell (1992)
		Difficulty in acquiring new technologies without instruction	
		Difficulty in acquiring new technologies without experience	
Perceived usefulness	Awareness of the advantages and usefulness of HACCP	Usefulness of HACCP technologies in improving productivity	Davis (1989) Venkatesh & Davis (2000) Venkatesh, Morris, Gordon & Davis (2003)
		Usefulness of HACCP technologies in improving profitability	
		Usefulness of HACCP technologies for the swine industry	
		Comparative usefulness of HACCP technologies versus conventional methods	
Perceived ease of use	Awareness that the utilization of HACCP is easy, does not take much effort, and is easily accessible	Ease of using technologies necessary for utilizing HACCP	Davis (1989) Venkatesh & Davis (2000) Venkatesh, Morris, Gordon & Davis (2003)
		Difficulty of technologies necessary for utilizing HACCP	
		Accessibility of information on HACCP certification and utilization	

Intention to adopt HACCP	The degree of willingness to adopt HACCP technologies in the future	Intention to continuously use HACCP technologies	Karahanna. Straub & Chervany (1999) Rogers (1995)
		Dissemination of HACCP technologies to neighboring farms	
		Intention to continuously use HACCP technologies even without governmental support	

3.2 Research Hypotheses

3.2.1 The Influence of Environmental Factors

Changes in the management environment increase the necessity of new, innovative technologies for companies and have a positive effect on the selection of innovation by external environmental elements, such as the uncertainty that the company feels and the intensity of the competition (Dess & Beard, 1984; Tan, Kannan, Handfield & Ghosh, 1999). Like a company, this principle applies to a farm when it functions as an agricultural business, and the sense of urgency that is felt when the number of competitors in the industry increases or when the product price or service competition in the industry becomes intense will necessitate the implementation of innovative technologies as a means of providing new, innovative measures (Grover & Saeed, 2007). Therefore, the following hypothesis is formulated:

H1: The intensity of competition within the industry will have a positive impact on the perceived usefulness of HACCP technologies.

According to Damanpour (1991), the uncertainty of the farm's environment acts as a factor to stimulate innovation in the organization. Faced with higher uncertainty, farms attempt to break out of the conventional mold as a way of increasing their value, and they feel that the need for the adoption of innovative technologies different from that of conventional technologies. Therefore, the following hypothesis is formulated:

H2: The uncertainty of the farm's environment will have a positive impact on the perceived usefulness of HACCP technologies.

3.2.2 The Influence of Institutional Factors

One factor that greatly affects the speed of the diffusion of innovation is the role of the change leader (Rogers, 1995), and hence, the competence of the ATSC as the change leader directly working with the implementation of new technologies for farms can be used as an external variable.

The competence of the ATSC elicits trust from the farmers and leads to the implementation and expansion of new technologies that are helpful for growth in productivity and profitability. Gefen, Karahanna & Straub (2003) proved that institutional credibility not only influences the intention to adopt to the same extent as the perceived usefulness and the perceived ease of use but it is also related to the two perceived variables. This study presumes that the credibility of the ATSC affects the intention to adopt, with the perceived usefulness and the perceived ease of use of HACCP as the mediators, and thus, the following hypotheses are formulated:

H3a: Institutional credibility will have a positive impact on the perceived usefulness of HACCP technologies.

H3b: Institutional credibility will have a positive impact on the perceived ease of use of HACCP technologies.

3.2.3 The Influence of Individual Factors

Numerous studies that are based on the TAM, as described by Davis (1989), illustrate that the innovativeness of an individual has a positive impact on the perceived usefulness and ease of use of an information system and the attitude toward the system (Park, 2004; Kim & Cho, 2007; Ham & Park, 2009; Kang, 2009). Individual innovativeness can be deemed to comprise the adopter's attitude toward new technologies, and increased innovativeness leads to increased interest in new technologies and a more positive disposition toward new experiences and stimulation. Hence, for the adopters with a high accessibility to new technologies, those technologies will be useful and easy to use. Therefore, the following hypotheses regarding the effects of the individual innovativeness on the perceived usefulness and ease of use are formulated:

H4a: Individual innovativeness will have a positive impact

on the perceived usefulness of HACCP technologies.

