Study for Doctoral Thesis

Determinants of Information Technology Assimilation in the Dairy Industry

-An Exploratory Perspective-

낙농업에서 정보 기술 적용의 결정 요인에 관한 연구

- 탐색적 고찰 -

August 2012

서울대학교 대학원

농경제사회학부 지역정보전공

Ronald S. Berger

Determinants of Information Technology Assimilation in the Dairy Industry

-An Exploratory Perspective-

낙농업에서 정보 기술 적용의 결정 요인에 관한 연구

– 탐색적 고찰 –

Advisor: Professor Young Chan Choe

Submitting a Doctoral Thesis of Economics
August 2012

서울대학교 대학원
농경제사회학부 지역정보전공

Confirming the Doctoral Thesis Written by
Ronald S. Berger
August 2012

Chair______________________(Seal)

Vice Chair__________________(Seal)

Examiner___________________(Seal)

Examiner___________________(Seal)

Examiner___________________(Seal)

Abstract

Determinants of Information Technology

Assimilation in the Dairy Industry

-An Exploratory Perspective-

Ronald S. Berger

Regional Information

Department of Agricultural Economics and Rural Development

Graduate School

Seoul National University

Information management in the dairy industry is more complex because of the intensification of information systems and the increase in knowledge about animal management, consumer demand for higher quality products, and government regulations. Technology enables precision agriculture (Wang et al., 2006), which obtains effective data in real time (Zhang et al., 2002). Precision livestock farming originates from the increased use of information technology for livestock and dairy management activities (Banhazi et al., 2007; Mertens et al., 2011). However, studies indicate that the application of information technology in agricultural production is minimal (Thomas and Callahan, 2002). Farmers did not take advantage of information technology during the 1980s and 1990s (Schmidt et al., 1994). Farmers have shown a low rate of information technology adoption (Morris et al., 1995). Studies in New Zealand indicate that dairy farms have not adopted or have been slow to adopt new technologies that would benefit their milk production (Crawford et al., 1989; Deane, 1993; Edwards and Parker, 1994; Stantiall and

Parker, 1997). In general, businesses do not utilize the full potential of information technology applications and components (Jasperson et al., 2005). Businesses typically operate at low levels of component use and rarely extend the use of available components that are offered by the technology (Davenport, 1998; Lyytinen and Hirschheim, 1987; Mabert et al., 2001; Osterland, 2000; Rigby et al., 2002; and Ross and Weill 2002).

There are two objectives for this dissertation. The first objective is to investigate factors for the post-adoption of a dairy management information system in South Korea. The second objective is to investigate factors for the assimilation and extended use of a dairy management information system. The first and second objectives are investigated in Chapters 3 and 4. The objectives are applied as two studies that focus on post-adoption and assimilation of information technology used in dairy management. A literature review on precision agriculture and precision livestock farming is also investigated in Chapter 2. Chapter 2 investigates the adoption, potential functions and actual applications of precision agriculture and precision livestock farming. Automated dairy systems are also reviewed.

Chapter 3 is an exploratory case study that examines the post-adoption of a dairy management information system in South Korea. We develop a multi-method case study to investigate the influences for adoption by early adopters. Individual adopter and environmental, technological and organizational factors are investigated. The results of this study can provide better insight for why the adoption of a dairy management information system and agricultural information systems in Korea and elsewhere is lagging. The propositions were evaluated using qualitative data collected through on site interviews with dairy managers that have already implemented the system. The study results suggest that environmental conditions appear more relevant than individual characteristics of the farmer. There was a general feeling that technology is a “good” thing rather than bottom-line profit. Trust is more important than economics. Although farmers adopted the technology, they still prefer to “observe” conditions on the farm manually. A number of farm processes remained somewhat of an “art.” Farmers prefer to follow known routines. This relationship may contribute or hinder the adoption of this emerging technology. The results of this case study closely follow and are linked to the Technology-Organization-Environment Framework (Tornatsky and Fleisher, 1990). The results of the study were a set of propositions and general framework, which lead to Chapter 4. We were able to support eleven of sixteen propositions. This is the first exploratory, multi-method case study to look at a dairy management information system in South Korea. The study further provides a better understanding of the relationship between dairy managers and vendor support. We investigate factors that affect assimilation and extended use of a dairy management information system in Chapter 4.

Chapter 4 is a quantitative study that examines the assimilation and extended use of an information system used in dairy management. We initially investigate this study through the Technology-Organization-Environment Framework. The theoretical model proceeds through two assimilation and extended use stages. The first stage is farm operational activities. These farm operational activities are daily operations, production planning and herd health management. The second stage is the level of process automation. There are many studies that are concerned with the adoption of information technology. There have rarely been studies on assimilation of information technology from an agricultural and dairy context. The study utilizes data collected through a Likert-type survey. Exploratory and confirmatory factor analysis and partial least squares for hypothesis testing are performed. Results indicate that measures for daily operations have a significant effect on the level of process automation. This effect is negatively impacted by the years of dairy industry experience. There is also evidence that farm size can facilitate information system assimilation and extended use to automate herd health management. Social influences such as other farmers and other support services outside the organization can affect future use of the system. The system can also improve outside relationships and farm image. These factors facilitate the

assimilation and extended use of the system in farm operational activities. The study introduces an information systems framework and demonstrates its applicability to extended farm operational activities from a theoretical perspective. The study also introduces a new component that involves biological phases of a domesticated animal in a dairy farm environment. This biological component is rarely seen in information technology adoption and assimilation research.

Keywords: Assimilation, Dairy Management Information Systems, Extended Use, Post-Adoption, Precision Agriculture, Precision Livestock Farming, Technology-Organization-Environment Framework

Student ID: 2009-30760
E-mail: ronberger@snu.ac.kr

Table of Contents

List of Tables

List of Figures

Chapter 1

Overview

Technology is dominated by two types of people: those who understand what they do not manage, and those who manage what they do not understand. –Archibald Putt, 2006

1.1 Research Background

Information technology (IT) can have a beneficial impact on the public. This impact has developed importance in areas such as education, health and medical services, and agriculture. How does IT impact agriculture? Technology enables what is referred to as precision agriculture (PA) (Wang et al., 2006). PA makes it possible to obtain effective data in real time (Zhang et al., 2002). In the context of dairy management, precision livestock farming (PLF) is a relatively new field originating from the increased use of IT that supports livestock management (Banhazi et al., 2007; Mertens et al., 2011). PLF was introduced to ensure that every process within a livestock activity is controlled and optimized within narrow limits (Banhazi and Black, 2009). Precision dairy farming (PDF) is an additional area that supports dairy operational activities with the use of IT (Schulze et. al., 2007). This optimization, in the case of PDF, can protect the consumer and animal, and ensure quality control within the dairy farm (Schulze et. al., 2007). For the intent of this dissertation, the implementation of an information system for dairy management (DMIS) can be equated to the recent implementation of PLF and PDF systems. Dairy farmers are now able to apply information systems (IS) software to manage milk through technology that monitors specific components such as fat, protein, blood, and other toxics with a predictable output. Other dairy functions such as cow activity, feeding and weighing can also be watched closely. An abbreviation list for this dissertation is provided in Appendix A.

1.2 Problem Statement

Why is it important to study the adoption and assimilation of information technology in agriculture and dairy management? Why has agriculture been slow to adopt and assimilate information technology? The literature shows that the adoption and assimilation of IT in agricultural production is minimal (Thomas and Callahan, 2002). Farmers did not adopt and assimilate IT during the 1980s and 1990s (Schmidt et al., 1994). Farmers have shown a low rate of IT adoption (Morris et al., 1995). Similarly, studies in New Zealand indicate that dairy farms have not adopted or have been slow to adopt new technologies that could benefit their milk production (Crawford et al., 1989; Deane, 1993; Edwards and Parker, 1994; Stantiall and Parker, 1997). Many cattle operations have also been slow to adopt and assimilate IT (Blezinger, 2001). Post-adoption behavior studies indicate similar results. Potential IT applications are underutilized by users (Jasperson et al., 2005). Users apply a minimal amount of applications, operate at a low level of use, and rarely initiate extended use of system components. Organizations need to accumulate collective intrinsic knowledge, and understand post-adoption behavior over time to fully utilize and assimilate IT.

The viability of IT depends on the continued use of the IT (Bhattacherjee, 2001; Karahanna et al., 1999). The assimilation of IT applications during post-adoption can increase overtime by intensification and routinization. The assimilation of IT can also decrease overtime with resistance, or treated with a lack of interest (Hartwick and Barki, 1994; Hiltz and Turoff, 1981; Kay and Thomas, 1995; Thompson et al. 1991, 1994) or enthusiasm (Thong et al., 2006). Overall, this can lead into decreased usage or disuse of the technology. Therefore, assimilation and post-adoption studies are ambiguous. One limitation is the research design. A cross-sectional design can be appropriate for pre-adoption research. However, a longitudinal design may be more appropriate for assimilation and post-adoption research.

It is our argument that dairy farm managers lack the business knowledge and expertise to apply “business best practices.” Rather, managers use intuition, experience and gut feeling (art versus science) to support their decisions in management and operational processes. It has not been easy to encourage farmers to accept and change the way that they manage information. However, business success, efficient production and the quality of agriculture and dairy products are dependent on reliable information. Ideally, dairy farms should be managed “like a business.” This is also apparent by the preference to assimilate and use technical solutions over business solutions (i.e., farming technology versus decision-making systems). However, business success and the ability to adopt and assimilate a reliable system can depend on factors such as the size of the farm, and the age and years of industry experience of the user.

1.3 Small and Medium-sized Enterprises

Typically, most farms are small and medium-sized enterprises (SMEs). They are operated by farming experts rather than business managers. For example, the United States dairy industry does have large-size corporate farms with 1000-2000 cows per farm.[1] There was a 25.2% increase for this group from 2000-2006. In contrast, 28% of the dairy operations have less than 30 cows per farm. There was a 31% decrease for this group from 2000-2006. The changes in the size of dairy farms in the United States are shown in see Table 1-1. By definition, The United States government considers farms with 200 or fewer cows per farm as small-size operations.[2] Although there has been some consolidation of small herd-size farms in recent years, most dairy farms in the United States (like other countries) are relatively small-size.

---

1 http://www.ers.usda.gov/publications/err47/err47b.pdf [Last accessed 06/27/2011]
2 http://www.epa.gov/npdes/pubs/sector_table.pdf [Last accessed 06/27/2011]

Table 1-1 Changes in the Size Structure of U.S. Dairy Farms, 2000-2006

Herd size	**Farms (2000)**	**%**		**Farms (2006)**	**%**	**% Change**
1-29	30,810	29.3		21,280	28.3	-31.0
30-49	22,110	21.0		14,145	18.8	-36.0
50-99	31,360	29.8		22,215	29.6	-29.2
100-199	12,865	12.2		9,780	13.0	-24.0
200-499	5,350	5.1		4,577	6.1	-14.4
500-999	1,700	1.6		1,700	2.3	+-0.0
1,000-1,999	695	0.7		870	1.1	+25.2
2,000+	280	0.3		573	0.8	+104.6
Total	105,170	100.0		75,140	100.0	-25.5

Adapted from MacDonald et al., 2007

Similarly in the United Kingdom, over 11,000 dairy farms are SMEs with an average herd-size of 113 cows per farm.[3] A majority of farms in Ireland have 50-60 cows per farm.[4] Canada has a herd-size average just over 60 cows per farm (Painter 2007). Nearly all dairy farms in South Korea are family-operated. They have a herd-size of less than a 100 cows per farm (Berger, Forthcoming). In contrast to most countries, farms in New Zealand are much larger and average over 300 cows per farm (Painter, 2007). In addition, a survey of thirty dairy farm equipment dealers from seventeen countries that service over 2000 farms indicate that 69.5% of these farms have less than 200 cows per farm. Only 2.8% are corporate farms with greater than 2000 cows per farm (Berger, Forthcoming). Therefore, our assumption is that most dairy farms are small-size and managed by farmers rather than business managers regardless of developed or developing country.

[3] http://www.wspa.org.uk/wspaswork/factoryfarming/UK_dairy_farming.aspx [Last accessed 06/27/2011]

[4] http://www.rte.ie/news/2011/0623/teagascdairyreport.pdf [Last accessed 06/27/2011]

1.4 Dissertation Objectives and Research Questions

The organization for this dissertation consists of three parts. A literature review is investigated on the adoption, potential functions and applications for precision agriculture and precision livestock farming in Chapter 2. Automated systems in dairy management are also reviewed. Second, an exploratory case study that investigates the post-adoption of a dairy management information system in Korea is conducted in Chapter 3. South Korea will be referred to as Korea for the remainder of this dissertation. Third, a quantitative study that examines the assimilation of a dairy management information system is conducted in Chapter 4. The survey for the quantitative study is developed from results of the exploratory case study. The assimilation of a DMIS from a Technology-Organization-Environment Framework (Tornatsky and Fleischer, 1990) design is investigated. The objectives of this dissertation are to investigate post-adoption factors for a DMIS currently used in Korea, and investigate factors for the assimilation of the same DMIS from an extended use and level of automation approach. The research questions for this dissertation are:

1. *To what extent does the relationship of environmental, technological, and organizational factors drive/inhibit post-adoption of a dairy management information system in Korea?*

2. *To what extent does the assimilation of a dairy management information system in extended use activities drive the level of process automation on dairy farms?*

3. *To what extent does the relationship between technological, organizational, and environmental factors drive the assimilation of a dairy management information system in extended use activities on dairy farms?*

1.5 Organization of the Dissertation

Businesses do not utilize the full potential of IT applications and system components (Jasperson et al., 2005). The adoption and assimilation of IT in agriculture has had varied results. This dissertation applies two related studies that focus on the adoption of a DMIS by early adopters in Korea, and the assimilation of the same DMIS in extended use activities and the level of process automation. Figure 1-1 shows the general structure and conceptual models developed in Chapters 3 and 4 of the dissertation.

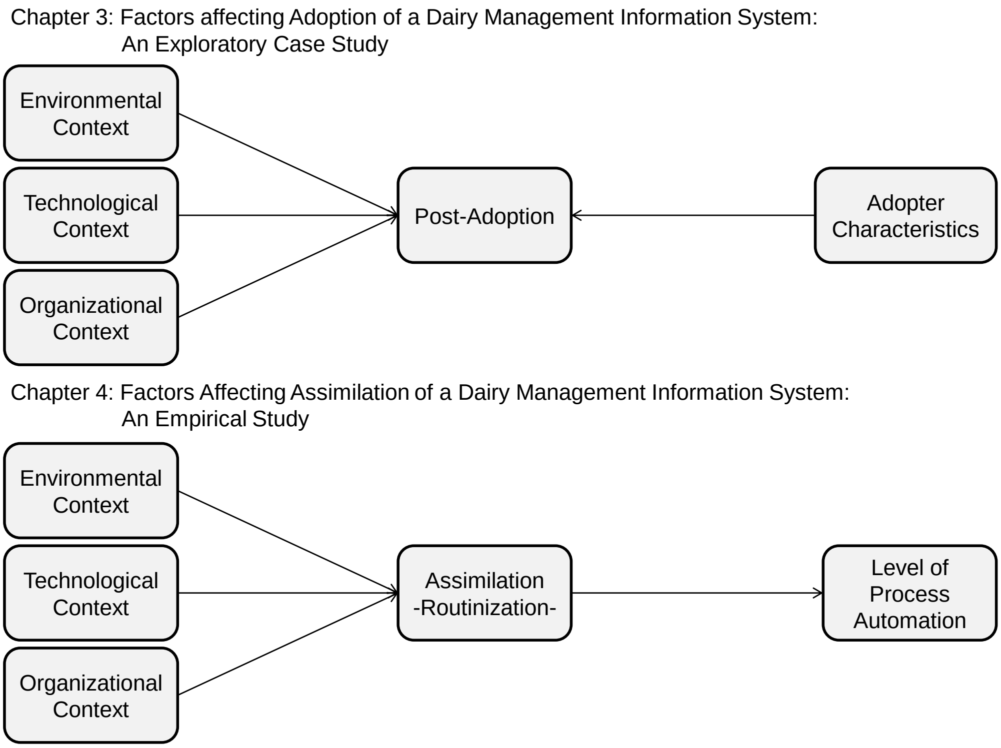

Figure 1-1 General Structure and Model Concepts for the Dissertation

Chapter 2 provides a literature review of the adoption, potential functions and applications within precision agriculture, precision livestock farming, and automated systems in dairy management. Chapter 3 provides an exploratory case study based on the motivations for adoption of a dairy management information system by early adopters in Korea. This is an unexplored topic using a qualitative method approach. Initially an interpretive case study, farm visits and interviews were conducted to understand where farmers are coming from. Chapter 3 also provides an explanation and an argument that supports case study research, and reasons for why it is implemented into this dissertation. The result was a set of propositions and general framework, which lead to Chapter 4. Chapter 4 provides a quantitative empirical study of a dairy management information system that extends the Technology-Organization-Environment Framework.

The level of process automation is derived through extended use measures of the system. The results from Chapters 3-4 lead to Chapter 5. Chapter 5 provides final conclusions that draw together the case and quantitative studies. An explanation for how they are related is provided and new integrate framework based on the results is developed. The final sections include the references and Appendices for Chapters 1-5. The reference section is formatted by using the American Psychological Association or APA style guide.[5][6][7] A list of abbreviations, open-ended interview questions for the case study, dairy management information system components description, Likert-type survey for the quantitative study (English, Taiwanese/Chinese, and Korean) and farmer comments are in the appendices. The final section is an abstract of the dissertation written in Korean.

[5] http://www.library.cornell.edu/resrch/citmanage/apa [Last accessed 06/22/12]
[6] http://owl.english.purdue.edu/owl/resource/560/01/ [Last accessed 06/22/12]
[7] http://library.nmu.edu/guides/userguides/style_apa.htm [Last accessed 06/22/12]

Chapter 2

Literature Review

The first rule of any technology used in a business is that automation applied to an efficient operation will magnify the efficiency. The second is that automation applied to an inefficient operation will magnify the inefficiency.[8] –Bill Gates

2.1 Introduction

The management of information in the agriculture and dairy sectors is more complex today in comparison to the 1990s. The reasons for an increase in complexity are the intensification of farming systems and the additional knowledge about plant and animal management, consumer demand for higher quality products, and government regulations. Predictable output for farming systems is desirable since it can reduce perceived financial risk (Baker, 1973). Supply chain outputs can be measured by performance in the quantity or quality produced (Beamon, 1999). For example, companies invest in Total Quality Management or TQM to minimize variance in product quality (Hendricks and Singhal, 1997). In addition, predicting a stable inflow of inputs such as raw material, labor, and energy use (assuming consistent quality, quantity and pricing), and a stable and predictable production process can benefit a company's manufacturing, marketing, communications, sales, and distribution processes (Zairi, 1997).

Predicting a stable inflow of inputs is relatively easy for most industries. A stable and predictable production process in a modern automated manufacturing environment is often accomplished by using robotics and shop-floor control systems (Grigori et al., 2001). Companies attempt to control their inputs by

[8] http://thinkexist.com/quotations/technology/ [Last accessed 06/14/12]

engaging in Just-in-Time alliances, and integrate production. Inter-organizational Systems (IOS) such as electronic data interchange (EDI), supply chain management (SCM), Web auctions, and automated purchasing agents provide the infrastructure used to improve the procurement of goods (Premkumar, 2000). Controlling inputs is more challenging for industries that rely on natural or perishable resources (e.g., food processing). Industries have also adopted different levels of sophistication and automation in their production and distribution processes. For example, the automobile industry (Gorlach and Wessel, 2008) and the hardware and networking components of the hi-tech industry (Marino and Dominguez, 1997) are highly automated. In contrast, the agriculture industry is well known to be technically inferior (Thomas and Callahan, 2002). For example, social and economic limitations such as low-skilled manual labor and the lack of capital investment with low value for their products are barriers for adoption of IT in agriculture. However, decision-making on the farm depends on an increased volume of data from sensors that record the growing environment and physiological conditions of the plant or animal.

Technology for agriculture enables what is referred to as precision agriculture (PA) (Wang et al., 2006). PA makes it possible to obtain effective data in real time (Zhang et al., 2002). Precision livestock farming (PLF) is a relatively new discipline for farm animals. PLF originates from the increased use of information technology (IT) that supports livestock management and dairy management activities (Banhazi et al., 2007; Mertens et al., 2011). PLF was introduced to ensure that every process within a livestock activity is controlled and optimized within narrow limits (Banhazi and Black, 2009). Information systems have a potential to help the production of agriculture and dairy products because of the increased complexity in decision-making and the availability of data.

2.2 The Agricultural Technology Revolution

Agriculture has been through a number of changes like most industries. Agriculture in the twentieth century went from a labor intensive to a capital intensive operation.[9] Traditional methods have been replaced by more mechanized and automated systems. The twentieth century has seen the mechanical, breeding, fertility, pesticide, biotechnology, and present electro-technology revolutions. Table 2-1 outlines a history of crop production revolutions for the United States. The electro-technology revolution has lead to PA and PLF.

Table 2-1 Crop Production Revolutions for the U.S. during the Twentieth Century

Name	Period	Change
Mechanical	1900s	Replaced horses with modern tractors, combines, cotton pickers
Breeding	1930s	Hybrid production: corn, rice, wheat, soybean
Fertility	1940s	Availability of fertilizers N-P-K test improved genetic potential
Pesticides	1950s	Herbicides and fungicides to control weeds, insects, diseases
Biotechnology	1990s	Herbicide; insect and disease resistance; environment friendly
Electro-technology	1990s	Availability of computers, software, satellites; precision agriculture

http://www.answers.com/topic/high-technology-farming

2.3 Precision Agriculture

2.3.1 Awareness and Adoption of Precision Agriculture

PA technologies have been available since the early 1990s. However, the pace of adoption in the United States has been moderate. A large number of producers are not familiar with PA technologies. User education and computer literacy, full-time

9 http://www.answers.com/topic/high-technology-farming [Last accessed 06/13/12]

farming, and farm size positively influenced PA awareness, while age had a negative effect from an awareness point of view (Daberkow and McBride, 2003). Grain and oilseed farms (corn, soybean and small grains) and specialty crops (fruits, vegetables and nuts), and Heartland and Northern Great Plains located farms were more likely aware of PA technologies. Farm size, full-time farming and computer literacy positively influenced the likelihood of PA adoption from an adoption point of view (Daberkow and McBride, 2003). Furthermore, grain and oilseed farms, and Heartland located farms were more likely to adopt PA. In a sample of Ohio farm operators, adoption intensity and probability of PA occurred by factors such as farm size, farmer demographics, soil quality, urban influences, farmer status of debt, and location of the farm within the state (Isgin et al., 2008). Farm and farmer characteristics that influence the importance farmers place on PA for improving the nitrogen fertilization of cotton have been investigated (Torbett et al., 2008). Yield monitoring, management zone and grid soil sampling, and real time sensing increased farmers' perceptions of the importance of PA for improving nitrogen fertilizer efficiency. In addition, farmers who implemented geospatial mapping were more likely than other farmers to find the importance of PA. Older cotton farmers with large land in production were more likely to place greater importance on PA for improving nitrogen efficiency. There are many factors that increase the likelihood of adoption. Similarly, there are also barriers that decrease the likelihood of adoption.

2.3.2 Barriers to Adopt and Automate Precision Agriculture

Initially, PA technology was used to improve the application of fertilizers. The rates and blend of nutrients required for that particular crop and environment are varied. The adoption of PA varies significantly by crop type, cropping system, and geographic location and country. Several barriers for the adoption of PA such as socio-economical, agronomical, and technological have been investigated (Robert, 2002). The socio-economic barriers are related to costs and lack of technical skills.

Agronomical barriers are related to the access to information which includes recommendations for site-specific fertilizer, qualified agronomic services, analysis procedures, and the misuse of information. Technological barriers are related to machinery, sensors, GPS, software and remote sensing issues. Determinants that can remove barriers to adopt PA are realized benefits in profitability and productivity, sustainability, crop quality, food safety, environmental protection, quality of life on the farm and rural economic development (Robert, 2002). However, the development of decision support systems (DDS) that can effectively help in the decision-making process could remove barriers for adopting PA (McBratney et al., 2005). Barriers for automation are similar for adoption.

Barriers for automation in agriculture are also an issue and can result from numerous factors. Table 2-2 lists and briefly defines these barriers.

Table 2-2: Barriers limiting Automation Systems in Agriculture

Barrier	Brief Explanation
Mechanical technology: not robust	Variety of environments with human intervention
Mechanical technology: costly	Machine repair; loss of production; low availability of parts
Knowledge to create dexterity	Lack of know-how to create skills of trained worker
Legal risk	User’s legal liability; insurance against damage
Seasonality of agricultural production	Idle time, loss productivity and anticipated payback time
Near properties follow same crop calendar	Infeasible to share use and cost of an automated machine
Limited capability	Capable of automating only one agricultural task
Modifying agronomic practices to simplify design of automated machinery impractical	Develop affordable products that operate in current agronomic environment rather than develop products that require major changes in the work environment to succeed

Adapted from Kassler, 2001

Automated process-data acquisition may be restricted by hardware and software compatibility, different data formats, lack of how to reuse data, and amount of data (Steinberger et al., 2009). An agricultural process-data service where the software can be adapted to the specific farms and users was implemented. Data are recorded on an ISOBUS communication system and transferred to a server, and analyzed. There are barriers limiting automated systems in agriculture. Eight barriers are identified that have prevented or delayed the implementation of automation systems in agriculture (Kassler, 2001).

2.3.3 Precision Agriculture Applications

There are many PA technologies and innovations that are either tested or in commercial use. Some PA technologies are sophisticated and based on remote-sensing and satellite images, and simulation modeling and supply chain database management. Others are more practical and fundamental such as aerator systems, and tracking soil compaction and analyzing soil nitrogen content. Examples of PA technologies are investigated in the following sections.

Farm Level Applications

A smart sprayer with an intelligent sensing and spraying system that integrates real-time machine vision sensing system and individual nozzle controlling with a commercial map-driven-ready (GPS) herbicide sprayer was developed and tested (Tian, 2002). The smart sprayer can estimate weed density and size, realize site-specific weed control, and effectively reduce the amount of herbicide applied to the crops in variable lighting conditions. Different sensors within a soil sensor system for measuring soil compaction were also developed and tested (Hemmat and Adamchuk, 2008). The sensors are able to simultaneously map soil mechanical resistance at different depths, water content, and fluid permeability. These factors can improve the knowledge of soil physical states and variability within the soil, which can potentially increase farm efficiency.

Geographic Information Systems

AERO is software package used in different geographical locations and weather conditions. Different types of aeration systems were developed using AERO (Lopes et al., 2008). AERO was designed for a grain aerator system. It functions by equalizing the temperature inside the storage bin for cooling grain mass and maintaining the moisture content of the grain under safe conditions. They also achieved significant energy saving with the AERO controller. Geographic information system (GIS) has been applied. GIS was utilized to generate a comprehensive view of crop fields and assist in agro-technical decision-making (Nemenyi et al., 2003). A mixed application for two different farm simulation systems was formulated. Each farm simulation system has advantages and disadvantages, resulting in complexity for using either of the two systems. A quantified management-induced reduction in nitrogen losses with a Nitrogen Trading Tool (NTT) was developed at the farm level (Delgado et al., 2008). GIS and a Nitrogen Losses and Environmental Assessment Package (NLEAP) simulation model were assessed by using Windows XP. In addition, sites from a humid environment, manure management and irrigated cropland areas were assessed. Nitrogen management practices increased savings in reactive nitrogen with a potential to trade nitrogen credits. NLEAP is used to identify the best scenario for environmental conservation and nitrogen credit earning for trade. NLEAP has a potential for maximized yield savings in reactive nitrogen.

Database Applications

An Internet-based coffee information system (CINFO) provides farmers with information on where and how to produce coffee. CINFO has special features that provide traders with information on product availability and specific traits (Niederhauser et al., 2008). CINFO is a unique specialty coffee supplies chain. The system can identify individual groups of product for how and when they were produced, and processed and distributed to the consumer. Product quality and variation can be monitored systematically. Product quality feedback as perceived by the customer can be addressed. CINFO can also be linked to other databases for identifying sites suitable for that particular need. Data-flows for a variety of PA techniques have also been modeled (Nash et al., 2009). The model demonstrates the relationships between datasets and for the optimization and automation of information management.

2.4 Precision Livestock Farming

2.4.1 Information Systems in Dairy Management

Information systems have the potential to help the dairy farmer with complex decisions in dairy farm activities. A framework to support the creation of information systems and a reference base for the analyses and improvement of existing information systems in dairy management was developed (Pietersma et al., 1998). The framework consists of management and control activities such as decision making, implementation, and assessment. The framework is divided by strategic, tactical, operational, and regulatory levels and management areas such as breeding, health, nutrition, environment, milk production, fixed assets, labor, and finance. They found a large amount of information exchange among management and control activities, and between farm environment and external representatives. In addition, PLF systems can be divided by diagnostic and management activities (Maltz, 2010). One sensor can monitor a physiological event and support decision-making. The framework includes sensors that generate data, a model for the data interpretation, management decision-making process, and execution of the decision.

2.4.2 Potential Functions of Precision Livestock Farming

PLF is based on the concept that IT would have an impact on dairy livestock production. One objective of PLF is to monitor animals continuously throughout their life with online technology. PLF uses the transfer of electronic information and applies it to control and optimize production and management processes. PLF is also applied to automated control for supporting biological production processes such as feeding strategies, growth rate control, activity control (Aerts et al., 2003a, b; Halachmi et al., 2002; Morag et al., 2001), and body weight scales, milk composition analysis, behavior, digestion, and heart rate (Maltz, 2010). A summary of the potential functions that can be achieved by PLF is provided in Table 2-3 (Berkmans, 2008),

Table 2-3 Functions Achieved by Precision Livestock Farming

Concepts	Description
Monitoring data	Feeding times, feed intake, and performance parameters for real time analysis of sounds, images, live weight assessment, condition scoring, on-line milk analysis
Collecting data	From animals and their environment
Evaluating data	Knowledge-based computer models
Full Analysis	Animal health, animal behavior and animal performance
Potential Uses	Continuous automatic monitoring and improvement of animal health, animal welfare, quality assurance at farm and chain level, and improved risk analysis and risk management

Adapted from Berkmans, 2008

PLF can also monitor the change or trend in herd activity. This can help in the prediction of health disorders and disease incidence, and not simply comparing individual cow activity or yield. Daily walking, cow activity and milk yields have been used as predictors of metabolic and digestive disorders (Edwards and Tozer, 2004). The management and control of biological processes is what differentiates IS used in PLF in comparison to IS for a typical business. For example, Enterprise Resource Planning (ERP) systems integrate internal and external information such as finance, accounting, manufacturing, sales and customer service throughout an organization. ERP automates these activities.[10] These differences show that PLF systems are unique for management and control of biological processes.

[10] http://en.wikipedia.org/wiki/Enterprise_resource_planning [Last accessed 06/13/12]

2.4.3 Adoption of Precision Livestock Farming

PLF technologies for animal status monitoring and management are expanding. However, availability in the dairy industry has been sparse (Gelb et al., 2001, Huirne et al., 1997). Factors influencing technology adoption are the economic returns for investing in new technology, impact on resources used in the production process, management necessary for implementation, risk aversion, and organizational goals, constraints, interest and motivation (Dijkhuizen et al., 1997; Van Asseldonk, 1999). Factors for the slow adoption of PLF technology have been suggested and are shown in Table 2-4 (Bewley and Russell, 2010).

Table 2-4 Factors for the Slow Adoption of Precision Livestock Farming Technology

Barriers	Problems
Technology	Not familiar with technologies that are available
Cost	Undesirable cost to benefit ratio
Information	Not knowing what to do with too much information
Time	Not enough time to spend on technology
Economic value	Lack of perceived economic value
Complexity	Too difficult or complex to use
Support/Training	Poor technical support/training
Alternatives	Better alternatives/easier to accomplish manually
Compatibility	Failure in fitting with farmer patterns of work

Adapted from Bewley and Russell, 2010

Table 2-5 Barriers and Challenges for the Adoption of Precision Livestock Farming Technology

Barriers	Challenges
Technology	Robust, low-cost sensing systems; data-based models for significant biological and physical processes; control systems managing; physical/biological processes
Applications	Growth, disease and behavior of livestock; based on biological principles
Marketing	Demonstrated at a commercial scale for manufacturer confidence by livestock farmers
Bioethics	Viewed unfavorably by consumers as a technology that encourages instrumental use of animals and potentially compromising welfare

Adapted from Wathes et al., 2008

There are also many barriers for the adoption of PLF. Barriers can range from the technology itself to applications of the system, marketing efforts and bioethical issues. Four barriers and challenges for the adoption of PLF technology are suggested and shown in Table 2-5 (Wathes et al., 2008).

2.4.4 Applications of Precision Livestock Farming

Dairy Sensor Monitoring

Electronic animal identification is sensor technology that has been available since the mid-1970s. It is commonly known as radiofrequency identification (RFID). The third generation of RFID has introduced automated monitoring of animal health and reproduction status. This is essential for animal longevity. Neural networks with a fast learning algorithms, and multivariate time series analyses are necessary for mating behavior (ostreus) detection (Eradus and Jansen, 1999). A problem for detecting mating behavior is that the sensors are efficient, however not necessarily more accurate than human observers (Lehrer et al., 1992). Mating behavior detection is commonly detected by human observers. On large dairy farms, this could be difficult because of the short feeding and milking periods (Eradus et al., 1992). Pedometers are used for mating behavior detection and received better results than human detection. Pedometers have a detection rate of 80-90% (Firk et al., 2002). However, error rates are at 17-55% and specificities at 96-98%, which indicates a large number of false positive readings. This has resulted as a barrier for adoption of pedometers. Detection percentages increased as much as 95% when there was an increase between the number of steps measured by pedometers, mating behavior factors and the time of ovulation (Roelofs et al., 2005). Pedometer measurements can detect mating behavior accurately. They appear to predict ovulation for improving fertilization rates. The monitoring of calf birthing (parturition), breast disease (mastitis), and the breakdown of energy, protein, and mineral metabolism are also major concerns for the dairy farmer. A primary event can be monitored to detect secondary and tertiary events such as conductivity,[11] milk yield and temperature changes (Mottram, 1997). However, sensor data have a high number of false positives. Therefore, sensor data limits current veterinary and nutritional models.

Dairy Lameness

Lameness in dairy herds is caused by a variety of foot ailments that initially begin as abrasions and trauma to the hoof. Foot ailments can occur with 20.4% of the animals. Therefore foot ailments result in reduced animal activity, milk production, and animal comfort (USDA, 2002). A RFID sensor that measures animal lying time detects the vertical position of the leg to detect lameness. The electronic sensor utilizes nano-watt technology, onboard memory, and a wireless transmitter for storing and transferring data. The sensor is within 2.2% of the value measured by a human observer. The sensor may be a more reliable measure in comparison to human observers (Darr and Epperson, 2009).

Environmental Detection

The exposure of airborne contaminants can have a detrimental effect to livestock. Various technologies can detect real-time measurements of pollutants and control the level of airborne contaminants to an acceptable level (Watt et al., 2010). However, measuring airborne contaminants in the livestock environment has not provided precise and reliable emission estimates (Cambra-López et al., 2010).

2.5 Automated Agricultural Systems

Automated agricultural technology can provide an abundant amount of food that is affordable, nutritious, high quality and safe. Automated technology can improve

[11] Conductivity is measured as a screening test for breast disease (mastitis) (Fernando et.al. 1982). Conductivity is used for tracking teat or breast (udder) health (Woolford et al., 1998).

productivity and enhance the health and job satisfaction of employees. However, serious challenges exist in automating farm operations and activities (Grift et al., 2008). Presently, the performance of automated methods has been insufficient in comparison to traditional methods. Many technologies have not progressed beyond the prototype or pilot trial stage for this reason. Agriculture and livestock automated technologies are shown in Table 2-6.

Table 2-6 Agriculture and Livestock Automated Technology

Sector	Components	Positive Affects	Negative Affects	References
Apple harvesting	Machine vision; laser ranging sensor	Detected single fruit 100 % accuracy, front and back lighted scenes; distance measurement accuracy was 3 mm; 90% success rate detaching fruit; image processing less than 1 second;	Successfully picked 89%; handling system, machine vision needs improvement; 7.1 seconds to pick 1 apple	Bulanon & Kataoka, 2010
Cherry harvesting	3-D vision sensor; end effector; computer; traveling device; visual servo system	Visibility of fruit important factor for correct harvesting; fruit hidden by leaves recognized by scanning upward; bounded leaves favorable for the visibility of the fruits	Cherries damage easy; character of plant different from model cherry	Tanigaki et al., 2008
Citrus harvesting	Robotic harvester; fruit detector; color vision and shape sensor	Redundant robotic manipulator precisely selects fruit; better dexterity and maneuverability; closed feedback loop system updates position of fruit	Image and machine vision systems with analog video need improving	Hannan & Burks, 2004
Cucumber harvesting greenhouse	Autonomous vehicle, manipulator, end-effector, two computer vision systems for detection:3D	End-effector designed to handles soft fruit without loss of quality; thermal cutting device included in end-effector prevents spreading of viruses; computer vision system able to detect 95%;	Success rate 80%; 45 seconds to pick 1- cucumber; need to improve picking speed and accuracy of eye-hand co-	Van Henten et al., 2002

	imaging;	weight and ripeness of the determined; collision-free eye-hand co-ordination	ordination	
Eggplant harvesting	Machine vision, manipulator control, end-effector units; visual feedback fuzzy control model to actuate a manipulator	Perform automatically basic harvesting operation, recognition, approach, and picking tasks; fundamental design of robotic harvesting was developed; control model enabled manipulator end to approach fruit at 300 mm	62.5% harvesting rate; end-effector cut the peduncle at higher position from fruit base; harvesting execution time 64.1 seconds	Hayashi et al., 2002
Mushroom harvesting	Harvester: location, sizing, selection, picking, trimming, conveying and transfer; machine vision and image analysis	Applies appropriate picking order; handling techniques for conveying, trimming and transferring mushrooms using flexible fingers, high-speed; knives and padded pneumatic gripper system; 81.6% picking efficiency; lower bruising, damage, soil	Commercial farm trial; 9-mushrooms/ minute picking speed; vacuum produced faint damage during grasping	Reed et al., 2001
Cherry petty-tomato, cucumber, grape harvesting	Manipulators, end-effecters, visual sensors and traveling devices	System modeled after Japanese agriculture; bioproduction space similar to Japan's agricultural system, few operators work in small space, robots for bioproduction in space is considered desirable in near future	Performance of robot components sometimes inferior to humans	Kondo et al., 1996
Pig identification and rearing	Mobile PDA reader , GPRS; mobile PDA embedded system	Embedded PDA identify special pig bar ear tag and general data matrix bar ear tag by mobile reader; record input data including bacterins, feed additives, animal drugs forbidden medicines; submitted to the center database through GPRS;	Low speed transmitting GPRS or may not work; if installed SIM card only used to collect and send data without calling functions,	Xiong et al., 2009

		tracking and tracing from origin to consumption	monthly fee will not exceed 5 Yuan	
Sheep and goat flock management	Decision support systems; SUPPRO VI.0; Visual Basic 6.0: MsAccess	Breeding value and animal breeding evaluations; matching unknown father to younglings; correct animal yields; high usability of software modules	Software challenges; hereditary value not calculated; small flock size with inbreeding; software uses constant values to avoid negative heritability values; inbreeding cannot be calculated; SUPPRO VI.0 does not work on other platforms	Onder et al., 2009
Dairy milking	Milking stall, robot arm, teat sensor, milk equipment & udder cleaner	Increases milking from 2-3/day; increase of 1000 kg/lactation; lower physical and mental load on farmer; savings on physical labor; labor reduction	Farmer working with complicated equipment; labor organizations	Rossing et al., 1997

The food and horticulture sectors also play an important function for agribusiness. These two sectors can have an impact on the agriculture industry. Food and horticulture technologies are shown in Table 2-7.