H4b: Individual innovativeness will have a positive impact on the perceived ease of use of HACCP technologies.

Ozer & Bandura (1990) stated that self- efficacy reduces the level of discomfort in a stressful situation because employees with high levels of self-efficacy believe that they can control the perceptions that might threaten their mental stability. Self-efficacy increases individuals' work efficiency and contributes to job satisfaction and productivity growth by allowing farms to attempt to overcome challenging tasks and to become proficient at them (Staples, Hulland & Higgins, 1998). A farmer's self-efficacy is the confidence that is activated in a certain situation so that the usefulness of the technology can be viewed without consideration of the difficulty of implementing new technologies. Therefore, the following hypotheses are constructed:

H5a: Self-efficacy will have a positive impact on the perceived usefulness of HACCP technologies.

H5b: Self-efficacy will have a positive impact on the perceived ease of use of HACCP technologies.

3.2.4 Factors Affecting the Intention to Adopt HACCP Technologies According to the Technology Acceptance Model (TAM)

Davis (1989) asserted that the perceived usefulness and the perceived ease of use were the two critical perceived factors for the adoption of information technology. According to Davis (1989), in the relationship between the usefulness and the ease of use, which are the major constituent concepts of TAM, the ease of use influences the usefulness; in other words, technology that is easy to use is used better by the users and produces better performance than technology that is not easy to use. This theoretical relationship has been corroborated by subsequent empirical studies (Mayer, DiPaolo & Salovey, 1990; Thompson, Higgins & Howell, 1991; Venkatesh & Davis, 2000). Presuming that the ease of use will influence the usefulness of HACCP technologies as well, the following hypothesis is formulated.

H6: The perceived ease of use of HACCP technologies will have a positive impact on the perceived usefulness of HACCP technologies.

Furthermore, the TAM asserts that two user perceptions, i.e., the perceived usefulness and the perceived ease of use, strongly predict technology acceptance (Davis, 1989), and the usefulness in particular has been verified to be an important element in the replacement or utilization of conventional technologies by the adopters (Mayer, DiPaolo & Salovey, 1990). In addition, the direct effect of the ease of use on the intention to use information technology indicates that this property can directly increase the degree of adoption of the user, and Adams, Nelson & Todd (1992) showed that the ease of use had a statistically significant impact on technology acceptance. Therefore, judging the perceived usefulness and ease of use of HACCP technologies to be the major variables influencing the intention to adopt HACCP technologies, the following hypotheses are constructed.

H7: The perceived usefulness of HACCP technologies will have a positive impact on the intention to adopt HACCP technologies.

H8: The perceived ease of use of HACCP technologies will have a positive impact on the intention to adopt HACCP technologies.

4 Testing of the Hypotheses and Discussion of the Research Results

4.1 Data Collection and Sample Characteristics

A survey was conducted for this study that was intended to assess the farm acceptance, the degree of utilization, and possible improvement measures of the "pig-rearing phase HACCP system" distributed to farms by the RDA (National Institute of Animal Science). This survey was conducted from July 2011 until November of the same year using all non-HACCP-certified farms as the population. The survey was distributed to a random selection of farms from the 5,700 pig farms that excluded the approximately 500 farms that had adopted HACCP technology as of the first quarter of 2011. Out of a total of 256 surveys that were distributed via mail, 98 surveys were returned, yielding a return rate of 39%.

Regarding the characteristics of the respondents to the surveys used in the analysis (Table 3), the largest age group was individuals aged in their 50s, which accounted for 54.1% of the total, followed by individuals in their 40s and 60s (18.4% each) and a few individuals in their 20s and 30s. With respect to pig-rearing experience, the

largest proportion of respondents had 21 or more years of experience (49.5%), followed by those with 16~20 years (21.4%) and those with 11~15 years (16.3%). The most common level of education was high-school graduation (50.0%), followed by college graduation (28.6%) and middle-school graduation or less (15.3%). Regarding the herd size, respondents rearing 1,000~1,999 head accounted for 28.6%, respondents rearing 2,000~2,999 head accounted for 23.5%, and respondents rearing less than 999 head accounted for 23.5%. Finally, the distribution of income from pig farming revealed that the income of most pig farms was robust, i.e., on the order of 50~100 million Won (31.6%), more than 100 million Won (30.6%), and 30~50 million Won (11.2%).