Table 2-7 Other Examples of Automation in the Food Industry

Industry	**Automation**	**Technology**	**References**
Food	Analysis of foods	Surface plasmon resonance sys.	Tothill, 2001
Horticulture	Grading of ornamental pot plants	Artificial neural network	Timmermans & Hulzebosch, 1996
Agriculture	Steering system for a cereal harvester	Laser beam, photodetector	Hieronymus, 2000
Agriculture	Identification of	LBS/DIN system with	Auernhammer et

to Office	implements	GPS and an implement indicator (IMI)	al., 2000
	Self-propelled, unmanned windrower	GPS data	Rider, 1998
Livestock	Robotic milking machines	Monitoring and control systems	Ordolff, 1997
Livestock	Cow udder geometry system	Database	Kimm & Heyden, 2000

Adapted from Cox, 2002

Swine Industry

The swine industry is a highly developed sector of livestock management that utilizes advanced IT. Potential areas for advanced development of pig management have been developed. These advances are shown in Table 2-8 (Banhazi and Black, 2007, Durack, 2002).

Table 2-8 Potential Areas of Development for Pig Management

Management	Tools and Systems	References
Environmental	On-farm measurement and documentation	Banhazi, 2005; Silva et al., 2007
Housing	Advanced climate control	Banhazi et al., 2008
	Animal welfare and behavior assessment	Shao & Xin, 2008
Production	Real time individual pig weighing	Kollis et al., 2007
	Real time feed and water consumption	Madsen & Kristensen, 2005; Madsen et al, 2005
	Disease monitoring	Maatje et al., 1997; Eradus & Jansen, 1999
	Integrated performance analysis of units	Heinonen et al., 2001; Pomar & Pomar, 2005
	Online KPIs monitoring and comparison with modeled performance norms	Tukey, 1997
Supply Chain	Slaughter house Information flow	Petersen et al., 2002
	Individual animal identification	Naas, 2001; 2002
	Automated record keeping	Holst, 1999
	Real time supply management	Dobos et al., 2004; Guerrin, 2004

Adapted from Banhazi and Black, 2007

There are many measures that are taken within pig management. Environmental management, housing management, production management, and supply chain management are monitored.

2.6 Automatic Milking Systems

Automatic Milking System (AMS) can be defined as a system that automates all the functions of cow management and the milking process. There is a mix of manual and machine systems. The importance is placed on the cow's enticement to be milked in a self-service manner several times a day by a robotic system without direct human supervision (De Koning and Rodenburg, 2004). In contrast, conventional milking systems (CMS) can be defined as a system where humans bring the cows to be milked at regular times (usually twice a day). Key factors for AMS are an efficient cow traffic system and available feed. These factors directly influence animal welfare problems such as behavioral or physiological condition of the cow. Table 2-9 is a summary of the advantages and disadvantages of AMS (Svennersten-Sjaunja and Pettersson, 2007). Increased chronic stress and the lack of a hygienic management program can have a negative effect on the functions of AMS.

Table 2-9 Advantages and Disadvantages of Automated Milking Systems

Function	Advantages	Disadvantages
Milking frequency	Predictable routine; reducing heavy milking workload; milking more than twice daily without extra labor costs (Dijkhuizen et al., 1997); gentler to the teats (Berglund et al. 2002)	High frequency milking that end abnormally increases udder health problems and reduce milk quality; depends on cow traffic conditions; reduction in lactation length (Hurnik, 1992); irregular intervals between milkings' and failure of teat cup attachment (Bach and Busto, 2005); over-milking has negative effects on teat end quality: hardness and discoloration (Hillerton et al., 2002)
Milking process	Consistent; successful milking requires both	Dependent on the milker; cows are fed concentrate during milking to reduce milking

	cisternal and alveolar milk obtained (Bruckmaier and Blum, 1998)	time and increase milk flow and udder emptying (Samuelsson et al., 1993); teat localization and teat cup attachment disturbed by a malfunctioning robotic arm
Milk fat quality	No differences between AMS and CMS for gross composition, such as fat and protein contents (Svennersten-Sjaunja et al., 2000)	Levels of milk FFA were increased (Justesen and Rasmussen, 2000; Klungel et al., 2000; de Koning et al., 2003) causing rancid flavors (Tuckey and Stadhouders, 1967) in dairy products; decreases ability to convert milk into processed dairy products (Sapru et al., 1997)
Milk hygiene	Enforces improved hygiene management	TBC increased in bulk milk (Klungel et al., 2000; Rasmussen et.al., 2002); bacteria may originate from teat skin or insufficient cleaning of the MU and inadequate cooling of the milk (Rasmussen et al., 2002)
Milk somatic cell count (SCC)	No increase incidence of intra-mammary infections and SCC or deterioration of teat tissue when cow health status and herd management are good (Zecconi et al., 2003).	Cows leak milk between milkings' more frequently (Persson-Waller et al., 2003), higher risk for mastitis
Cow traffic	Great potential for control and decision-making in individual management systems (Stefanowska et al., 1999, Melin et al., 2005)	Free traffic result in lowest milking frequency compared with forced or semi-forced traffic systems (Forsberg et al.,2002; Harms, 2004); forced traffic cows spent more time standing in the feeding area (Ketelaar-de Lauwere et al., 1998) and have lower milk yields
Animal welfare	Stress and heart rate measurements (Hagen et al., 2005) nor significant differences in behavioral or physiological responses of cows during milking was not observed during milking (Hopster et al., 2002)	Increased chronic stress, measured as heart rate variability (Hagen et al.,2005); wide individual variation to adapt (Weiss et al., 2004); missed milking negatively influenced cow behavior: time spent lying and frequent urinating (Stefanowska et al., 2000)
Maintenance	Presence of technical staff	High; relies on a more skilled operator available on short notice; herd manager troubleshoots

Adapted from Svennersten-Sjaunja and Pettersson, 2007

2.7 Summary

Chapter 2 provided a literature review of the adoption, potential functions and applications within precision agriculture and precision livestock farming. Automated systems in dairy management are also investigated. Chapter 3 provides an exploratory case study based on the motivations for adoption of a dairy management information system by early adopters in Korea. This is an unexplored topic using a qualitative method approach. Initially an interpretive case study, farm visits and interviews were conducted to understand where farmers are coming from. Chapter 3 also provides an explanation and an argument that supports case study research, and reasons for why it is implemented into this dissertation. The results were a set of propositions and general framework, which leads to Chapter 4. Chapter 4 provides a quantitative empirical study of a dairy management information system that extends the Technology-Organization-Environment Framework. Through assimilation of the system and extended use activities, we approach a measure for the level of process automation by dairy farms. Chapter 5 provides final conclusions that draw together the exploratory case study and the quantitative assimilation study. An explanation for how they are related is provided and a new integrate framework based on the results is developed. The final sections include the references and appendices for Chapters 1-5. The reference section is formatted by using the American Psychological Association or APA style guide. The appendices consist of a list of abbreviations, description for the individual components and sub-components of the dairy management information system, interview and survey questionnaires for the two studies, and farmer comments. The final section is an abstract of this dissertation written in Korean.

Chapter 3

Factors Affecting Adoption of a Dairy Management Information System: An Exploratory Case Study

If we knew what it was we were doing, it would not be called research, would it?[12] – Albert Einstein

3.1 Introduction

There are many uncertainties that exist in dairy farming. These uncertainties could be minimized if farmers were able to manage milk and dairy information through technology that monitors specific qualities. For example, fat content, protein, blood and other toxic substances could be observed. A dairy farmer may analyze their data output through an information system (IS) that is connected to their office at the farm or home instead of viewing milk products through traditional means on site. This type of farming management relies on new technologies such as information technology (IT). This is referred as precision agriculture (PA) (Wang et al., 2006). PA technology makes it possible to obtain effective data in real time (Zhang et al., 2002). PA can be driven by financial and economic factors (Zilberman et al., 1997), food safety (Levidow and Bijman 2002) and food insecurity (Cassman, 1999). PA can more effectively help a company plan their marketing, sales, and distribution. Industries that rely on outside sources for their production are likely to face higher variations in their inputs. Businesses have to account for these variations in their production processing (Meade and Sarkis, 1999). Therefore, PA which heavily relies on outside sources would greatly benefit from controlled production. However, the literature suggests that the application of information technology (IT) in agriculture is minimal (Thomas and Callahan,

[12] http://www.goodreads.com/author/quotes/9810.Albert_Einstein [Last accessed 06/14/12]

2002). Farmers did not take advantage of IT during the 1980s and 1990s (Schmidt et al., 1994). Similarly, many cattle operations were slow to adopt and utilize IT (Blezinger, 2001).

3.1.1 Statement of the Problem

Agricultural information systems (AgIS) are uncommon even with the availability of computer hardware, software, and networks (Wang et al., 2006). AgIS are relatively simple in today's standards (Banhazi and Black, 2009). In general, the agriculture industry is well known to be technically inferior (Thomas and Callahan, 2002). However, in recent years, industrial agriculture such as dairy farming has progressed by developing automated production using sensor networks. Dairy management information systems (DMIS) have been developed and assimilated in large farms in the past two decades (Devir et al., 1993). For example, Precision Livestock Farming (PLF) has been developed in the dairy industry to ensure that every process within a livestock activity is controlled and optimized within tight limits (Banhazi and Black, 2009). PLF is a relatively new discipline that originates from the increased use of IT that supports livestock and dairy management (Banhazi et al., 2007; Mertens et al., 2011). Therefore, we apply the dairy farm as a case study of such an environment. The developer of this particular DMIS has high expectations for implementing the system. However, adoption by the dairy sector in Korea has been relatively slow and gradual.

Seventy percent of the total land in Korea is mountainous. There is sparse land area available for farming. Small-size farm conditions are sustained long-term through intensive cultivation. The Korean government has a vested interest to increase the use of AgIS for improving productivity and food safety, and generating financial security among farmers considering the challenges for agriculture and dairy specifically. Korean dairy farmers produced 2.11 million tons of fresh milk in 2009. Korea requires 1.6 million tons of fresh milk per year including 200,000 tons of milk needed for powdered milk. 200,000 tons of milk is needed for premium quality yogurts, cheeses, baby formulas and ice cream.[13] However, despite the availability of PA and PLF technologies and some early attempts to implement AgIS by agribusinesses, the adoption of technology in the Korean agricultural sector is relatively low compared with other industries such as finance, healthcare, and manufacturing. The characteristics of the farmer may be an attribute or barrier for the low adoption rates.

Farmers are generally less educated and older than people working in other industries. Farmers are also generally slower to adopt technology. A farm study in Ohio shows that seventy-six percent of farmers had less than or equal to a high school education, and eighty-three per cent were over the age of thirty-six (Batte et al., 1990). Only twenty-four percent of the farms surveyed were using computers. Large-size farms typically adopted computers over small-sized farms. In Korea, farms are typically small-size family-driven enterprises. The average age for farmers in Korea is 60 years. The average for farmers has increased compared to other sectors. The problem exists with the children of farmers. The offspring leave the farm because of economic conditions and are sent by their parents to the city for higher education (Han, 2004). Rev. Han Kyung Ho is president of the Korean Rural Mission. He indicates that the percentage of farmers in Korea dropped from 11.6 percent (5,167,000) in 1995 to 7.1 percent (3,415,000) in 2004. Farm debt is at US $30,000 and has quadrupled. The income disparity between the general public and farmers has broadened from 99.4 percent in 1994 to 76.2 percent in 2003. The wealthier top twenty percent of the farmers have an income 12 times more than the poorer 20 percent. It was 7.2 times more in 1998 (Wong, 2006). Therefore, it appears farmers in Korea are less likely to adopt and assimilate IT under these conditions. Social influences such as farmer to farmer relationships and other external relationships can have an effect on the adoption of IT in agriculture.

The literature suggests three social roles that can influence the adoption and

---

[13] http://balita.ph/2010/03/08/s-korea-to-help-local-dairy-industry-cope-with-eu-fta/ [Last accessed 06/13/12]

diffusion of new technology. These roles are the sponsor, evangelist and opinion leader (Rogers, 1995). Government involvement could be regarded as sponsorship. Government can create a more favorable environment for the initial adoption of AgIS. However, to sustain adoption and dissemination of technology among a majority of stakeholders or farmers in this case, there is a need for an evangelist and opinion leaders. An evangelist is a person or group that supports new technology over time. Evangelists are especially important in collective and traditional cultures. Dairy farmers in Korea are known to be collective and traditional such as the focus of our study. Korea in general is characterized as a more collectivist society. Collectivist cultures stress interdependent activities while holding back individual goals. Korea is ranked low for individualism and is positioned as a more collectivist society than as an individualist society (Hofstede, 2009). Koreans have a long-term commitment to the member or group, extended family and relationships. Loyalty is the most dominant factor in a collectivist society. Therefore, loyalty is more important than rules and regulations. Strong relationships and full responsibility for the group is highly emphasized. Innovation Diffusion Theory (IDT) (Rogers, 1995) may provide an initial starting point for explaining the adoption of a DMIS. To better understand these factors, we develop a theoretical model for the adoption of an emerging technology based on IDT.

3.1.2 Significance of the Study

This study examines post-adoption of a DMIS from a dairy farm or business perspective. The significance of this study is to evaluate post-adoptive factors of a DMIS from an organizational perspective in Korea. Why was the system adopted? To what extent was the system adopted? The proposed theoretical model is linked to the Technology-Organization-Environment Framework (Tornatsky and Fleischer, 1990). The significance of the study is that environmental factors such as farmer to farmer relationship, dealer trust, government sponsorship, and organizational factors such as uncertainty and risk, and cash flow have not received attention in prior IDT research.

3.1.3 Purpose of the Study

The purpose of this exploratory case study is to investigate factors for the adoption of a DMIS at four farms in Korea. One non-adopting DMIS farm in California is investigated as a control group. We investigate characteristics of the DMIS system as an emerging technology and determine factors that influenced select dairy farmers to be early adopters of the system from a multi-paradigmatic approach. We approach theorizing as a blend of “ground theory building” and as an extension of existing theories to explain farmer’s motive for adopting the system. The “ground theory” approach is based on observations of the farmer. The extension of an existing theory is to modify for a new context. A complete understanding of individual adopter and environmental, technological, organizational characteristics are necessary to understand the phenomena for why some farms have adopted the DMIS while other farms have not adopted or have delayed adopting and assimilating system components. It is our argument that IDT Theory may explain factors for why some dairy farmers have adopted the DMIS in Korea. There are barriers for adoption at the California dairy farm. By identifying the potential opinion leaders that are using the system, social influences that affect adoption can be identified. The environmental context is social influences such as farmer to farmer relationships, dealer trust and support, and government sponsorship. The technological context is the effectiveness of the system such as reliability, knowledge, compatibility, planning and complexity. The organizational context is the return on investment, cash flow, and uncertainty and risk issues for the dairy farmer.

3.1.4 Research Question

The goal for this case study is to investigate adopter characteristics and environmental, technological and organizational factors for the post-adoption of an emerging dairy management information system in Korea. We answer the following research question:

> *To what extent does the relationship of environmental, technological, and organizational factors drive/inhibit post-adoption of a dairy management information system in Korea?*

The first section investigated the uncertainties that exist in dairy farming, agricultural information systems, situation of the dairy farmer in Korea, three social roles that can influence the adoption and diffusion of new technology, significance of the study, purpose of the study, and the research question. The case study proceeds as follows. We describe different streams of literature for IDT as well as adoption of IT in agriculture and dairy farming in the second section. We then describe individual adopter and environmental, technological and organizational attributes that may influence adoption of IT in the third section. Propositions are developed for each attribute. Section three describes the study methodology, brief description of the DMIS and the four case study dairy farms. Section three also defines what a case study is and why it was implemented in this study. Section four provides an analysis for the four farms and proposed research framework for factors affecting the adoption of the DMIS. This is followed by a discussion, and academic and practical contributions in the fifth section. We conclude our study with limitations and future research.

3.2 Literature Review

3.2.1 Adoption of Information Technology in Agriculture

In this exploratory case study, we investigate factors that may influence dairy farmers to adopt or not adopt a DMIS in Korea and California. In general, agriculture has been slow to adopt technology. For example, there is a long-term trend for the adoption and diffusion of technologies designed to reduce environmental harm of farmers in the United States (Fuglie and Kasak, 2001). Farmers were slow to adopt tillage, integrated pest management and soil fertilizer testing technologies. Adoption time delays are also a result of land quality, farm size, farmer education and other regional issues. Farmers that have adopted organic methods are different than conventional method farmers. Organic farmers in Andalucía Spain are younger and more involved in management of the business. These organic farmers also attended more extension courses and have more representation in agricultural associations (Lopez, 2005). Organic farmers received better information (control, certification and training) from the Andalusia Committee for Organic Agriculture rather than from conventional agricultural associations. Farmers that adopted organic techniques perceived greater returns and satisfaction even though more time was spent on farming (Lopez, 2005).

Agriculture has been slow to adopt IT. Other industries have evolved more rapidly. For example, the automobile industry (Gorlach and Wessel, 2008) and the hardware and networking components of the hi-tech industry, (Marino and Dominguez, 1997) are highly automated. In contrast, the agriculture industry is well known to be technically inferior (Thomas and Callahan, 2002).

Farmer characteristics may be the reason. Older farmers in Ohio are less likely to adopt computers and less likely to find computers useful (Batte et al., 1990). Older farmers made fewer applications on the computer for their business. Education level was also positively associated with an increase number of computer applications (Batte et al., 1990). Sierra Leone was quite the reverse.

Sierra Leone farmers' perceive the adoption of technology as technology specific rather than traditional factors in adoption-diffusion studies (Adesina and Zinnah, 1993). Common business rather than farm activity applications determined the level of complexity for farm management information systems (FMIS) (Lewis, 1998). More complex FMIS are typically used by younger innovative managers that have a higher demand for managed information. In addition, adoption success depended on the prior use of information provided by a farm records system (FRS). FRS provides information that supports decision-making for farm operations. Farmers that were more educated and successful were using computers, managed larger farms and performed more office-related work (Alvarez and Nuthall, 2001). In addition non-users were characterized as having alienated feelings, lack of knowledge, incompatible skills to manage information, and perceptions of deprived economic assistance. Operational skills can be improved through training and a positive attitude towards use (Alvarez and Nuthall, 2001). Software developers should work with farmers in training and technical support. The system should be designed to fit a range of farmer or adopter characteristics. A study of U.S. farm manager characteristics that influence the adoption of PA technology was conducted (Daberkow and McBride, 2003). Education, computer literacy, full-time farming and farm size positively affect PA technology adoption. Age negatively affects PA technology adoption. In addition, grain and oilseed farms were the most likely to adopt PA technology. Human factors such as analytical nature and commitment to life-long learning were perceived as factors for adoption and use (Doye et al., 2000). The farm managers were educated with at least a bachelor's degree. They planned to transfer their operations to their children. Managers also agreed that the system would provide them with better monitoring of financial and production performance, and time savings (Doye et al., 2000). In contradiction, even with the above mentioned attributes, hand records were still a main component for all of the case study managers. It is obvious by the past studies that various factors may contribute or hinder the adoption of an IS in agriculture.

3.2.2 Adoption of Information Technology in Dairy

There are some past studies on the adoption of technology by dairy farmers. A New Zealand dairy study investigated the affect of the Technology Acceptance Model (TAM) on adoption (Flett et al., 2004). The two main attitudinal constructs of TAM are perceived usefulness and perceived ease of use. The adoption of new and complex technology by dairy farmers was influenced by perceived usefulness and perceived ease of use in addition to economic factors (Flett et al., 2004). Other studies have also investigated attitude and economic factors. Barriers to adoption by Australian dairy farmers have been examined (Guerin and Guerin, 1994). Barriers to adopt technology were a result of farmer attitude, and the complexity and financial costs of the new technology. Farmer perception for the relevance, risk and change to implement the new technology was also a barrier. Similarly, barriers to adopt technology are the result of risk and uncertainty factors such as farmer perceptions about technology risk and farmer attitudes towards risk (Marra et al., 2003). In contrast, a study on economic and subjective factors affecting technology adoption indicated that larger dairy farms and more educated dairy farmers are more likely to adopt technology if they perceive yield increase and minimized costs (Saha et al., 1994). In addition, risk, attitude and perceptions of the new technology did not influence adoption by the dairy farmer. This is an important factor. PLF was implemented to meet the needs of the dairy sector.

PLF is a new discipline that originates from the increase use of IT in livestock and dairy management (Banhazi et al. 2007; Mertens et al., 2011). PLF assures that every process within a livestock activity is controlled and organized within narrow limits through technology and minimal human intervention and error. Therefore, this can ensure consistency and high quality output. PLF can have a negative or positive effect on productivity and profitability (Banhazi and Black, 2009). PLF can optimize feed, water and health conditions in a highly variable environment. An important objective of PLF is to provide support to the farmer that automatically monitors livestock without stress to the animal (Berckmans, 2004).

An additional objective of PLF is to accurately, continuously and automatically measure important process factors for different types of livestock production (Mertens et al., 2011; Wathes et al. 2008). PLF has been applied in biological production processes studies such as feeding strategies, animal growth rate, and animal activity control (Aerts et al., 2003a, b; Halachmi et al., 2002; Kristensen et al., 2004; Morag et al., 2001). PLF can also monitor the change or trend in activity, rather than just the activity of the animal. This can help in the prediction of health disorders and disease incidence, and comparing individual cow activity or yield for individual cows. Daily walking, cow activity and milk yields have been used as predictors of metabolic and digestive disorders (Edwards and Tozer, 2004). The management and control of biological processes is what differentiates IS used in PLF from typical business IS. For example, Enterprise Resource Planning (ERP) systems integrate internal and external information such as finance, accounting, manufacturing, sales and customer service throughout an organization. ERP automates these activities.[14] These differences show that PLF systems are unique for management and control of biological processes.

3.2.3 Innovation Diffusion Theory

Initial IDT studies viewed innovation as a social process. Adopters became aware of an innovation and were socially influenced to adopt over time. Economic influences from a community approach have been investigated (Fichman and Kemerer, 1993; Hovav et al., 2004). The economic viewpoint also integrates social influences. IDT studies follow three main streams. These streams are voluntary adoption by individuals, diffusion through organizations, and the economists' approach. Diffusion of an innovation is based on increased returns for the adopter.

Innovation is the process of developing and implementing a new idea (Rogers, 1995). Adopters are influenced by various factors. A decision is made whether to

---

[14] http://en.wikipedia.org/wiki/Enterprise_resource_planning [Last accessed 06/13/12]

accept or reject a new technology in IDT. Five perceptions that are considered to influence the diffusion process are identified (Rogers, 1995). These perceptions are relative advantage, compatibility, complexity, trialability and observability of benefits for the new technology with respect to existing technology. Roger's diffusion process perceptions were extended to eight factors (Moore and Benbasat, 1991). These extended perceptions are voluntariness, relative advantage, compatibility, image, result demonstrability, visibility, trialability and ease of use. Trialability and observable benefits of an innovation are an inherent risk for adopting an innovation (Fichman and Kemerer, 1993). The adopter will perceive that there is added risk and a lack of value for adopting the innovation if an innovation does not add beneficial value (Hovav et al., 2004).

A decision to adopt can be based on how and when individuals choose to adopt an innovation. There are limited studies on the timing of adoption. There are five social groups for how and when an adopter would adopt (Rogers, 1995). These social groups are innovators, early adopters, early majority, late majority, and laggards. Table 3-1 is a brief description for how and when an adopter will adopt.

Table 3-1 Categories of adopter

Group	Characteristics
Innovators	Venturesome, educated, multiple info sources
Early Adopters	Social leaders, popular, educated
Early Majority	Deliberate, many informal social contacts
Late Majority	Skeptical, traditional, lower socio-economic status
Laggards	Neighbors and friends are main information sources, fear of debt

Adapted from Rogers, 1995

Adoption for these five social groups can occur as a bell-shaped curve. Figure 3-1 illustrates the adoption/innovation continuum.

The literature for economic factors that influence technology diffusion is based on the return on investment for the adopter (Arthur 1996; Hovav et al., 2004). Adopting an innovation will increase within a community of adopters. Network externalities refer to the value of a technology, product or service and the number of adopters using the technology. The likelihood of adoption is a function of adopters in a social network (Forrell and Saloner, 1987; Katz and Shapiro 1986). The number of adopters for a social network may increase when costs decrease as the volume increases (Arrow, 1962). In addition, “learning by using” among adopters (Rosenburg, 1982), and the development of a related technology infrastructure (Arthur, 1988) that increase demand and market size created by competition (Hovav et al., 2004) may increase the number of adopters for a given social network.

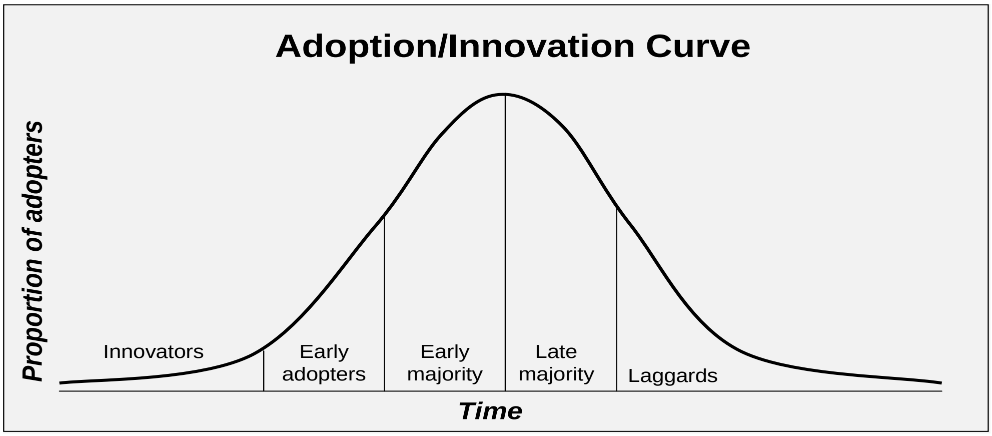

Figure 3-1 Adoption Innovation Curve
Source: Rogers, 1995

3.3 Theoretical Model and Propositions

We investigate factors that could influence adoption of a DMIS from an individual adopter, and environmental, technological and organizational context. Propositions have been assigned for factors in each group. Figure 3-2 is the theoretical model for the case study.

The theory development first focuses on the more practical influence of adoption from an individual adopter perspective (farm size, years experience, age, education and social influence). We then examine the environmental context (sponsorship, information sharing and dealer trust), technological context (advantage, knowledge, compatibility, planning and complexity) and organizational context (profitability, cash flow and loans, and uncertainty and risk).

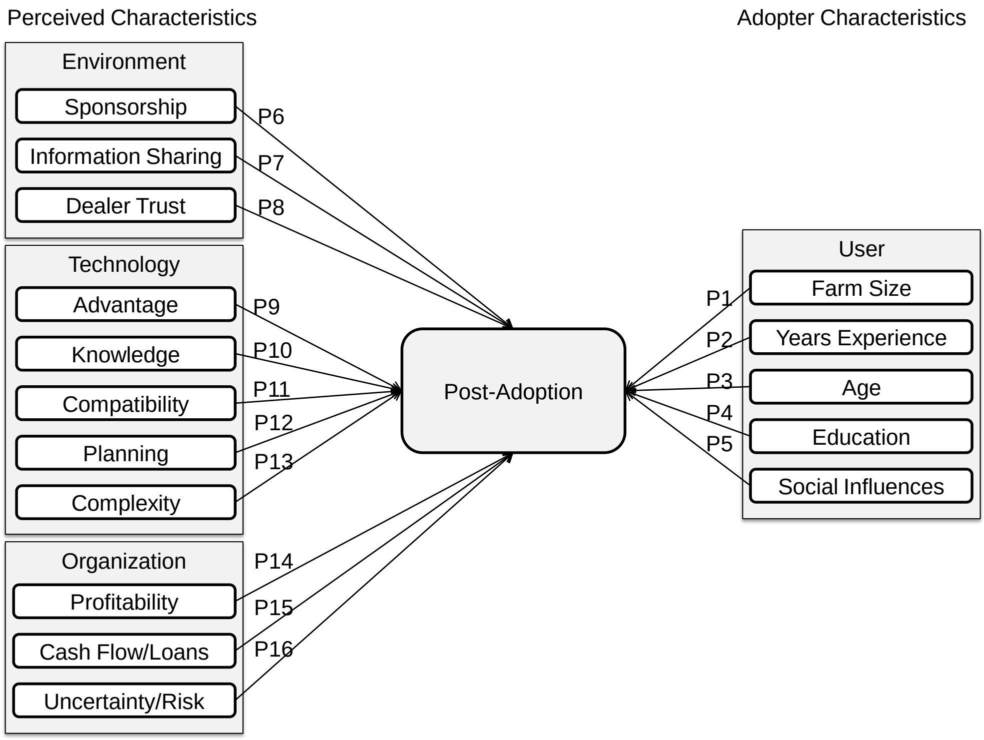

Figure 3-2 Theoretical Model

The environmental, technological and organizational factors are perceptions by the farmer and hypothetical in nature. We derive the findings in IDT literature to support the propositions. The research question for this case study is:

To what extent does the relationship of technological, organizational and environmental factors drive/inhibit post-adoption of a dairy management information system in Korea?

Case studies derive propositions from the research question. The researcher has to make a speculation on the basis of the literature. Other earlier evidence for what they expect the findings of the research to be should also be inferred. The data collection and analysis can then be structured to support or refute the research propositions (Yin, 2003; Rowley, 2002). Most technology adoption models focus on the context of the technology and the individual adopter rather than organizational and environmental factors. The Technology-Organization-Environment Framework (Tornatsky and Fleischer, 1990) is adapted for this case study. A case study should be linked to a theoretical framework (Tellis, 1997).

3.3.1 Adopter characteristics

Adopter characteristics can influence the decision to adopt. Five factors at the adopter level are investigated. These factors are farm size (Al-Qirim, 2007; Harrison et al., 1997; Iacouvou et al. 1995; Palvia et al., 1994; Prekumar and Roberts, 1999; Thong, 1999; Thong and Yap, 1995), experience (Fink, 1998; Triandis, 1971; Karahanna et al., 1999; Yap et al., 1992), age (Daberkow and McBride, 2003; Morris et al., 2005; Morris and Venkatesh, 2000; Raub, 1981), education (Cooper and Zmud, 1990; Chun, 2003; Koundouri et al., 2006; Nelson and Phelps, 1966; Wozinak, 1987), and social influences (Bandiera and Rasaul, 2006; Conley and Udry, 2001; Frambach and Schillewaert, 2002; Lu, 2005; Morris and Venkatesh, 2000; Zack and McKenney, 1995)

Farm size

IT adoption for small firms is often a decision made by the owner or executive. There have been many studies that have focused on the adoption of IT in small firms. The size of small firms in rural communities is a critical factor for the adoption of new technologies and IT use (Palvia et al., 1994). Other factors also exist in combination with the adoption of IT by small firms. Relative advantage, top management support, firm size, and external and competitive pressures are important factors for adoption (Prekumar and Roberts, 1999). Three factors for adoption on small firms – organizational readiness, external pressures and perceived benefits that influence Electronic Data Interchange (EDI) have been investigated (Iacouvou et al. 1995). The study findings indicate that efforts should be made to improve perceptions of EDI benefits. Small firms with low knowledge access should also be provided financial and technological assistance. Selecting and applying influence strategies to reduce barriers for adoption of IT should also be implemented. Firm size and executive characteristics are the most significant factors for adopters and non-adopters of IT (Thong and Yap, 1995). Large firms are more likely to adopt IT and small firms are slow to adopt IT. Executives that are more innovative and have a positive attitude for adoption, have greater IT knowledge. Small firms are more likely to adopt IS with executives that are innovative and have a high level of IS knowledge, and understand IS advantage, compatibility and complexity (Thong, 1999). Yet, innovation characteristics of executives from small firms do not affect the extent of IT adoption. Instead, firm size and employee IS knowledge have a better effect on the extent of IT adoption. It was also identified that adoption relies heavily on individual executive qualities (Al-Qirim, 2007). In contrast, a study using the Theory of Planned Behavior (TPB) to explain and predict small firm executive decisions to adopt IT was conducted (Harrison et al., 1997). Firm size and executive characteristics had no effect on adoption. However, as firm-size increased, potential adoption barriers decreased. Therefore, we propose the following:

Proposition 1 (P1): *Small-size farms are less likely to adopt the system.*

Experience

Social norms have more effect in determining consumer behavior when it is prior to adoption. As users gain more experience, social norms influence on behavior will decrease (Triandis, 1971). Inexperienced IT users are more influenced by social norms than experienced IT users, and the ease of use can influence inexperienced users more than experienced users (Thompson et al., 1994). In a study on adoption beliefs, it is assumed that pre-adoption beliefs are formed on indirect experience (i.e. cognition) and post-adoption beliefs are based on past experiences (Karahanna et al., 1999). Social norms alone induce initial adoption and post-adoption usage and therefore are based on the attitude of the user. Therefore, without prior knowledge of the IT, social norms influenced adoption. However, perceived usefulness and image influenced attitude when experienced users have knowledge of the IT. Firms that already have more IT experience or IT in use (post-adoption) are more likely to adopt IT (Fink, 1998; Yap et al., 1992). Smaller firms that have strong managerial influence, supportive external environment, and available experiences within the firm largely benefit from adoption (Yap et al., 1992). Finally, small-size firms are significantly challenged by changes in technology. Top management support and IT experience are necessary to meet these challenges (Fink, 1998). Therefore, we propose the following:

> Proposition 2 (P2): *Experienced information technology users are more likely to adopt the system.*

Age

Younger workers that use technology are more influenced by attitude towards that technology. Older workers are more subjected to the influence of other people in their social environment and the perception for their performance and difficulty to use the technology (Morris and Venkatesh, 2000). Age can negatively affect PA technology adoption (Daberkow and McBride, 2003). Gender can also have an effect on adoption and can vary based on age. Gender differences are less clear for younger workers. Social influences were more important for older women. Performance and difficulty to use the technology were more important for older men (Morris et al., 2005). A relationship between age and computer anxiety indicates that older users have less computer knowledge and training (Raub, 1981). Therefore, we propose the following:

Proposition 3 (P3): *Younger users are more likely to adopt the system.*

Education

There have been many studies focused on the adoption of technology and the education level of senior management. Senior management support and user education level assisted in Material Requirements Planning (MRP) adoption (Cooper and Zmud, 1990). Human capital and information about the technology are significant factors for the adoption of technology (Wozinak, 1987). Education and information about the technology improve the probability for adoption over costs and uncertainty. Farmer education, improvement and information accumulation can increase the probability that a farmer will adopt new irrigation technology (Koundouri et al., 2006). Education can facilitate the implementation of IT (Chun, 2003). Farmers with a high level of education tend to adopt technology earlier than farmers with less education (Chun, 2003; Nelson and Phelps, 1966). Therefore, we propose the following:

Proposition 4 (P4): *Educated users are more likely to adopt the system.*

Social influences

The adoption of IT can be influenced by a social network of family and friends within a community. Individual perceptions and ease of use towards technology (i.e. Internet services via mobile technology) are significantly credited to social influences, and more specifically, informal social networks (Lu, 2005). Users within an organization will show more positive attitudes if other users in their social environment also use the technology (Frambach and Schillewaert, 2002). Social relationships can have an influence at the sub-community level (Zack and

McKenney, 1995). Adoption may vary across an organization or may not be needed in other parts of the organization. This results in varying degrees of adoption by a sub-community. As mentioned, age has an impact for older managers. Older managers can develop a positive attitude about the new technology through opinion leaders within the organization (Morris and Venkatesh, 2000). In agriculture, farmers decisions to adopt a new crop relates to choices made by family and friends (Bandiera and Rasaul, 2006). Paradoxically, they found social influences to be positive in a smaller network of adopters and negative in a larger network. Conversely, farmers that have access to better information about a new crop are less influenced by adoption choices of others in their social network. Learning about technology occurs through communication networks within a community. Social learning is required for optimal learning behavior such as tracking and finding history of production performance for members in that farmer's community or social network (Conley and Udry, 2001). Therefore, we propose the following:

Proposition 5 (P5): *Farmers with social influences are more likely to adopt the system.*

3.3.2 Environment Context

Environmental factors can influence the decision to adopt. Three factors at the environmental level are investigated. These factors are sponsorship (Au and Kauffman, 2001; Dos Santos and Peffers, 1998; Fichman, 1999), information sharing (McAfee, 2003; Jarvenpaa and Staples, 2000); Nambisan and Wang, 1999; Bahardwaj, 2000), and dealer trust (Chiles and McMackin, 1996; Crosby et al., 1990; Komiak and Benbasat, 2004; Nwana et al., 1998).

Sponsorship

It is argued that sponsorship can influence the adoption of technology. The argument is focused on the timing of adoption for most studies. A sponsor is an individual or organization that has property rights to the technology with the intent to make investments to promote the technology (Katz and Shapiro, 1986). Three findings are indicated. If sponsors are absent, the superior present technology has strategic advantage and likely dominates the market. If one of two rival technologies has a sponsor, they will have a strategic advantage and will most likely adopt even if the technology is inferior. If both technologies are sponsored, the technology superior for the future will have strategic advantage. Network externalities (i.e. number of users), and the relationship of sponsorship and competing technologies influences the pattern of adoption (Au and Kauffman, 2001; Katz and Shapiro, 1986). Strong sponsorship in the form of subsidies provided to early adopters is critical in the early part of the diffusion cycle (Fichman, 1999; Katz and Shapiro, 1986; King, et al., 1994; Rogers, 1991). Sponsorship or external influences are needed for adoption for the first few years after the introduction of a new technology (Dos Santos, 1998). Competitor influences appear more predominant after one-fourth to one-fifth of potential adopters use the system. Therefore, we propose the following:

> Proposition 6 (P6): *Farmers are more likely to adopt the system if they have sponsorship in the early part of the diffusion cycle.*

Information sharing

There are research studies on information sharing and the adoption of technology. The argument is focused on organizational policies, culture and divisions for most studies. Training time and physical disruptions for production outweighed adjustment costs for introducing new technology into the process (McAfee, 2003). Information sharing through the complicated web of organizational relationships and systems is more important than the technology itself (Chew, 1985). This implies that the introduction of new technology can embed new interrelationships within the organization and that organizations can incur adjustment costs resulting in a performance dip. Information flow in an organization is influenced by political and cultural boundaries (Markus, 1984; Jarvenpaa and Staples, 2000). Organization-wide policies on data ownership and information sharing are necessary for transparent information flow within the organization (Nambisian and Wang, 1999). Finally, the sharing of resources and capabilities across organizational divisions enables flexibility and faster response for market needs (Bahardwaj, 2000). Therefore, we propose the following:

> Proposition 7 (P7): *Farmers who share information if organizational policies, culture and divisions are set are more likely to adopt the system.*

Dealer Trust

Dealer and customer trust is a very important factor for the adoption of new technology. Trust is necessary for a relationship between the buyer and seller (Chiles and McMackin, 1996; Crosby et al., 1990). Trust in the dealer is necessary before a customer is willing to adopt (Nwana et al., 1998, Komiak and Benbasat, 2004). The buyer must be assured that private information is not compromised, dealer acts in a reasonable manner, and that the buyer has the overriding approval of the purchase agreement in order for a buyer to trust a dealer. Therefore, we propose the following:

> Proposition 8 (P8): *Farmers are more likely to adopt the system if they trust their dealer.*

3.3.3 Technology Context

Technological factors can influence the decision to adopt. Five factors at the technological level are identified. These factors are advantage (Karahanna et al., 1999, Moore and Benbasat, 1991, Cragg and King, 1993), knowledge (Thong and Yap, 1995; Feder and Slade, 1984; Newall, 2000), compatibility (Tornatzky and

Klein, 1982), planning and complexity (Tornatzky and Klein, 1982). Relative advantage, compatibility and complexity were consistently found as decisions for adoption or utilization (Tornatzky, and Klein, 1982).