Table 3. Demographic Characteristics of the Study Subjects

Classification	Categories	Number of specimens (farms)	Proportion (%)
Age	Less than 30 years	3	3.1
	31~40 years	4	4.1
	41~50 years	18	18.4
	51~60 years	53	54.1
	61 years and over	18	18.4
	No response	2	2
Rearing experience	Less than 5 years	5	5.1
	Less than 10 years	8	8.2
	Less than 15 years	16	16.3
	Less than 20 years	21	21.4
	21 years and over	45	45.9
	No response	3	3.1
Level of education	Middle school graduation or less	15	15.3
	High school diploma	49	50.0
	College graduate	27	28.6
	Graduate school and beyond	4	4.1
	No response	3	3.1
Herd size	~999	23	23.5
	1,000~1,999	28	28.6
	2,000~2,999	23	23.5
	3,000~4,999	11	11.2
	5,000~9,999	3	3.1
	10,000 head and up	1	1.0
	No response	9	9.2
Level of pig-rearing income	Less than 10,000 thousand Won	5	5.1
	10,000~29,990 thousand Won	9	9.2
	30,000~49,990 thousand Won	11	11.2
	50,000~99,990 thousand Won	31	31.6
	More than 100,000 thousand Won	30	30.6
	No response	12	12.2

4.2 Verification of Measurement Tools

4.2.1 Selecting the Measurement Tool

This study used PLS (Partial Least Squares) for the statistical analysis of the causal relationships among the latent variables of the research model. PLS is a second-generation structural equation model for multivariate analysis, and it has several differences from the conventional structural equation methods, such as LISREL, which are based on conventional covariance analysis. Whereas most covariance analysis models employ the factor analysis method when analyzing the relationships between latent variables and measurement parameters, PLS employs the key-factor analysis method and is thus free from strict assumptions about the normal distribution of the collected data, which is a major constraint on the conventional structural equation method.

Moreover, conventional structural equation methods primarily focus on estimating the model-fit and analyzing the theoretical agreement of the measured covariance and the hypothetical covariance, whereas PLS maximizes the predicting power of the path coefficients by minimizing the measured errors and the forecast errors between the latent variables. Therefore, the indices that are generated by PLS in the end are not represented in terms of the indices that show the model-fit, such as GFI, NFI, or NFFI, but rather in terms of the R2 value, which shows how well the independent variables predict the dependent variables (Chin & Todd, 1995).

Given that PLS is applicable for smaller sample sizes and free from the constraints that affect conventional structural equation methods regarding the strict set of assumptions about the normal distribution of the collected data and the sample size (Abdi, 2003), it was judged to be more appropriate than covariance analysis for the structural equation modeling of this study, which has a relatively small sample size. According to Barclay, Thompson & Higgins (1995), there should be no problems in PLS structural equation analysis if the sample size exceeds 10 times the number of parameters of measurement of the latent variable with the most parameters of measurement. Because the latent variable that has the most measurement parameters in the research model of this study, 'trust in the institution', has five parameters of measurement, the collected data from 93 survey samples can be used.

4.2.2 Verification of Internal Consistency

First, the reliability of the measurement tool used in this study was analyzed. The reliability refers to the degree of similarity in the results that are produced when repeated measurements of identical concept are assumed to be taken, and the composite reliability, Cronbach's Alpha, and average variance extracted (AVE) are used for its analysis. The reliability of the measurement tool is verified when the composite reliability is greater than or equal to 0.7, the value of Cronbach's Alpha is greater than or equal to 0.7, and the AVE value is greater than or equal to 0.5 (Fornell & Larcker, 1981). Because the composite reliabilities of all of the constituent concepts of this study are over 0.7, the Cronbach's Alpha values are over 0.7, and the AVE values are also over 0.5, the reliability of the measurement tool is judged to be appropriate (Table 4).