Relative Advantage

Relative advantage is the degree to which adopting innovation is perceived better than existing technology (Rogers, 1995). Relative advantage and compatibility were the more consistent factors determining adoption of Windows (Karahanna et al., 1999). Relative advantage and compatibility appear distinct from each other. However, relative advantage and compatibility may covariate (Moore and Benbasat, 1991). Relative advantage is a significant factor for IT adoption in small firms (Cragg and King, 1993). Therefore, we propose the following:

> Proposition 9 (P9): *Farmers are more likely to adopt the system if they perceive relative advantage.*

Knowledge

Knowledge is a very important factor for the adoption of new technology. Prior literature links attitude, access to information, firm size, and uncertainty of the technology as probable dependents for adoption. An executive for small-size businesses is more likely to adopt technology when he is innovative, has a positive attitude for adoption and has greater IT knowledge (Thong, 1995). The degree of uncertainty and risk to adopt diminishes with these factors in mind. Farmers that can access information more readily are able to acquire higher levels of knowledge (Feder and Slade, 1984). Large-size farms with better access to information and greater knowledge will adopt earlier than small-size farms. The adoption of new technology is a dynamic process where the diffusion and utilization of knowledge influence each other (Newall et al., 2000). Therefore, we propose the following:

Proposition 10 (P10): *Farmers are more likely to adopt the system if they are knowledgeable about information technology.*

Compatibility

There are many adoption studies on compatibility. Compatibility is the degree to which adopting an innovation is perceived consistent with the existing values, needs and past experiences of potential adopters (Rogers, 1995). Compatibility is a good predictor of usage behavior (Agarwal and Prasad, 1998; Moore and Benbasat, 1996; Rogers, 1995). Compatibility, perceived usefulness, and complexity are important for continued use (Moore and Benbasat, 1996). Usage behavior such as perceived usefulness and result demonstrability intentions on the Web determine level of usage (Agarwal and Prasad, 1997). Factors for adoption behavior have been investigated (Moore and Benbasat, 1996; Agarwal and Prasad, 1997). However, relative advantage, complexity (ease of use), and compatibility were the only factors affecting the adoption of new technology (Tornatzky and Klein, 1982; Karahanna et al., 1999). Therefore, we propose the following:

Proposition 11 (P11): *Farmers are more likely to adopt the system if they find compatibility in the system consistent with their past experiences.*

Planning

There are very few studies on strategic planning and the adoption of IT. IS infrastructure, top management support, and strategic IS planning are an important determinant of Inter-organizational systems adoption (Grover, 1993; Prekumar and Potter, 1995). The effectiveness of mass media and interpersonal channels were investigated (Agarwal and Prasad, 1998). When the firm is formal (high degree of formal planning) and resource-intensive (organizational resources such as time, in-house financial and human capital), communication occurs early in the adoption process and the use of the technology occur early (Carter et al., 2001). Firms that expressed formal communication, but are low resource-intensive are also early adopters. Therefore, we propose the following:

> Proposition 12 (P12): *Farmers are more likely to adopt the system if they have formal strategic IS planning.*

Complexity

Complexity is the degree to which adopting an innovation is perceived as difficult to use (Rogers, 1995). There are many studies that have looked at a combined set of factors at a level of use approach such as compatibility, perceived usefulness, result demonstrability intentions, and complexity. Complexity of the technology is a significant barrier for implementation success (Tomatzky and Klein, 1982; Cooper and Zmud, 1990). Therefore, we propose the following:

> Proposition 13 (P13): *Farmers are less likely to adopt the system if they perceive complexity.*

3.3.4 Organization Context

Organizational factors can influence the decision to adopt. Three factors at the organizational level are identified. These factors are profitability (McCardle, 1985; Wozinak, 1987), cash flow/financial resources (Brynjolfsson and Hitt, 2000; Ein-Dor and Segev, 1978), and risk-taking/uncertainty (Feder and Slade, 1984; Marra et al., 2003; Howell and Higgens, 1990; Thong and Yap, 1995).

Profitability

The profitability of adopting technology is uncertain at the moment of adoption. Reducing the level of uncertainty or the amount of risk one is willing to take to gain profit is something to consider prior to the adoption of technology (McCardle, 1985). The uncertainty for profitability may be within the firm or the technology itself. If the profitability of the technology were known, adoption may further depend on other factors such as competitiveness. The likelihood for adoption may vary across firm size, education and information, and reduced adoption costs and uncertainty or risk (Wozinak, 1987). Therefore, we propose the following:

> Proposition 14 (P14): *Farmers are less likely to adopt the system if they perceive risk and uncertainty for profitability.*

Cash flow/Financial Resources

The U.S. Department of Energy's Industrial Assessment Centers Program found that 58% of the projects not adopted were for the lack of cash flow (Anderson, 2004). However, an increase in cash flow or availability of funds does not necessarily mean that a firm will adopt IT. Firms with an increase in cash flow may invest in other things such as human capital or labor, rather than IT (Brynjolfsson and Hitt, 2000). Cash flow can also be associated with business size. Small firms experience a condition called "resource poverty," which is a result of high competitiveness, lack of expertise and more at risk to external sources. Small firm's experience unique conditions such as constraints with financial resources, internal IT expertise, and short-term planning (Thong and Yap, 1995). Consequently, small firms have more barriers for adoption of technology than large firms (Ein-Dor and Segev, 1978). Therefore, we propose the following:

> Proposition 15 (P15): *Farmers are less likely to adopt the system if they do not have accessible financial resources.*

Risk-taking/Uncertainty

The adoption of IT requires a large expenditure of financial resources. The adoption of IT could be considered as risk-taking because of its inherent complexity. Barriers to adopt technology are the result of risk and uncertainty factors such as the farmers' perceptions about technology risk and farmers attitudes towards risk (Marra et al., 2003). Small firms would not be willing to take the financial risk, and less innovative executives will look for more conservative solutions, and therefore are less risk-taking (Thong and Yap, 1995). More innovative executives are described as being more risk-taking (Howell and Higgens, 1990). Large farms are more likely to have access to financial resources for seeking information in the initial phases of diffusion. Therefore, large farms possess more cumulative information. There needs to be a certain amount of cumulative information achieved before adoption can occur (Feder and Slade, 1984). Therefore, farmers that have financial resources available for accessing information are less risk averse and will adopt earlier than farmers that lack financial resources. Therefore, we propose the following:

> Proposition 16 (P16): *Farmers are less likely to adopt the system if they do not have financial resources to avert risk and uncertainty.*

There are sixteen propositions for this case study. The propositions emphasize a range of causes that can effect adoption. These propositions represent individual adopter and environmental, technological, and organizational factors and their role in the adoption of IT. The stream of literature used for this case study support the propositions. Table 3-2 outlines selected related research and expected relationships for each developed factor.

Table 3-2 Selected Related Research, Factors and Expected Relationships

Independent Variables	**Expected Relationship**	**Selected Related Research**
User		
Farm size	Negative	Feder, 1980; Feder & O'Mara, 1981; Feder & Slade, 1984; Palvia et al, 1994; Thong & Yap, 1995
Years experience	Positive	Triandis, 1971; Yap et al., 1992 ; Thompson et al., 1994; Fink, 1998; Karahanna et al., 1999

Age	Positive/ Negative	Harrison & Rainer, 1992; Morris & Venkatesh, 2000; Venkatesh et al., 2003; Morris et al., 2005
Education	Positive	Wozinak, 1987
Social influences	Positive	Zack & McKinney, 1995; Morris & Venkatesh, 2000; Conley & Udry 2001; Frambach & Schillewaert, 2002; Lu, 2005; Bandiera & Rasaul, 2006
Environment		
Sponsorship	Positive Varies	Fichman, 1999; Dos Santos & Peffers, 1998 Katz & Shapiro, 1986; Choi & Thum, 1998
Information sharing	Negative	Jarvenpaa & Staples, 2000; McAfee, 2002; Nambisan & Wang, 1999
Dealer trust	Varies	Komiak & Benbasat, 2004
Technology		
Relative advantage	Positive	Moore & Benbasat, 1991; Craig and king (1993); Karahanna et al., 1999
Knowledge	Positive	Feder & Slade, 1984; Thong & Yap, 1995; Newall et al., 2000
Compatibility	Positive Undetermined	Tornatzky & Klein ,1982; Moore & Benbasat, 1996; Agarwal & Prasad, 1997
Planning	Positive	Grover, 1993; Prekumar & Potter, 1995; Carter et al., 2001; Russell & Hoag, 2003
Complexity	Negative	Tornatzky & Klein, 1982; Cooper & Zmud, 1990; Moore & Benbasat,1996
Organization		
Profitability	Uncertain/varies	Jensen, 1982; McCardle, 1984; Wozniak, 1987
Cash flow/loans	Negative	Brynjolfsson & Hitt, 2000; Anderson & Newell, 2004;
Uncertainty/risk	Negative	Feder & Slade, 1984; Thong & Yap, 1995

3.4 Methodology

3.4.1 Case Study Research Methodology

Introduction

Case studies allow the exploration and understanding of complex issues. Case studies are viewed as a useful tool for exploratory and preliminary research even though case study methodology is controversial. However, case studies are considered to be a reliable research method. They are "particularly well suited to new research areas or research areas for which existing theory seems inadequate. This type of work is highly complementary to incremental theory building from normal science research. The former is useful in early stages of research on a topic or when a fresh perspective is needed…the latter is useful in later stages of knowledge" (Eisenhardt, 1989).

Definition

Case study research method is defined "as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used (Yin, 2003)." A case study allows the researcher to examine information about a particular subject within a specific context. A case study may look at a small geographical area in some situations with a limited number of participants. A case study is a unique method for observing "natural phenomenon" that may exist for a given observation (Yin, 2003).

Past Applications of Case Study Research

Case study research is a common methodology used in social science studies. It has been used in many conditions in information systems and agriculture research. There are many information systems studies that use case study methodology. Intranet adoption (Zolla, 1999), Internet adoption by SMEs (Mehrtens et al., 2001), human factors in geographic information systems adoption (Nedović-Budić and Godschalk, 1996), electrical and electronic goods adoption for manufacturing firms in India (Lal, 1999), managing academic electronic publishing (Hovav and Gray, 2001), development of a research method to explore sustained delivery of cognitive services (Kaae et al., 2010), Internet standards adoption for IPv6 (Hovav et al., 2004) are a few examples in the stream of literature. There are many studies in agriculture and dairy management that use case study methodology. Agricultural innovations in developing countries (Feder et al., 1985), small ruminant production in mixed farming systems (Okali and Knipscheer, 1985), new technology adoption in Ethiopian agriculture (Kebe et al., 1990), farmer participatory research review of concepts and recent fieldwork (Farrington and Martin, 1998), precision farming and use (Batte and Arnholt., 2003), and financial implications of changing a farming system (Bennett, 2003) are a few examples in the stream of literature.

Case Study Design

There are two types of case study methods. The single-case design is used when there is only one example or a unique situation that cannot be replicated. A single-case design cannot provide a generalized conclusion because events are limited to one occurrence. The multiple-case design can be adapted to situations where there is evidence of multiple occurrences. The results can be generalized and built more on the application of theory (Yin, 2003), and theoretical proposition development (Campbell, 1975). Therefore, multiple-case design provides validity to the study. Guidelines for a suitable case study design are suggested (Tellis, 1997). Case study design should:

1. Show that a case study is the only viable method to obtain information.
2. Provide appropriate research questions.
3. Follows a set of procedures with proper application.
4. Follow scientific rules used in the social sciences.
5. Systematically record and archive a ‘Chain of evidence’ when interviews and direct observation are the main sources of data.
6. Link the case study to a theoretical framework.

Types of Case Studies

There are three types of case studies. These types are exploratory, descriptive and explanatory case studies (Yin, 2003). Exploratory case studies explore a phenomenon and will typically ask general research questions to continue further research. A pilot study is considered to be an exploratory case study (Yin, 2003). Descriptive case studies are more descriptive and narrative, and specific in scope. A theory must support the case study. Explanatory case studies can examine from a generalized and specific level. They are used in causal relationships and have more complex multivariate relationships (Yin and Moore, 1987). They suggest that for more complex and multivariate cases, knowledge-driven, problem-solving, and social-interaction theories can be used to explain a phenomena. Interpretive and evaluative case studies are another type of case study that interprets results through conceptual categories (McDonough and McDonough, 1997). Evaluative case studies go a step further by including an opinion of findings by the researcher.

Disadvantages and Advantages of Case Studies

There are some disadvantages of case study research. Case study research is criticized for having a lack of generalization (Scapens, 1990). Biased views can influence the findings and conclusions. A small number of subjects can also provide insignificant foundation for generalization. It is also difficult to conduct and produce documentation, and manage and organize case study research (Yin, 2003). However, there are some advantages for case study research. Proponents of case study research argue that the objective is to generalize back to theory rather than drawing inferences to a larger population. Examined data may be conducted where the activity or use takes place. They also allow both quantitative and qualitative analysis. The study can also be solely quantitative. In addition, qualitative studies are detailed and can explain the complexities that cannot be acquired through quantitative survey research (Yin, 2003). The uniqueness of case studies is that they derive propositions from the research question. The researcher has to make a speculation on the basis of the literature. In addition, other earlier evidence for what they expect the findings of the research to be should be inferred.

The data collection and analysis can then be structured to support or refute the research propositions (Rowley, 2002; Yin, 2003).

Why did we use case study methodology as part of this dissertation research? Case studies are used to describe and test theory. The aim of this exploratory multi-method case study is to investigate factors regarding the motivation for adopting a dairy management information system. This study can be considered exploratory because the objective is to investigate the motivations for adopting. Therefore, this case study main objective is to explain information system adoption by dairy farms in the form of a theoretical model. The four cases studied are applied to a non-random sample of dairy farmers from different geographic locations in Korea. Little is known about the adoption of information systems from a dairy context even though there are many studies regarding the adoption of information technology in a nonagricultural setting. Also, this study is unique from a post-adoption approach. The case study farms have already adopted some components and of the system. Therefore, case studies were employed as a research methodology to determine with a real-life setting why farmers that have already adopted this particular DMIS have actually adopted the system. We generalize the findings back to theory. An exploratory multi-case study can be considered an important supplement to the existing literature on adoption and post-adoption motivation of information technology in both agricultural and nonagricultural settings.

3.4.2 Ethics of Survey Research

Responsibilities to Participants

Farm managers are the livelihood of this survey research and their confidentially is protected from disclosure to third parties. The dissertation study does not discuss the collected identifiable data by the participant, and disclose identifiable information of the participant. The responses will be anonymous and kept in the strictest confidentiality. Collected notes and data used by the researcher have legitimate internal research purposes.

Privacy and the Avoidance of Harassment

The privacy of the survey participant has protection from unnecessary and unwanted personal harassment. The questionnaire is voluntary and the interviewer asks for the cooperation of the participant. This study values the participants' feedback and relies on their insights, comments and suggestions regarding the interview, the DMIS and its appeal to dairy farmers. The researcher respects the right of participants that refuse to discuss, or terminate an interview in progress. The researcher is responsible to minimize any discomfort to the interviewed participant.

3.4.3 Study and Interview Permission

Study and Interview Permission

The doctoral thesis is partial requirements of a PhD in Economics in the Information Program, Department of Agricultural Economics and Rural Development, at Seoul National University in Seoul, Korea. The developer of the system has granted the thesis author to interview farmers that use the system. The thesis researcher developed and designed the interview questionnaire. The interview questionnaire was reviewed by the developers' and the research and development department of the system. The interviews were conducted in April 2010. The exact wording of the interview questions is in Appendix B. Interviews will continue to be conducted throughout the 2010-2011 school term.

3.4.4 Research Method

We have adopted an in-depth exploratory case study approach (Yin, 2003). The sampling method for this case study is qualitative research. Case studies may be used during the early stages of research or when little is known about a topic (Eisenhardt, 1989). We use this exploratory approach because little is known about adoption of an information system in the dairy sector. Exploratory studies can answer questions for why a manager would adopt IT. The research questions investigate the farmers' characteristics and their environmental, technological and organizational perceptions for adoption of an emerging DMIS. Sixteen propositions address the issue of what may motivate farms to adopt this particular DMIS. The survey research design is multiple-case with a single unit of analysis (Yin, 2003) for each dairy farm studied. Case design provides persuasive evidence that supplies multiple data points and rich descriptions. We intend to do a comparative analysis of the four farms in Korea and one farm in California as a control. The study adopted a multiple case strategy in two phases. The first phase consists of four dairy farms which have adopted the DMIS in Korea. The second phase consists of one farm in California that has not adopted and has chosen not to adopt a DMIS. The non-adopting farm provides a "critical case" to strengthen the proposed theory developed by the four adopting farms (Scapens, 1990). We selected this DMIS since it is considered a leader in the dairy sector. Within the farms that adopted the DMIS, we:

1. Conducted an interview with the dairy manager at the farm.
2. Observed a demonstration of the system.
3. Toured four farms that use the system.
4. Reviewed official information system documentation.
5. Reviewed academic studies conducted on the adoption and diffusion of IT.

Interviews were conducted in person and followed a scripted set of open-ended questions. Follow-up questions were asked when clarifications were needed. The interview questions (Appendix B) were phrased in such a way to be "neutral" so that the respondent would not be led to answer in a particular way. Each of the interviews took approximately two hours. One site visit and demonstration took an additional two hours. The second site visit took approximately three hours. Notes were coded and summaries were written by two researchers after the interviews. The notes and resulting analysis were compared for consistency. We found close to 90% inter-rater agreement. Inconsistencies were resolved by follow up e-mails with respective interviewees and the vendor. Table 3.3 lists the dairy farms we studied which include location, farm size, age of the manager, and years of dairy farm experience.

3.4.5 Survey Population

The participants in the exploratory study were male (husband or son) and female (wife) adult managers from four dairy farms in Gyeonggi Province, Korea. The four adopting farms in Korea are listed as farms '1-4.' The cases varied in location and the type of manager in charge. The non-adopting farm investigated in California as a control is listed as farm '5.'

3.4.6 Sampling Method

The survey population consists of volunteer manager participants. The sampling method is a non-probability and non-random convenience survey that utilizes volunteer participants. Dairy farms that currently use this particular DMIS were selected by the system vendor or dealer. The selected dairy farms also have experience with the system and are considered to be well-respected in the dairy community. The case farmers are considered early adopters because they are the first to use this particular DMIS within their community. These farms varied in their level of system components used, manager in charge of the farm, and accessibility of the farm. One or more technical managers were selected as subjects for interviewing within each dairy farm. These managers are responsible for operation decisions within their farm and reasonably represent a managerial and technical perspective regarding the adoption of the DMIS. Volunteer participants differ from non-volunteer participants (McMillan, 2004). Volunteer participants "tend to be better educated, higher socio-economically, more intelligent, more in need of social approval, more sociable, more unconventional, less authoritarian, and less conforming than non-volunteers" (McMillan, 2004). The managers chosen for this case study do not represent all DMIS users of the system in Korea. However, the findings can be informative for a larger population.

3.4.7 Sample validity and Representative sample

There are potential weaknesses and limitations for using volunteer participants. The interviewed manager may not fully represent the target population that have adopted and use the DMIS. According to the system dealer, approximately thirty dairy farms are presently using the DMIS in Korea. Four dairy farms from the target population that use the system were investigated in April 2010. Although considered a small percentage, this sampled population represents volunteer participants that are early adopters of the system. They are educated and knowledgeable about the system. One non-adopter farm with an unknown target population in California was investigated.

3.4.8 Survey Instrument

The data collection instrument for this case study was an opened-ended questionnaire that required short responses. The questionnaire consists of six parts. Part 1 provide general demographic information such as name, location, farm size, years in industry, age, education, place of birth. Part 2 questions are concerned with how the farmer feels about the system and issues such as automation, food safety and processing, and return on investment. Part 3 questions are concerned with the adoption of the DMIS such as system components using and not using, partial adoption of individual system components, and if they know of others in the community using the system. Part 4 questions are concerned with factors that affect adoption (i.e. reliability, knowledge of the system, flexibility, profitability, compatibility, planning tool, and saving time). Part 5 questions are concerned with barriers of adoption such as the systems complexity or the difficulty using and learning to use, cash flow and capital outlay, uncertainty and risk, and the lack of social infrastructure and manager access to knowledge of this particular system. Part 6 are examples of other topics that may have come up during the interview. Interview questions for this study can be found in Appendix B.

3.4.9 The Dairy Management Information System

The case study company was founded in the 1970s. The company is considered a pioneer in introducing electronics into the milking parlor. The first electronic milk meter was developed by an inventor and visionary as a new philosophy of dairy farming. The system is a set of hardware and software system components and sub-components custom designed for dairy management. The dairy farm system consists of milk meters, individual cow identification, pedometers, milk analyzer, management and analysis software, and sorting, weighing and automatic individual feeding. The system works for a variety of dairy animals such as cows, goats and sheep. The software package contains six system components and four system sub-components. A description of system components and sub-components can be found in Appendix C. The system components enable herd farmers to monitor milk production, yield and quality in real time. The system also provides cow welfare support (e.g., quality of bedding, feeding, and weather stress), early disease detection, and cow quality management (e.g., individual cow productivity, cow life-cycle from birth to culling, heat management, and health management). The system also enables automated herd management. This is especially important for large dairy or grazing farms. The modularity of the software package enables dairy managers to adopt the system in phases. The components functions of the DMIS are briefly described in Table 3-3.The system has been installed in over fifty countries since February 2010. User interfaces have been translated in twenty-one languages.

Table 3-3 Components and Functions of the Dairy Management Information System

Component	Function
Lab	Identify the presence of blood and contaminants in the milk
Farm	Provide list of daily activities based on state of the herd
Weigh	Feeding management
Meter	Measure milk yield and flow rate
Tag	Identify cow health
Act	Detect cows in heat
Ideal	Accurately identify each cow
Weigh	Track cows' weight
Sort	Direct the flow of cow traffic

3.5 Analysis

The goal for this case study is to investigate adopter characteristics and environmental, technological and organizational factors for the post-adoption of an emerging dairy management information system in Korea. We answer the following research question:

> *To what extent does the relationship of technological, organizational and environmental factors drive/inhibit post-adoption of a dairy management information system in Korea?*

Case studies derive propositions from the research question. The researcher has to make a speculation on the basis of the literature. Other earlier evidence for what they expect the findings of the research to be should also be inferred. The data collection and analysis can then be structured to support or refute the research propositions (Rowley, 2002; Yin, 2003). The following sections describe the adoption of DMIS in terms of adopter characteristics and environmental, technological and organizational factors. First, we determined adopter characteristics such as the size of the farm, years of experience, age and education level for the manager. We also noted if the manager grew up in a city or rural setting or if brought up on a farm. We then investigated the system components implemented for each farm and what environmental, technological and organizational factors influenced the manager to adopt the DMIS. We determined similarities and differences for perceived relative advantage, knowledge, compatibility, complexity, profitability, cash flow and loans, and uncertainty and risks for the four farms. Tables 3-3, 3-4 and 3-5 provide summaries of adoption for individual adopter and perceived environmental, technological and organizational factors for the four farms in Korea (farms 1-4). The non-adopting farm in California (farm 5) is included in the Table summaries.

3.5.1 Farm Size

The DMIS analysis is post-adoption conditions for the four farms in this case study. Approximately thirty dairy farms in Korea have adopted the DMIS. Consequently, this is a low percentage considering the large total number of small dairy operators in Korea. Farm size is a measure in terms of cows per farm. Dairy farms in Korea are typically 45-90 cows per farm. They are relatively small-sized operations. Farms 2 and 3 had 90 cows, farm 1 had 64 cows, and farm 4 had 45 cows. Adoption is slow or unlikely for small-size operations according to the literature. Farm 1 used Farm, Act, Tag and Lab. Farms 2, 3 and 4 also used Feed in addition to Farm, Act, Tag and Lab. One-half of the existing system components are partially supported and have been implemented. As firm-size increased, potential adoption barriers decreased (Harrison et al., 1997). Firm size and executive characteristics are the most significant factors for adopters and non-adopters of IT. They confirm that large firms are more likely to adopt and small firms are slow to adopt IT (Thong and Yap, 1995). Therefore P1: *Small-size farms are less likely to adopt the system* is supported.

3.5.2 Experience

Experience is another important factor for adoption. Experience is measured in terms of years total in the dairy industry. Experience is not measured in terms of IT experience use. This may present an unclear or limiting condition. Dairy farms in Korea are traditionally labor-intensive and have more recently started to adopt IT. All four farms were managed by the father with each having twenty or more years of dairy business or industry experience. In the case of farms 2 and 4, the son has taken ownership of the system. The wife claims ownership of the system for farm 3 and seeks advice from the son at farm 1. In general, it appears that the dominant male figure has passed on ownership of the system to the wife and son. With the exception of farm 3, the son is unmotivated to learn the system. The father is also not confident to use the system. The other three farms, 1, 2, and 4, appear to demonstrate confidence using the system. Small-size firms are significantly challenged by changes in technology. Top management support and IT experience are necessary to meet the challenge of change (Fink, 1998). Therefore, P2: *Experienced information technology users are more likely to adopt the system* is supported.

3.5.3 Age

Age is measured in terms of the number of years for the manager (father, son, and wife) at the farm. The son may inherit the family business in most cases. Dairy farms are typically operated by the father. The age for the managers varied for the four farms. The managers were in their 50’s for farms 1 and 3. The farm 2 manager was 23 and the farm 4 manager was in his 30s. Either the son or wife managed the dairy operations and claimed ownership of the DMIS in three of the four farms. The father at farm 1 had a prior lunch engagement and appeared intimidated or lacked the interest to demonstrate the system. His wife demonstrated use of the system. Younger workers that use technology were more influenced by attitude (Morris and Venkatesh, 2000). Gender can also have an effect on adoption, but vary based on age (Morris et al., 2005). A relationship exists between age and computer anxiety suggesting that older users have less computer knowledge and training (Raub, 1981). Therefore, P3: *Younger users are more likely to adopt the system* is supported.

3.5.4 Education

Education was measured in terms of the manager's completed level of university, technical college or high school. The education level for the managers varied for the four farms. The managers either graduated with a bachelor's degree from a top Korean University or a lower tier college for farms 1 and 3. The manager for Farm 2 recently graduated in computer programming from a technical college. However, it was unclear for the level of education for the manager at farm 4. In general, the education level is reasonable given that the manager's represent small-size dairy operations. Education and information about the technology improves the probability for adoption. This predominates over costs and uncertainty (Wozinak, 1987). Therefore, P4: *Educated users are more likely to adopt the system* is supported.

3.5.5 Social Influences

Social influences were measured in terms of whether the farm represented was an early or late adopter of the system. Social influences varied by farm. Farms 1, 2 and 4 were the first farms in their particular community to use the DMIS. This fact assigned them as early adopters. Each farm has influenced a neighbor to use the system. Farm 2 has become a demonstration facility for the system dealer and it is utilized for showing and marketing purposes. Social relationships can have an influence at the sub-community level (Zack and McKenney, 1995). The farmers decisions to adopt a new crop relates to choices made by family and friends (Bandiera and Rasaul, 2006). Therefore, in the case of farm 3, P5: *Farmers with social influences are more likely to adopt the system* is supported. Farm 4 manager is a president of a local dairy group. However, it was unclear if he has had any influences within his social network. Other than dealer support and recommendations given to the farmer, other social influences could have impacted farms 1, 2 and 4 to adopt the system. They were the first farms and early adopters in their network to implement the system. Therefore, P5: *Farmers with social influences are more likely to adopt the system* is supported. A summary for individual adopter characteristics (farm size, experience, age, education, and social influences) are provided in Table 3-4.

Table 3-4 Individual Adopter Characteristics

	Herd Size	**Years Exp.**	**Age**	**Education**	**City/ Rural**	**Farm Raised**	**Module Used**	**Social Influences**
1	64	20	50-60	Bachelors (SNU Ag)	Rural	Yes	Farm Act Tag Meter	Dealer training; First farm in community
2	90	22 father 1 son	23 son	Technical college; Agriculture and computer programming	Rural	Yes	Farm Act Tag Meter Feed	First farm in community; Neighbor now using; Demonstration farm
3	90	20	50+ father 23 son	Technical college	Rural	Yes	Farm Act Tag Meter Feed	Neighbor
4	45	20	30s	Unclear	Rural	Yes	Farm Act Tag Meter Feed	First farm in community; Neighbors will follow; President of dairy group
5	~1000	20+	40s	High School	Rural	Yes	None used	Nearby farmer attempt unsuccessful to adopt technology

3.5.6 Sponsorship

A sponsor for an individual or organization has property rights to the technology. The intent is to invest and promote the technology (Katz and Shapiro, 1986). The

DMIS developer does not provide an exclusive agreement to service dairy farms in Korea. An outsourced company provides that function. In addition, if one of two rival technologies has a sponsor, they will have a strategic advantage and will likely be adopted even if the technology is inferior (Katz and Shapiro, 1986). A rival technology dominates the dairy technology market in the case of Korea. Although it is unclear if the rival provides this type of sponsorship, their strategic advantage may suggest sponsorship. The Korean government offers an economic incentive for farmers that have their children complete college. 50,000,000 are offered by the Korean government if the son takes over farm. The intent is to have offspring return and manage the family dairy farm. However, the perceptions and understanding of the Korean government policy for the four farms in this study are ambiguous and unclear. Even with the uncertainty of sponsorship, adoption of the DMIS in Korea has been a slow process. However, there is adoption activity. Therefore, P6: *Farmers are more likely to adopt the system if they have sponsorship in the early part of the diffusion cycle* is unclear.

3.5.7 Information Sharing

Information sharing was measured by the inter-relationships for each farm. Farmer to farmer, and farmer to dealer and vice versa interactions were observed and investigated. Information sharing is focused on organizational policies, culture and divisions in the past stream of literature. Organizational relationships (Chew, 1985), influence of political and cultural boundaries (Markus, 1984), and organization-wide policies on data ownership and information sharing (Nambisian and Wang, 1999) rather than the technology itself are the focus. Korean dairy farms are typically small-size family-run operations with the manager demonstrating clear ownership of the system. Therefore, P7: *Farmers who share information if organizational policies, culture and divisions are set are more likely to adopt the system* is varied. Information sharing in an intra-farm relationship also appears varied. Therefore, P7 is unpredictable in this situation.

3.5.8 Dealer Trust

Trust was measured by the appearance of a respectable or unrespectable relationship between the dealer and manager. Trust is necessary for a relationship between the buyer and seller (Chiles and McMackin, 1996; Crosby et al., 1990). Trust in the dealer is necessary before a customer is willing to adopt (Nwana et al., 1998; Komiak and Benbasat, 2004). The relationship between the dealer and farms 1, 2, and 4 appeared reasonable. The relationship between the dealer and farm 3 did not appear as convincing as the other three farms. Conceivably, the familiarity and knowledge concerning the system was not as favorable for farm 3. However, farm 3 did adopt the system. We could assume that there must have been established trust prior to adoption of the system. Therefore, P8: *Farmers are more likely to adopt the system if they trust their dealer* is supported.

3.5.9 Relative Advantage

Relative advantage is defined as the degree to which adopting innovation is perceived better than prior technology used by the adopter (Rogers, 1995). Relative advantage was measured by the manager's pre-adoption and post-adoption perceptions of the systems performance. The four farms in this study agreed that they had perceived that there was an advantage with the new system prior to adoption. Farms 1, 2 and 4 perceived the farm as performing better with the new system in post-adoption. Farm 3 did not show farm improvement with the system. Older cows had breast or teat (mastitis) disease. Relative advantage is a significant factor for IT adoption in small firms (Cragg and King, 1993). Relative advantage was a significant factor for farms 1, 2 and 4. Therefore P9: *Farmers are more likely to adopt the system if they perceive relative advantage* is supported.

3.5.10 Knowledge

Knowledge was measured by IT experience and the level of education for the manager or user of the system. An Executive for small-size firms is more likely to adopt technology when he is innovative, has a positive attitude for adoption, and has greater IT knowledge (Thong and Yap, 1995). All of the managers for the four farms demonstrated ownership of the system and expressed a positive attitude towards learning system capabilities. Korea traditionally has a high regard for education beyond the high school level. The education level for farm 4 was unclear. The other three managers were educated at a top university or technical college. Two managers received computer training with a specialization in computer programming. Therefore, P10: *Farmers are more likely to adopt the system if they are knowledgeable about information technology* is supported.

3.5.11 Compatibility

Compatibility is the degree to which adopting an innovation is perceived as being consistent with the existing values, needs and past experiences of potential adopters (Rogers, 1995). Compatibility was measured by the values, needs and past experiences of the manager. Compatibility is a good predictor of usage behavior (Rogers, 1995; Agarwal and Prasad, 1998; Moore and Benbasat, 1996). The system appears compatible for farms 1, 2 and 4. These three farms are experiencing less labor usage for production. The managers were confident given the improvement offered by the new system in the case of farms 2 and 4. The farm will eventually be operated by the son as a result of the improvement. Farm 3 was not as fortunate. Therefore, in general, P11: *Farmers are more likely to adopt the system if they find compatibility in the system consistent with their past experiences* is supported.

3.5.12 Planning

There are very few streams of literature on strategic planning and the adoption of IT. IS infrastructure, top management support and strategic IS planning is an important determinant of Inter-organizational systems adoption (Grover, 1993; Prekumar and Potter, 1995). Strategic IS planning was measured by the usage of other technology that supports the DMIS. All four farms have fully or partially installed feeding optimization hardware and software. Feeding optimization using 'Feed' did not perform to expectations in most cases. Formal (high degree of formal planning) and resource-intensive (organizational resources such as time, in-house financial and human capital) (Carter et al., 2001) were difficult to determine. Therefore, P12: *Farmers are more likely to adopt the system if they have formal strategic IS planning* is unclear. A summary for the variables (relative advantage, knowledge, compatibility, planning) are provided in Table 3-5.

Table 3-5 Advantage, Knowledge, Compatibility and Planning

	Advantage	**Knowledge**	**Compatibility**	**Planning**
1	Yes	Dealer training; Wife on-the-job learning; Wife has ownership of the system	Less hard labor	Feeding optimization
2	Yes	Skilled game programmer; Technical courses and computers in high school; Son on-the-job learning and eager to learn; Son appears to have ownership of the system; Father and son studied all available milking technology and after complete investigation decided on this system	Less hard labor; Hand-off business to son	Feeding optimization
3	No	Manager wife gets technical support from son at farm 2; Father is on-the-job training to use the system; Father appears to have ownership of the system		Feeding optimization (partially)
4	Yes	Investigates technical capabilities on his own; Son is on-the-job learning how to use system; Son appears to have ownership of the system	Less hard labor; Hand-off business to son	Feeding optimization

3.5.13 Complexity

Complexity is the degree to which adopting innovation is perceived as being difficult to use (Rogers, 1995). Complexity of the system was measured by observing numerous factors. These factors are how the manager has been trained to use the system, partial versus full usage of the system, dealer technical support, and individual user motivation. The complexity of technology is a significant barrier for implementation success (Tomatzky and Klein, 1982; Cooper and Zmud, 1990). In general, the system is learned on-the-job. The system use is partially understood for most farms. The manager's wife has been able to learn 30% of the system in the case of farm 1.The manager's son would like to have more simplified menus in the case of farm 2. Farm 3 had an unusual circumstance. The son was unmotivated to learn the system and the father was uncertain about the system ease of use. The dealer appeared supportive from a dealer to farmer relationship rather than a technical representative of the system. These evaluations are based on post-adoption of the system. Others in the community could resist adoption if the system appears complex. Therefore P13: *Farmers are less likely to adopt the system if they perceive complexity* is supported.

3.5.14 Profitability

The profitability of adopting technology is uncertain prior to adoption. We measured profitability as a post-adoptive factor by examining aspects of the system that improved return on investment. Farms 1, 2 and 4 believe that they had achieved cost savings in heat detection (cow impregnation) functions. They did not have to perform unnecessary semen injections. Farm 2 also experienced savings for feeding management and reduced labor costs. Perceived profitability was mostly conjecture. There were no hard numbers to support profitability. Farm 4 had eight diseased cows preventing them from achieving grade 'A' milk quality. They experienced a loss in revenue and the manager did not foresee profitability for the near future. Since there is uncertainty for profitability and return on investment, P14: *Farmers are less likely to adopt the system if they perceive risk and uncertainty for profitability* is unclear. There were conflicting success and failure stories concerning profitability of the system.

3.5.15 Cash Flow/Financial Resources

Small-size firms tend to have more barriers for adoption of technology than large-size firms (Ein-Dor and Segev, 1978). The Korean government offers an economic incentive for farmers that have their children complete college. The intent is to have offspring return and manage the family dairy farm. Farms 1 and 2 have conveyed those intentions. The wife has claimed ownership of the system with the intent to have her son manage the dairy farm and system in the case of farm 1. The son has clearly demonstrated ownership of the system in the case of farm 2. He gained technical computer skills in college. Farms 3 and 4 claim that cash flow/financial resources are not an issue. It may be difficult or awkward for some farmers to talk about their cash and financial resources. There was also considerable doubt and uncertainty about the status of the government-sponsored program. In general, small-size firms experience a condition called “resource poverty,” This is a result of high competitiveness and lack of expertise. They are more at risk to outside sources. Small firm’s experience cash flow, internal IT expertise limitations, and short-term planning conditions (Thong and Yap, 1995). Therefore, P15: *Farmers are less likely to adopt the system if they do not have accessible financial resources* is generally supported. Although, it is unclear if this factor received reliable information.

3.5.16 Risk-taking/Uncertainty

The adoption of IT requires a large expenditure of financial resources. Farms 1, 2 and 4 expressed uncertainty and risk as not being an issue. However, the managers may not understand the conditions for uncertainty and risk from a business perspective. Before adoption can occur, there needs to be a certain amount of cumulative information (Feder and Slade, 1984). Farm 3 experienced disease of their cows during post-adoption of the system. Old milking machines were blamed for grade “B” milk quality. Older cows were infected with breast or teat disease (mastitis). They perceived that the system is risky. This may be a reflection of their attitude. Innovative executives are described as being more risk-taking (Howell and Higgens, 1990). Small firms would not be willing to take the financial risk, and therefore are less risk-taking (Thong and Yap, 1995). Therefore, P16: *Farmers are less likely to adopt the system if they do not have financial resources to avert risk and uncertainty* is supported by the successes of farm 1, 2, and 4's willingness to take the financial risk. Farm 3 lacked success with the system and regrets using the system. Therefore, P16 is not supported. A summary for the variables (complexity, profitability, cash flow/financial resources, and risk-taking/uncertainty) are provided in Table 3-6.