Table 4 Analysis of the Composite Reliability, the Average Variance Extracted, and Cronbach's Alpha

Variable	Composite Reliability	AVE	Cronbach's Alpha
Intensity of Competition (comp)	0.839	0.635	0.701
Environmental Uncertainty (env)	0.919	0.792	0.867
Institutional Credibility (cr)	0.936	0.745	0.914
Individual Innovativeness (inno)	0.9	0.695	0.852
Self-efficacy (se)	0.873	0.698	0.783
Usefulness (use)	0.937	0.788	0.909
Ease of Use (eou)	0.837	0.631	0.705
Intention to Adopt (ui)	0.825	0.612	0.700

4.2.3 Verification of the Convergent Validity and Discriminant Validity

To investigate the convergent validity and the discriminant validity, a confirmatory factor analysis was conducted. The convergent validity was verified when the factor loading was greater than or equal to 0.7. Because the factor loadings for all of the variables were over 0.7, as shown in Table 5, the tool assessing the measured variables of this study satisfies the convergent validity condition.

Next, a cross-loading analysis and AVE square-root analysis were conducted to verify the discriminant validity. The loadings for the constituent concepts of all of the latent variables were over 0.7, and the loadings for the other constituent concepts turned out to be mostly less than 0.7. This result shows that the measurement tool has discriminant validity. The AVE analysis compares the value of the square root of the AVE of each latent variable and the coefficient of correlation among the latent variables. The discriminant validity can be considered to be verified when the value of the AVE square root of a latent variable is larger than all of the coefficients of correlation among the other latent variables (Chin, 1998). As observed in Table 6, when the coefficients of correlation among all of the latent variables and the AVE square roots are obtained, the value of each AVE square root is larger than the other coefficients of correlation in the adjacent column and row, which verifies the discriminant validity of the measurement tool used in this study.

Table 5 Analysis of Cross Loading

	Intensity of Competition	Environmental Uncertainty	Institutional Credibility	Individual Innovativeness	Self-efficacy	Usefulness	Ease of Use	Intention to Adopt
comp1	.810	.331	.337	.343	.289	.430	.045	.387
comp2	.814	.191	.361	.364	.326	.198	-.148	.159
comp3	.766	.356	.362	.514	.120	.369	.048	.389
env1	.330	.884	.197	.112	.081	.120	-.016	.024
env2	.337	.883	.157	.047	-.012	.199	-.114	.117
env3	.309	.903	.219	.075	.025	.137	-.100	.078
cr1	.608	.261	.809	.484	.283	.577	.156	.492
cr2	.368	.144	.845	.258	.163	.477	.160	.320
cr3	.275	.155	.875	.271	.198	.491	.317	.327
cr4	.353	.187	.902	.361	.095	.517	.241	.389
cr5	.326	.184	.882	.415	.137	.533	.365	.450
inno1	.497	.053	.401	.873	.373	.362	.288	.480
inno2	.454	.104	.334	.926	.464	.317	.348	.471
inno3	.446	.198	.397	.780	.419	.421	.191	.388
inno4	.283	-.072	.240	.744	.487	.202	.416	.233
se1	.325	.048	.202	.677	.759	.167	.329	.201
se2	.182	.071	.212	.303	.861	.109	.267	.140
se3	.278	-.028	.094	.355	.880	.060	.122	.134
use1	.405	.194	.564	.369	.111	.879	.247	.629
use2	.394	.139	.561	.384	.097	.923	.209	.590
use3	.336	.090	.512	.312	.074	.934	.171	.586
use4	.342	.192	.494	.327	.191	.809	.172	.476
eou1	-.031	-.029	.201	.275	.308	.193	.731	.329
eou2	.019	-.120	.239	.239	.109	.120	.796	.187
eou3	-.046	-.055	.247	.367	.257	.223	.852	.318
ui1	.413	.021	.416	.508	.094	.665	.267	.821
ui2	.314	.138	.479	.347	.121	.530	.234	.826
ui3	.166	.028	.147	.252	.239	.286	.329	.693

Table 6 Cross Loading and AVE Values among the Latent Variables

	Intensity of Competition	Environmental Uncertainty	Institutional Credibility	Individual Innovativeness	Self-efficacy	Usefulness	Ease of Use	Intention of Adopt
Intensity of Competition	0.834							
Environmental Uncertainty	0.520	0.835						
Institutional Credibility	0.413	0.200	0.863					
Individual Innovativeness	0.508	0.310	0.443	0.797				
Self-efficacy	0.088	0.035	0.215	0.365	0.890			
Usefulness	0.391	0.130	0.600	0.416	0.171	0.888		
Ease of Use	0.371	0.280	0.289	-0.025	-0.086	0.225	0.794	
Intention to Adopt	0.478	0.187	0.457	0.389	0.082	0.644	0.349	0.782

* The correlations between the latent variables for the shaded cells are 1.000, and the values marked are the AVE square roots.