Table 3-6 Complexity, Profitability, Cash Flow, and Uncertainty and Risk

	Complexity	**Profitability**	**Cash/Loans**	**Uncertainty/Risk**
1	On-the-job-training Dealer support; Wife learned 30% of system in three months	Act heat detection improves bottom-line	Government will give family; 50,000,000 if son takes over farm	Not an issue
2	On-the-job-training; Dealer and technician support; Son able to learn the system well, but, needs simplified menus	Able to save money on insemination, feed and labor	- Government will give family; 50,000,000 if son takes over farm	Not an issue
3	On-the-job-training; Dealer and technician support; Son appears unmotivated to learn; Father appears uncertain	8 diseased cows have prevented grade 'A' production; Does not see profitability for some time	Not an issue	Mastitis (teat) disease from old milking machines and older cows; Reason for having grade B quality
4	Pedometer hurts the cows ankle if mud collects underneath	Act heat detection (95% accurate) is improving bottom-line; Money saved from unnecessary semen injections	Not an issue	Not an issue

3.6 Research Model Results

We investigated factors that may influence the adoption of a dairy management information system in Korea. The study investigated adopter characteristics and environmental, technological and organizational factors. Various studies on information system adoption and implementation were described. A case study should be linked to a theoretical framework (Tellis, 1997). Figure 3-3 illustrates a developed research model for this study and resulting analysis of the propositions.

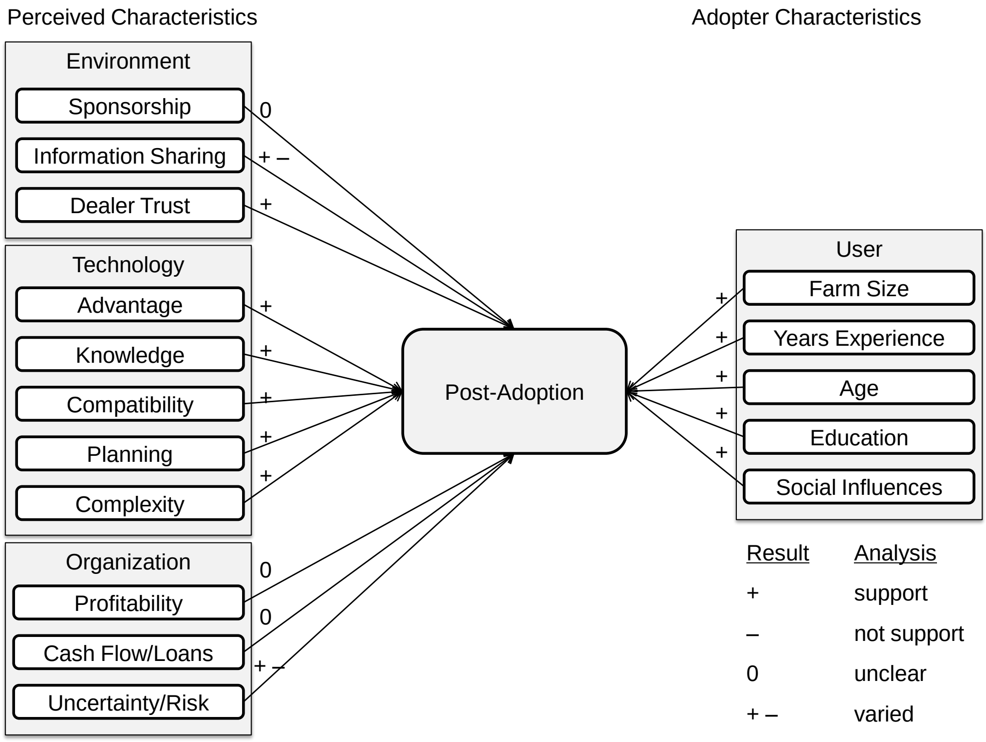

Figure 3-3 Developed Research Model and Resulting Analysis

The Technology-Organization-Environment Framework (Tornatsky and Fleischer, 1990) is adapted for this case study. Factors such as farm size, years experience and age may be straight forward to understand. Environmental, technological and organizational factors such as dealer trust, information sharing, knowledge, complexity, and uncertainty or risk are more conceptual and problematic. The researcher has to make a speculation on the basis of the literature and any other earlier evidence as to what they may expect to be the findings of the research. The data collection and analysis is then structured to support or refute the research propositions (Rowley, 2002; Yin, 2003). Table 3-7 is a summary of supported or refuted results for the propositions.

Table 3-7 Results of Propositions

	Propositions	**Support**
P1	Small-size farms are less likely to adopt the system.	Yes
P2	Experienced information technology users are more likely to adopt the system.	Yes
P3	Younger users are more likely to adopt the system.	Yes
P4	Educated users are more likely to adopt the system.	Yes
P5	Farmers with social influences are more likely to adopt the system.	Yes
P6	Farmers are more likely to adopt the system if they have sponsorship in the early part of the diffusion cycle.	Unclear
P7	Farmers who share information if organizational policies, culture and divisions are set are more likely to adopt the system.	Varied
P8	Farmers are more likely to adopt the system if they trust their dealer.	Yes
P9	Farmers are more likely to adopt the system if they perceive relative advantage.	Yes
P10	Farmers are more likely to adopt the system if they are knowledgeable about information technology.	Yes
P11	Farmers are more likely to adopt the system if they find compatibility in the system consistent with their past experiences.	Yes
P12	Farmers are more likely to adopt the system if they have formal strategic IS planning.	Yes
P13	Farmers are less likely to adopt the system if they perceive complexity.	Yes
P14	Farmers are less likely to adopt the system if they perceive risk and uncertainty for profitability.	Unclear
P15	Farmers are less likely to adopt the system if they do not have accessible financial resources.	Unclear
P16	Farmers are less likely to adopt the system if they do not have financial resources to avert risk and uncertainty.	Varied

3.7 Discussion

3.7.1 Research Question

The goal for this case study is to investigate adopter characteristics and environmental, technological and organizational factors for the post-adoption of an emerging dairy management information system in Korea. We answer the following research question:

> *To what extent does the relationship of technological, organizational and environmental factors drive/inhibit post-adoption of a dairy management information system in Korea?*

3.7.2 Findings

We used this particular dairy management information system in this case study as an example of an agricultural information system. The basic premise of a dairy management information system is that adoption of the system by dairy managers can be regarded as the driving strength for operational efficiencies, improved milk production and better return on investment. We illustrate that a dairy management information system can be adopted for individual adopter characteristics, and environmental, technological and organizational factors. Our case study also illustrates factors that determine adoption of a technology can be adapted to the agriculture and dairy industry. The case study can be used to support the adoption of precision agriculture and precision livestock farming. The farmers interviewed were selected by the dealer or vendor based on the farmers knowledge of the system and influence within their community.

The key findings for this study suggest that education level, dealer support and other social influences such as friends, community, and normative pressures affected the early adoption of the system by small-size farms in Korea. We found that lack of information, limited knowledge of information technology, and uncertainty and risk associated with the lack of financial resources are some of the more noted barriers to adoption. Our case study found that education background (e.g., a 2 year professional or a college degree) is an important driving force for adoption. University and technical college background may be an important driving force for adoption. The farmers that represented the four farms in Korea were well educated. Current literature for small-size farms suggests that farm managers should be innovative and have information technology knowledge. Our analysis shows that the managers or other family members (i.e. wife/son) were knowledgeable and demonstrated ownership of the system. They felt that the system provided them with a relative advantage. The past stream of literature suggests that small-size farms have more barriers to adoption than large-size farms. Factors such as information sharing, information technology knowledge, and uncertainty and risk associated with the lack of financial resources are noted barriers for adoption that we encountered in this investigation. The adoption of this particular dairy management information system will transpire slowly when we consider the small size of dairy farms in Korea.

Farmers or other designated system users who were experienced with the system assert that the system provided them with an economic advantage. The farmers saved time and reduced manual labor. Farmers stated that trust in the system and the dealer or vendor was more important than economic factors. The general sentiment is that the technology itself is a better feature as opposed to the benefit for return on investment. However, the managers did articulate economic advantages for adopting the system. The system provided better feeding optimization as feeding costs increased. The feature used for heat detection has helped farmers find cows ready for impregnation, therefore improving product cost. The farmers saved money on insemination, feed and labor. However, cash flow appeared uncertain.

Dealer and farmer relations had a positive relationship for the four farms in this study. There would not be the awareness and adoption of this particular technology if it were not for the positive relationship and mutual trust developed between the dealer and farmer. In general, the farms investigated were early adopters of the system. Farm 3 was an early majority adopter and was socially influenced by the manager at farm 2. The farmers said that others in the community were looking closely at the system. These other farmers will evaluate at a later date if they would adopt the system. Therefore, normative beliefs from community contacts and social interaction are having a positive effect. A summary of key findings for all of the case study factors are shown in Table 3-8.

Table 3-8 Key Findings

Variables	Findings
Farm size	Korean dairy farms are small-size suggesting a low and slow adoption rate
Experience	Mostly 20 or more years in dairy industry
Age	Two generations; parent and adult children operate system
Education	University and technical college background; Driving force for adoption for Korea; Limited education for management in California also suggests slow adoption rate
Social Influences	Community members are looking at system; early adopters are role model; Could also be a barrier if unsuccessful with another technology (i.e. California)
Sponsorship	Uncertain if existing government-sponsored program for funding is still in service
Information Sharing	Uncertainties exist between the sharing of information (i.e. farmer to farmer; farmer to dealer and vice versa)
Dealer Trust	Positive relationship between dealer and manager; Mutual trust and respect carries awareness of technology
Advantage	As feeding costs increased, the Feed feature provided better feeding optimization; Heat detection support the managers to discover cows ready for impregnation
Knowledge	Demonstrated ownership of the system; Sharing and sourced varied
Compatibility	manually operated prior to adoption; First time users of technology
Planning	4 of 9 modules used: Farm, Act, Tag, Meter, and Feed; Mostly feeding operations; California: manual operations
Complexity	On-the-job training helps; Depends on user motivation; Need easier interface
Profitability	Save money on insemination, feed and labor; Diseased cows prevent grade A production; Low wage labor in California prevents adoption
Cash Flow/Loans	Undetermined
Uncertainty/Risk	Trust with the system is more important than return on investment

A non-adopting dairy farm in California was also investigated as a control. There were two issues that hindered adoption of an information system. Technology was not adopted on this farm because there is cheap farm labor in California. A nearby farm also had an impact. The neighboring farm did not succeed with the adoption of a similar dairy management information system. The cow identification tag and heat detecting system was problematic and became an issue with a nearby farmer.

3.8 Study Limitations and Future Research

The objective of this study is to understand and explain factors for the adoption of a dairy management information system in Korea. First, the internal validity of the research design may be a limiting factor to this study. Measuring farm manager perceptions may also be subjective. Open-end interviews have inherent biases that are unpredictable at the time of formulating and implementing the questionnaire. You really do not know the internal validity of the research design until the interview has been conducted in the field for some time and the results analyzed. For example, if the questions are positioned in a positive manner, the participant may be inclined to respond with an agreement to the question. Did the participant understand the question? Some negative questions/statements embedded in the interview would be an option to consider. The interview questions are in a random positive and negative order in this case study. Second, dairy managers may have given their perceived usefulness of an innovation rather than their actual reason to adopt the system. The discussions were also bi-directionally translated (English-Korean and Korean-English) by the dealer during the interview process. Therefore, information may have been translated incorrectly or lost in the translation process. Third, qualitative interviews have less control and allow the observer to make their own perceived judgments or biases about the content discussed. Fourth, the relatively small sample size (four farms) of selected managers used in the analysis may not represent the general population for this particular dairy management information system in Korea. Caution should be taken in interpreting the results. The expense, time consumption, and smaller sample size are some disadvantages of the interview method. Selected interviews may contain sample bias and not represent the true population (McMillan, 2004).

Streams of research in precision agriculture, precision livestock farming and precision dairy management are predominately focused on technical farming aspects. This exploratory case study described a dairy management information system in adoption and post-adoption terms and analyzes determinants in the context of adopter characteristics, and environmental, technological and organizational factors. However, the analysis described above is subjective and based on the researchers' view of the current state of affairs in the Korean dairy sector. Although we followed traditional case study methodology with an inter-rater of 90%, the discussion, conclusions and the system's applicability in Innovation Diffusion Theory research are based on subjective analysis. Future research should develop objective (quantitative) measures for the study of adoption-diffusion of a dairy management information system. Given the generally low use of dairy management information systems, future research should also investigate the environmental and policy drivers, and inhibitors for the adoption of such systems.

Although the dairy management information system in this study is implemented in various dairy farms around Korea, the relations between the level of use of the various system components, herd-size, farmer's education, social conditions, and the economic benefits of the system are unclear. Our analysis illustrates that adoption of the system can be determine by a combination of adopter characteristics, and environmental, technological and organizational factors. However, it is unclear what would be the idea mix in the Korean context. Future research should investigate these issues across cultures and an international context. In addition, further simplifying of the systems software may also increase the potential for extended use and improved use of the system. The education level appears to be at a reasonably high level considering that this is agriculture. Training and continued education of the system may be a limiting factor for full adoption of the system components. Future research could focus specifically on the effects of education and training on the adoption and extended use of the system.

Finally, the shortage and safety of dairy products are a major concern for both developed and developing countries. Encouraging the adoption of a dairy management information system that can monitor product yield and quality throughout the food supply chain may possibly alleviate safety and shortages of dairy products. Adoption encouragements may require national and international policies and agreements due to the increasing issues that involve food safety. Countries that trade dairy products may consider establishing test-beds, training and education facilities, and information centers that can help dairy farmers in the adoption process. Future research can examine the effectiveness of a dairy management information system on food safety and shortage.

3.8.1 Theoretical Contributions

Our findings would be valuable for academicians and practitioners considering that agricultural information systems and dairy management information systems are typically difficult systems to adopt. This study contributes to an understanding of the Korean dairy farmer’s adoption of information technology. A majority of research on the diffusion of innovation focus on the timing and degree of adoption or if an innovation is even adopted. This study investigates adopter characteristics and environmental, technological and organizational factors for the adoption of information technology. The results of this study should provide academicians with an example of an exploratory case study of an information system implemented by dairy managers in Korea. This study is the first exploratory, multi-method case study to look at post-adoption of a dairy management information system in Korea.

3.8.2 Practical Contributions

The results of this study should also provide practitioners with better insight of the dairy farmer perceptions for the adoption of a dairy management information system in the Korean context. This could lead to better insight of technology adoption for dairy farms in Korea. The study may further provide a better understanding of the relationship between dairy farmers and vendor support. These factors may contribute or hinder the adoption of this dairy management information system.

3.9 Conclusions

This is the first exploratory, multi-method case study to look at a dairy management information system in Korea. This exploratory case study examines adoption of the system (by early adopters) in the context of adopter characteristics and environmental, technological and organizational factors. Dairy farms in Korea have been slow to adopt information systems. Dairy farms in Korea are typically small-size operations. The percentage of dairy farmers in Korea that have adopted information systems is still relatively small. We propose that by analyzing these characteristics for adoption of a dairy management information system in Korea, farmers can without hesitation implement the system and improve their farm operations. The results of this study can provide better insight for why the adoption of dairy management information systems and agricultural information systems in Korea and elsewhere is lagging. We were able to support eleven of sixteen propositions. Two of the propositions were varied and three were unclear. Although, at least for very large farms, we can stipulate that a dairy management information system could be adopted without risk or uncertainty. However at present, we cannot assert that support for small-size dairy farms. The case study findings suggest that environmental conditions appear more relevant than individual characteristics of the farmer. There was general feeling that technology is a “good” thing rather than the return on investment (trust versus economics). Although farmers adopted the technology, they still prefer to “observe” conditions manually on the farm. A number of farm processes remained somewhat of an “art.” Farmers prefer to follow known routines. The study may further provide a better understanding of the relationship between dairy managers and vendor support. This relationship may contribute or hinder the adoption of this emerging technology. The findings of this case study closely follow and can be linked to the Technology-Organization-Environment Framework (Tornatsky and Fleisher, 1990). The results were a set of propositions and general framework, which lead to Chapter 4. In Chapter 4, we investigate factors that affect assimilation and post-adoption of dairy management information systems.

Chapter 4 provides a quantitative empirical study of a dairy management information system that extends the Technology-Organization-Environment Framework. We ultimately measure the level of process automation by dairy farms through assimilation of the system and extended use activities. Chapter 5 provides final conclusions that draw together the exploratory case study in Chapter 3 and the quantitative assimilation study in Chapter 4. An explanation for how they are related is provided and new integrate framework based on the results is developed. The final section includes the references and Appendices for Chapters 1-5. The Appendices consist of a list of abbreviations, description for the individual components and sub-components of the dairy management information system, interview and survey questionnaires for the two studies, and farmer comments. The final section is a summary written in Korean.

Chapter 4

Factors affecting Assimilation of a Dairy Management Information System: A Quantitative Study

There is no such thing as qualitative data. Everything is either 1 or 0.[15]

–Fred Kerlinger

4.1 Introduction

Information technology (IT) can have an effect on public interests. Presently, industries such as agriculture, education, and health and medical services rely more on IT. How does IT impact agriculture? How does IT impact dairy operations and business activities? Technology in agriculture facilitates precision agriculture (PA) (Wang et al., 2006). PA makes it possible to obtain effective data in real time (Zhang et al., 2002). Technology in livestock farming facilitates precision livestock farming (PLF). PLF is a relatively new discipline originating from the increased use of IT that supports livestock management and dairy management activities (Banhazi et al., 2007; Mertens et al., 2011). PLF was introduced to ensure that every process within a livestock activity is controlled and optimized within narrow limits (Banhazi and Black, 2009). The implementation of a dairy management information system (DMIS) in farms can be equated to the recent implementations of PLF systems. Dairy farmers are now able to apply information systems (IS) software to manage milk and dairy product information through technology that monitors specific ingredients such as fat and protein, and toxics such as blood.

[15] http://wilderdom.com/research/QualitativeVersusQuantitativeResearch.html [Last accessed 06/14/12]

4.1.2 Problem statement

Why is it important to study the use of information technology in agriculture and dairy management? The application of IT in agricultural production is minimal (Thomas and Callahan, 2002). Farmers did not take advantage of IT during the 1980s and 1990s (Schmidt et al., 1994). Farmers have shown a low rate of IT adoption (Morris et al., 1995). Similarly, studies in New Zealand indicate that dairy farms have not adopted or have been slow to adopt new technologies that would benefit their milk production (Crawford et al., 1989; Deane, 1993; Edwards and Parker, 1994; Stantiall and Parker, 1997). Many cattle operations were also slow to adopt and utilize IT (Blezinger, 2001). Encouraging farmers to accept change and transform the way they manage information has not been simple. However, reliable information is critical for business success and the efficient production and quality of agriculture and dairy products. Dairy farms should be ideally managed "like a business." It is our argument that dairy farmers lack the business knowledge and expertise to apply "business best practices." More accurately, farmers use intuition, experience and gut feeling to support their decisions in operational processes. This is also apparent by the preference to implement technical solutions over business solutions (i.e., farming technology versus decision-making systems). The size of the business can be a factor.

4.1.3 Small and Medium-sized Enterprises

In general, farms are operated by farming experts rather than business managers. Most farms are typically small and medium-sized enterprises (SMEs). For example, the United States dairy industry tends to have large herd-size farms with 1000-2000 cows per farm[16]. There was a 25.2% increase for this group from 2000-2006. In contrast, 28% of the dairy operations have less than 30 cows per farm. There was a 31% decrease for this group from 2000-2006. The changes in the size of dairy farms in the United States are shown in see Table 4-1. By definition, The United

[16] http://www.ers.usda.gov/publications/err47/err47b.pdf [Last accessed 06/27/2011]

States government considers farms with a herd-size of 200 or fewer cows per farm as small herd-size operations[17]. Although there has been some consolidation of small herd-size farms in recent years, the fact remains that most dairy farms in the United States (like other countries) are relatively small herd-size.