4.3 Verification of the Research Model

4.3.1 Verification of the Hypotheses

Figure 5 shows the values of the path coefficient and R2 for each group in the suggested research model using PLS based on the constructed hypotheses. The R2 values for the perceived usefulness, the perceived ease of use, and the intention to adopt were 0.428, 0.187, and 0.487, respectively; the R2 values for the variables other than the perceived ease of use were high.

Table 7 shows whether the hypotheses were accepted, along with the path coefficient and the statistical significance. Based on the path coefficient analysis, among the environmental factors, only the intensity of competition was statistically significant at the $p<0.01$ level, with a coefficient of 0.225 for the influence of the perceived usefulness. The environmental uncertainty did not affect the perceived usefulness. Therefore, only hypothesis 1 was supported.

Institutional credibility, which is an institutional factor, did not affect the perceived ease of use and influenced only the perceived usefulness (0.454, $p<0.01$). Individual innovativeness and self-efficacy, which are individual factors, had no impact on the perceived usefulness or the perceived ease of use. Therefore, only hypothesis 3a was supported, and the other hypotheses regarding the institutional factors and the individual factors were rejected.

The perceived usefulness did not have any influence on the perceived ease of use. The coefficients of influence of the perceived usefulness and the perceived ease of use on the intention to adopt (0.622 and 0.203, respectively) were statistically significant. Therefore, hypotheses 7 and 8 were supported.

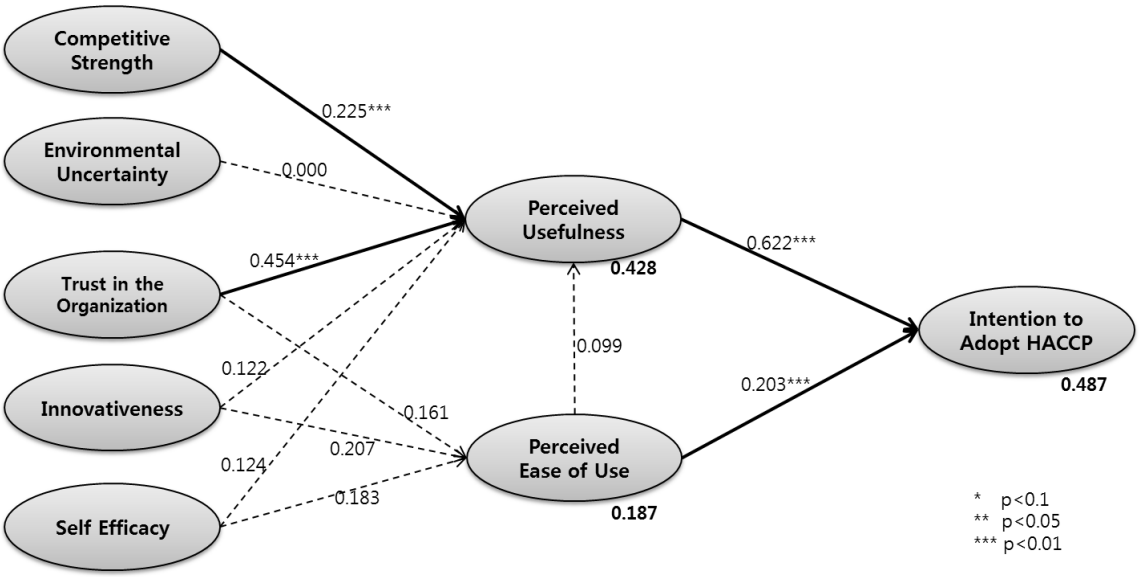

Fig. 5 The Results from Testing the Research Model

Table 7 The Results from Testing the Hypotheses

Hypothesis	Path	Path Coefficient	t-value	Acceptance
H1	Intensity of competition → Perceived usefulness	0.225***	2.2571	Accepted
H2	Environmental uncertainty → erceived usefulness	0	0	Rejected
H3a	Institutional credibility → Perceived usefulness	0.454***	5.5665	Accepted
H4a	Individual innovativeness → Perceived usefulness	0.122	1.0184	Rejected
H5a	Self-efficacy → Perceived usefulness	0.124	1.2588	Rejected
H3b	Institutional credibility → Perceived ease of use	0.161	1.4831	Rejected
H4b	Individual innovativeness → Perceived ease of use	0.207	1.5598	Rejected
H5b	Self-efficacy → Perceived ease of use	0.183	1.5277	Rejected
H6	Perceived usefulness →Perceived ease of use	0.099	1.2593	Rejected
H7	Perceived usefulness → Intention to adopt	0.622***	7.2383	Accepted
H8	Perceived ease of use → Intention to adopt	0.203***	2.1446	Accepted
***p<0.01, **p<0.05, *p<0.1				

4.3.2 Interpretation and Discussion of the Study Results

The results of the present study indicate that the intention of the farms to adopt HACCP was influenced by the perceived usefulness and the perceived ease of use of HACCP technologies. The perceived usefulness can be augmented by the environmental factor of the intensity of competition within the swine industry and the institutional factor of institutional credibility. However, the influence of the perceived ease of using HACCP technologies could not be evaluated with the variables used in this study.

The major study results are as follows. First, whereas the intensity of the competition felt by a farm is an important factor that increases perceived usefulness, environmental uncertainty did not affect perceived usefulness. Considering that perceived usefulness is a mediating variable for HACCP acceptance, it can be inferred that the acceptance of HACCP by pig farms increases when the com-

petition within the swine industry is intensified through an increase in the number of pig farms within the industry or heightened quality or pricing pressure. This observation reflects the willingness of the farms to adopt HACCP technologies to reduce the production costs and produce safe, high-quality food, thereby permitting survival when the competition within the industry becomes intense. However, the uncertainty of the external environment, which affected both productivity and profitability, did not affect perceived usefulness; therefore, the swine industry in Korea likely feels that it is able to withstand changes in the external environment, with the assistance of the robust home market and the advanced technologies available for managing the specifications of pig rearing.

Second, the value of the influence coefficient for the effects of the credibility of agricultural institutions, such as the ATSC, on perceived usefulness was very large (0.454), which indicates that institutional credibility is an important prerequisite for perceived usefulness. Although the value of the path coefficient computed by the PLS analysis does not represent the absolute value of the influence, the coefficient for the influence of institutional credibility on perceived usefulness was more than twice the coefficient for the intensity of competition, which implies that the ATSC and RDA play an important role in the adoption and expansion of HACCP technologies. This function is important because it is difficult for most of the small-to medium-sized farms to obtain information on new technologies themselves, thereby necessitating their reliance on the education and information dissemination of the ATSC; thus, it is necessary for the ATSC and the RDA to gain credibility among the agricultural population by reinforcing the competence of the organizations. Because several empirical studies have attested to the adoption of HACCP improving the productivity and profitability of pig farms (Nam, Cho, Kim, Kim, Lim et al., 2008; Nam, Kwak, Pyo, Hwang, Kim et al., 2008; Cho & Kang, 2009; Kim, Cho, Pyo, Kwak & Nam, 2009), the propagation of the merit of HACCP technologies, aided by the credibility of the ATSC and the RDA, is indispensable for the adoption and expansion of HACCP technologies. Moreover, improvements in the quality of HACCP instruction and scrupulous support and post control are necessary.

Third, individual variables, such as individual innovativeness and self-efficacy, did not affect either perceived usefulness or the perceived ease of use. Many studies have proven that individual innovativeness and self-efficacy can be prerequisites for the perceived usefulness and ease of use of technologies, but verification of the research model and hypotheses in this study led to a conclusion that differed from those of previous studies. This result signifies that, among the agricultural population and in contrast to the adopters of technology in other fields and industries, individual innovativeness and self- efficacy do not influence the perceived usefulness and ease of use of technology; furthermore, these factors have no significant influence on the intention to accept technology.

Finally, it was proven that the TAM as described by Davis (1989) is applicable to HACCP technologies, and thus, the extensibility of the TAM was confirmed. The adoption of HACCP technologies was largely affected by how useful the HACCP technologies were for the farmer and how easy it was to adopt and use the technologies; in particular, because the coefficient for the influence of perceived usefulness was especially high, it can be concluded that the usefulness of HACCP plays a crucial role in its adoption. However, the lack of an effect for perceived ease on perceived usefulness indicates that the farmers considered the ease of use and the usefulness of HACCP technologies to be separate, independent concepts with no causal relationship. This study had one limitation: it failed to identify any prerequisite variables that affect the perceived ease of use of HACCP technologies, which was the original intention of this study. Therefore, this aspect will be complemented by future studies.

5 Conclusion

This study intended to examine the factors that exert a major influence on the adoption and expansion of innovative technologies through a research model that combines strategic contingencies theory, the theory of the diffusion of innovation, and technology acceptance theory, using farms that had not adopted the ‘pig-rearing phase HACCP system’ as subjects. Among the five influential factors of the speed of innovation diffusion outlined by Rogers (1995), this study set out to elucidate the effects of the credibility of the ATSC as a leader of change on innovations. A survey touching on these points was distributed to 256 pig farmers, and 98 valid surveys were returned. The major conclusions are as follows.

First, based on strategic contingencies theory, the theory of the diffusion of innovation, and TAM, the intensity of competition and the institutional credibility were determined to be the prerequisite factors for the perceived usefulness of innovative technologies.

Second, the positive effects of institutional credibility on the perception of usefulness and the positive effects of perceived usefulness on the intention to adopt were

validated.

Thirdly, the perception of intensified competition positively affects perceived usefulness but does not significantly affect the perceived ease of use. In addition, perceived usefulness has a positive effect on the intention to adopt.

The innovativeness and self-efficacy of an individual were suggested to influence a farmer's attitude toward new technologies. However, these factors did not have a statistically significant influence on the perceived usefulness and ease of use. Incidentally, several studies (Cho, 2006; Sung, Shin & Ahn, 2009) have proven that the innovativeness of an individual, which is a variable of individual attitude, has an effect with self-efficacy as the mediator or is able to act as a moderating variable.

The implications of this study are as follows. First, the path leading to the adoption of the HACCP system by farmers at the rearing phase of pig production was "trust in the instructing institution → perceived usefulness → intention to adopt." This scenario occurs because it is difficult for most small- to medium-sized farms to acquire information about new technologies, which leads them to rely on education and information dissemination by the ATSC. Hence, the ATSC and RDA must gain credibility among the farming population through the reinforcement of the competence of the organizations.

Second, this study discovered the path of "intensity of competition → perceived usefulness → intention to adopt." This scenario reflects the willingness of farms to implement HACCP technologies to reduce their production costs and to produce safe food to facilitate their survival when competition within the industry becomes intense.

Third, this study clarified the role of the agricultural extension organization as a leader of change. It is the leader's role to gain credibility, and hence, the ATSC, which is the foremost agricultural extension organization, is at the crux of the projects introducing new technologies. Although it is important to advertise that HACCP adoption can increase farm productivity, the development of credibility by strengthening the instructional competence of agricultural extension organizations is an urgent task for the expansion of system acceptance. To accomplish this goal, the professionalism and technological level of the ATSC must be enhanced. Providing relevant information and technology at an appropriate time is central for promoting the adoption of new technologies by farmers.

This study contained several limitations, and future research can address these limitations. First, the return rate of survey in this study was low. Only 38% of the surveys distributed to non-adopter farms were returned; additional studies are needed to review the intention to adopt by farms that did not respond to the survey. Second, only the institutional credibility was measured; the role of the institution in promoting the adoption of the system needs to be assessed in more detail by measuring the quality of the instructional support and post control. Additional studies are also necessary that consider variables such as the credibility of the system that can affect the adoption of HACCP. Third, the effects of individual innovativeness and self-efficacy need to be considered separately with respect to the herd size. This analysis is necessary because small-scale farms could be majority adopters who prioritize economic values, whereas medium- to large-scale farms could manifest the characteristics of early adopters of new technology. An approach based on scale will be helpful in establishing a policy that reflects the adopter characteristics.

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