Table 4-1 Changes in the Size Structure of U.S. Dairy Farms, 2000-2006

Herd size	Farms (2000)	% Change		Farms (2006)	%	% Change
1-29	30,810	29.3		21,280	28.3	-31.0
30-49	22,110	21.0		14,145	18.8	-36.0
50-99	31,360	29.8		22,215	29.6	-29.2
100-199	12,865	12.2		9,780	13.0	-24.0
200-499	5,350	5.1		4,577	6.1	-14.4
500-999	1,700	1.6		1,700	2.3	+-0.0
1,000-1,999	695	0.7		870	1.1	+25.2
2,000+	280	0.3		573	0.8	+104.6
Total	105,170	100.0		75,140	100.0	-25.5

Adapted from MacDonald et al., 2007

Similarly in the United Kingdom, over 11,000 of the dairy farms are SMEs with an average herd-size of 113 cows per farm.[18] In Ireland, a majority of farms have an average herd-size of 50-60 cows per farm.[19] In Canada herd-size average is just over 60 cows per farm (Painter 2007). In Korea, nearly all dairy farms are family-operated and have a herd-size of less than a 100 cows per farm (Berger, Forthcoming). Opposite to most countries, farms in New Zealand have much larger herd-size farms averaging over 300 cows per farm (Painter 2007). In addition, a survey of thirty dairy farm equipment dealers from seventeen countries that service over 2000 dairy farms suggests that 69.5% of these farms have less than 200 cows per farm while only 2.8% are corporate farms with greater than 2000 cows per farm (Berger, Forthcoming). Therefore, our basic assumption is that most dairy

[17] http://www.epa.gov/npdes/pubs/sector_table.pdf [Last accessed 06/27/2011]

[18] http://www.wspa.org.uk/wspaswork/factoryfarming/UK_dairy_farming.aspx [Last accessed 06/27/2011]

[19] http://www.rte.ie/news/2011/0623/teagascdairyreport.pdf [Last accessed 06/27/2011]

farms are small herd-size and managed by farmers rather than business managers regardless of country (developed or otherwise).

4.1.4 Significance of the Study

Businesses do not use the full potential of IT applications and components (Jasperson et al., 2005). Users in general operate at low levels of feature use. Users rarely extend the use of available features that are offered by the technology (Davenport, 1998; Lyytinen and Hirschheim, 1987; Mabert et al., 2001; Osterland, 2000; Rigby et al., 2002; and Ross and Weill 2002). This study examines assimilation and extended use activities, and the level of process automation for a dairy management information system (DMIS) from a post-adoptive context. This is the first quantitative study to look at the assimilation of a dairy management information system from a three section framework. The significance of this study is to evaluate the assimilation factors of the system during extended use activities. Are the applications and components for this particular system used? What extent? What level of automation? The Technology-Organization-Environment (TOE) is an ideal framework for measuring assimilation and is adapted for this study. Factors such as organizational competence, perceived benefits and cooperative support have received minimal attention in prior information systems research. Cooperative support and social influences have received minimal attention in TOE Framework literature. This study extends the TOE Framework, and integrates assimilation and extended use activities.

4.1.5 Intent of the Study and Research Questions

This study blends concepts of the TOE Framework (Tornatzky and Fleischer, 1990; Cooper and Zmud, 1990; Thong and Yap, 1995; Prekumar and Ramamurthy, 1995; Chau and Tam, 1997; Thong, 1999; Kuan and Chau, 2001), assimilation of information technology (Iacovou et al., 1995; Fichman, 1997; Armstrong and Sambamurthy; 1997; and Fichman, 2001), and the extended use of information technology (Jaivingh, 1992; Mumtaz, 2000; Hogeveen and Ouweltjes, 2003; Jasperson et al., 2005; Berger and Hovav, forthcoming). Blending the TOE Framework and streams of literature for assimilation and extended use can provide an enriched analysis. The TOE Framework in this study consists of technological (system complexity and compatibility); organizational (competence and perceived benefits); and environmental (social influences, and cooperative support) factors. Assimilation and extended use for this study consists of three farm operation activities that typically occur on a dairy farm. The farm activities are daily operations, production planning, and herd health management. The assimilation and extended use of the DMIS further measures the system component interaction at the level of process automation stage.

The intent of this study is to investigate post-adoptive factors that are associated with influencing DMIS assimilation and extended use of daily operations, production planning and herd management activities. We investigate to what capacity the DMIS is used and routinized. We also determine the level of process automation based on the extended use and routinized activities. The TAM Model has been applied in many adoption studies. The TAM Model focuses on the ease of use and perceived ease of use. We theorize that environmental factors can have an impact in the post-adoption of IT. Environmental factors are not a function of the TAM Model. Therefore, we extend the TOE Framework to explain farmer's perceptions to what extent, or to what level of use they are employing the system. This is a "ground theory building" approach. We investigate the characteristics of the system as an emerging DMIS and we determine primary factors that have influenced organizations to assimilate the system. We also investigate why farms partially assimilate certain components of the DMIS. The "ground theory" approach is based on interviews and observations with the farmer (see case study, Chapter 3). The extension of TOE is ideal because it has been tested in the past. The extension of TOE may provide richer detail for post-adoption studies. Factors that are perceived by the farmer may lead to a better understanding of the TOE

Framework, assimilation and post-adoptive behavior.

How does the organization perceive assimilation and post-adoption with respect to farm operation activities? How does the organization perceive assimilation and post-adoption with respect to component use and the level of automation? From a theoretical approach, we answer the following research questions:

1. *To what extent does the assimilation and extended use of a dairy management information system drive the level of process automation in dairy farms?*

2. *To what extent does the relationship between technological, organizational, and environmental factors drive assimilation and extended use of dairy management information system activities in dairy farms?*

4.1.6 Limitations

Study limitations exist to the internal validity of a research design. Measuring system user's perceptions may be subjective. One solution to overcome the subjective nature is to use a Likert evaluation instrument to measure these factors. Limitations for using this type of instrument may have inherent bias and variables that are unpredictable at the time of formulating and implementing the survey. You really do not know the internal validity of the research design until the survey has been in the field for some time and the results analyzed. For example, if the survey positions every statement in a positive manner, the participant may be inclined to respond with all "strongly agree". Did the participant read the question? Some negative statements set in the survey as a test needs consideration. However, all of the survey questions are in a positive manner for this study. A second limitation inherent in the survey instrument is that system users, and people in general, have short attention spans and require a short survey. The survey was relatively long in this study. Data was collected for further research. Questions may have also been repetitive as well as questions that were not required. In addition, participants may not respond to demographic questions and various perception statements?

4.1.7 Delimitations

Study delimitations exist to the external validity or generalization of a study. The surveyed population for this study relies on volunteer participation that is selected non-randomly. This may have an inherent non-response bias. Convenience survey results may not represent the target or total population. This is not an inherent weakness or disclaimer for this study. Even though volunteer participants for this study are from the USA, Taiwan, South Africa, South Korea, Israel and Mexico, it would be impossible to design a study that would take into account equally all systems users in different places and times in which to generalize.

A second delimitation for the study is the process to administer the survey questionnaire. The dealer or vendor administered the survey questionnaire to the organization. The user may lack the appropriate time to complete the questionnaire. This may depend on the participant and dairy farm environment. The participant may hurry through the responses. Participants have the option to complete the survey by paper or an online link, which may limit the survey return rate. The dealer representative was given the authority to determine the most effective way to distribute the hardcopy survey. The internet may be sluggish for the online method. This could be discouraging to the participant. An older version of Microsoft Windows or Internet Explorer may also limit responses for the online participant.

A third delimitation is that the system user motivation to participate may also not reflect their actual intentions, but that of their personal image or how they are perceived from external sources. Is it their opinion or what they want others to think? Would you be willing to admit that you implemented the system because your neighbor has implemented the system? The dealer representative told you to implement? The government provided financial support?

Finally, the analysis of the system components is moderated by assimilation and extended use activities. This may be subjective. The question becomes how to evaluate the system components with validity and reliability given the subjective nature. However, the benefits to evaluate outweigh the above concerns even with the limitations to evaluate participant perceptions during post-adoption.

4.1.8 Assumptions

The literature review suggests that small-size firms have more barriers to adopt IT. Firm size and executive characteristics are the most significant factors for adopters and non-adopters of IT (Thong and Yap, 1995). Large-size firms are more likely to adopt IT, small-size firms are slow to adopt, and executives that are more innovative and have a positive attitude for adoption have greater IT knowledge. The assumption of this study is to assume in general that the farms in this study are SME's. The organizational user may also be an owner or manager of the farm.

4.1.9 Organization of the Study

The first section has provided a brief introduction and problem statement for the adoption and use of information technology in agriculture and the dairy industry. The role of precision agriculture and precision livestock farming, and herd-size of dairy farms are investigated. We also discuss the study significance and intent, and the study research questions, limitations, delimitations, and assumptions. The quantitative study proceeds as follows. The second section presents a stream of literature that investigates the TOE Framework, assimilation and extended use, and dairy management activities. The third section develops a framework for the research model and hypotheses. The fourth section details the research overview, standards and ethics of survey research, research questions, hypotheses, and methodology. This includes the survey population and sample, data collection instrument, and data analysis with a brief description of the information system used for this study. The fifth section details an analysis for user perceptions of the system under the TOE Framework, the level of process automation and extended use activities guided by the assimilation of the system. The sixth section discusses the research findings derived from the analysis in the fifth section. Academic and practitioner contributions are also discussed. We conclude our study with limitations and recommendations for future research.

4.2 Theoretical Background

The following section is the literature review for this study. The adoption-infusion process, assimilation process, studies on the Technology-Organization-Environment Framework, assimilation, and extended use of IT are investigated. Dairy management activities, dairy farm supply chain, and the milk production cycle are also discussed.

4.2.1 Adoption-Infusion Process

There are two ways to view the adoption-infusion process. These processes are information technology implementation and the assimilation process "Information technology implementation is defined as an organizational effort directed toward diffusing appropriate information technology within a user community" (Cooper and Zmud, 1990). A model of IT implementation activities are based on six stages. These stages are initiation, adoption, adaptation, acceptance, routinization, and infusion (Kwon and Zmud, 1987). Table 4-2 defines the five stages of IT implementation activities, and the associated implementation process and product level of use (Cooper and Zmud, 1990; Sullivan, 1985).

Table 4-2 Information Technology Implementation Model for an Organization

Stages	Process	Product
Initiation	Scan problems and opportunities; IT solutions start	Match of IT solution and application
Adoption	Organizational backing for implementing IT	Decision to invest resources to help effort
Adaptation	IT application developed, installed and maintained; procedures revised and developed; members trained in new procedures and IT application	IT application available for use
Acceptance	Members obligated to application use	Application is used in process
Routinization	Usage encouraged as normal activity	Governance system adjusted to account
Infusion	Increased effectiveness when using application to support higher aspects of organizational work	Application used to its fullest potential

Adapted from Cooper and Zmud, 1990; Sullivan, 1985

4.2.2 Assimilation Process

The assimilation process is a "three steps that occurs through a social system over a period of time. An individual or organization can accept or reject at anytime during or after the adoption stage of the process." Table 4-3 defines the three steps of the assimilation process (Zhu et al., 2006).

Table 4-3 Three-Steps of the Assimilation Process

Stages	Process
Initiation	Initial evaluation at pre-adoption stage
Adoption	Allocating resources and physically acquiring the technology
Routinization	Full-scale deployment

Adapted from Zhu et al., 2006

4.2.3 Technology-Organization-Environment Framework

Most technology adoption models focus on the technology and individual user. Organizational and environmental factors have mostly been neglected. A three factor framework characterized by the leadership within an organization, and organizational and environmental factors was developed (Kimberley and Evanisko, 1981). Seventy-five innovation studies identified ten frequently used factors for the adoption of technology (Tornatsky and Klein, 1982). Over time, the Technology-Organization-Environment (TOE) Framework was developed (Tornatzky and Fleischer, 1990). The three factors were categorized in the context of technological, organizational, and environmental constructs. Factors developed from these three concepts influence technology adoption by an organization. The technological context is the technology relevant to that organization. The organizational context is managerial and human aspects. The environmental context is industry-related, competition, economics and regulatory practices (Tornatzky and Fleischer, 1990). These were Tornatzky and Fleischer's initial intentions. Many adaptations have been derived from the TOE Framework. Several key studies that have adapted the TOE Framework are investigated below.

Five factors were investigated for technological and environmental components (task compatibility, technology, complexity, user and organization) of the TOE framework, and implementation stages (adoption, and infusion) that influence Material Requirements Planning (MRP) implementation (Cooper and Zmud, 1990). These factors affect the adoption, but not the infusion of MRP. Three factors (perceived benefits, organizational readiness, and external pressures) that influence EDI adoption practices for small businesses were investigated (Iacovou et al, 1995). The results indicate that awareness of EDI benefits was low at pre-adoption, readiness for adoption was weak, and the relationship between adoption and the influence of external forces is strong. Three external factors (technical capabilities, influences and strategic motivations) were identified in a second study that influences the adoption of advanced manufacturing technologies (AMT) (Lefebvre et al., 1996). The strongest factor that affected the level of adoption of AMT was technical skills. The weaker factors were customer influences and vendors, customer-focused and process improvement motivations. Seven factors (perceived benefits and barriers, perceived importance of compliance to standards, interoperability and interconnectivity (technological), complexity of the IT infrastructure, satisfaction with existing systems, formalization on system development and management (organizational) and market uncertainty (environmental) that influence open systems adoption were investigated (Chau and Tam, 1997). Adopting organizations focus more on ability rather than benefits, and have a more reactive than proactive attitude. The TOE Framework was expanded and included a CEO/management component as an additional primary factor to the technology (i.e. information systems), organization and environment framework (Thong, 1999). Managers are more likely to adopt if they have a high level of technology and IS knowledge, and perceive relative advantage, compatibility and complexity (ease of use) as positive. A competitive environment has no effect on adoption. The extent of adoption is mostly influenced by organizational factors such as business size and level of internal knowledge.

The role of government and external factors became a focus in the mid 2000s (Iacovou et al, 1995). Six factors (direct and indirect benefits, financial costs and technical competence, and industry and government pressure) that influence EDI adoption were investigated (Kuan and Chau, 2001). Indirect benefits are not perceived differently by adopters and non adopters. Lower financial costs and higher technical competence are perceived positive by adopters. And, higher government pressure and lower industry pressure are perceived negatively by adopters. External factors (competitive pressure, government intervention, and buyer and supplier influences) that influence adoption decisions of the internet were introduced (Scupola, 2003). Five factors (technology readiness, firm size, global scope, financial resources, competition intensity, and regulatory environment) that influence the value of e-business was investigated (Zhu et al, 2004). Technology readiness appeared the strongest factor and a negative relationship exists with firm size. This suggests that large firms inhibit value. External pressures drive adoption of e-business rather than internal organizational capital. Financial resources are important for developing countries as technological capabilities are for developed countries. Government regulation is an important factor for developing countries. The role of government in a financial support and policy role in the form of technology adoption tax breaks and, financing, and business regulations has also have been investigated (Chong et al., 2007; Scupola, 2003; OCED, 2000).

These studies are significant for the purpose of this study because they are in the context of the TOE Framework. They identify a number of factors affecting IT adoption and diffusion. These studies can be applied to the agriculture and dairy context. Table 4-4 is a summary of TOE Framework literature from a more recent to classic order that have had an academic impact on the adoption and diffusion of information technology.

Table 4-4 Technology-Organization-Environment Framework Literature

Subject	Technological	Organizational	Environmental	Reference
e-procurement adoption	Direct/indirect benefits and costs	Firm size; top management support; information sharing culture	Business partner influence	Teo et al., 2009
Internet-EDI Adoption	Relative advantage; complexity; compatibility	Strategic use of ICT; application knowledge; trust in technology; top management support; organization size; organization slack	Network externality	Huang et al., 2008
Member loyalty	Information quality; system quality	Member satisfaction	Trust; social usefulness; sense of belonging	Lin, 2008
IT initiation, adoption, implementation	Readiness; acceptance; institution-alization	Internalization-satisfaction, utilization; realized benefits; technology performance	Interpersonal and technology trust	Lippert & Davis, 2006
Deployment of B2B e-commerce; B2B firms versus non-B2B firms	Unresolved technical issues; lack of IT expertise; infrastructure;	Difficulties: change, project management, top management support, cost-	Unresolved legal issues; fear and uncertainty	Teo et al., 2006

	interoperability	benefit assessment, e-commerce strategy		
e-business initiation, adoption, routinization	Readiness; integration	Firm size; global scope; global trade; managerial obstacles	Competitive intensity; regulatory environment	Zhu et al., 2006
e-business usage	Competence	Firm size; global scope; financial commitment	Competitive pressure; regulatory support	Zhu & Kramer, 2005
e-commerce use	Technology resources; compatibility	Benefit; lack of organization; financial resources; firm size	External pressure; government promotion; legislation barriers	Gibbs & Kramer, 2004
e-business value	Technology readiness	Firm size; global scope; financial resources	Competition intensity; regulatory environment	Zhu et al., 2004
e-business intent to adopt	Competence; IT infrastructure; know-how	Firm scope; size	Consumer readiness; competitive pressure; trade partner readiness	Zhu et al., 2003
EDI adoption	Benefits	Financial cost; competence	Government pressure	Kuan & Chau, 2001
Likelihood and extent of adoption	CEO innovativeness, attitude and knowledge; IS relative advantage, compatibility, complexity	Business size; employee knowledge; information intensity	Competition	Thong, 1999
IT Innovation decision making; open systems adoption	Benefits; barriers and compliance to standards; interoperability; inter-connectivity	IT infrastructure complexity; satisfaction with existing system; formalization of development and management	Market uncertainty	Chau & Tam, 1997
EDI adoption, integration,	Benefits	Readiness	External pressure	Iacovou et al., 1995

impact				
EDI adoption, extent of adaptation, internal diffusion, external connectivity	IS infrastructure; compatibility	Internal need; top management support; champion	Dependence; exercised power; transaction climate; competitive pressure	Prekumar & Rama-murthy, 1995
Adoption of IT	CEO innovativeness; attitude towards adoption of IT; IT knowledge	Business size,; information intensity	Competitiveness of environment	Thong & Yap, 1995
EDI implementation-adoption and infusion	Task compatibility; technology complexity	User; organization		Cooper & Zmud, 1990

Adapted from Oliveira and Martins, 2011; Zhu et al., 2003

4.2.4 Assimilation

There are many definitions for assimilation. Assimilation was initially defined as the "extent to which the use of technology diffuses across organizational work processes and become routinized in the activities associated with these processes" (Chatterjee et al., 2002; Cooper and Zmud, 1990; Fichman and Kemerer. 1997; Tornatsky and Klein, 1982). There is a more current definition. "Assimilation commences as the IT innovation begins to be absorbed into the work life of the firm and to demonstrate its usefulness." "In time, the innovation may come to be infused and routinized (Swanson and Ramiller, 2004)." There are several seminal studies on assimilation that looked at adoption, assimilation and implementation.

A model of IT implementation activities are based on five stages. These implementation activities are initiation, adoption, adaptation, acceptance, routinization, and infusion (Kwon and Zmud, 1987). Managerial task can affect the adoption, but not infusion of MRP (Cooper and Zmud, 1990). Political and learning models may be more effective for investigating infusion of technology. Three factors that influence EDI adoption (organizational readiness, external pressures, and perceived benefits) for SMEs and expanding the level of diffusion of EDI within the organization were investigated (Iacovou et al, 1995). SMEs are typically resistant to adopt EDI. Efforts to provide financial and technical assistance to those with low readiness, influence strategies to reduce resistance, and improve the perception of EDI benefits should be provided. External and internal institutional forces on the assimilation of metrics programs in software organizations were investigated (Gopal et al., 2005). Customers and competitors (external) and managers (internal) directly influence organizational change to their work processes. This adaptation leads to an increase use of the metrics programs for decision-making. An assimilation study of enterprise systems (ERP) in the post-implementation stage within organizations showed that the participation of top management mediated a positive effect on institutional pressure, and ERP usage level (Liang et al., 2007). An added value within organizational knowledge study established that it was not enough to adopt and install IT-enabled knowledge platforms (Purvis et al., 2001). Blends of institutional, social and political factors influence the level of assimilation of information technology within organizational applications.

These mentioned studies are significant for the purpose of this study because they are in the context of IT assimilation. They identify a number of factors affecting IT diffusion. These studies can be applied to the agriculture and dairy context. Table 4-5 is a summary of literature from a more recent to classic order that has had an academic impact on the assimilation of information technology.

Table 4-5 Assimilation Studies Based on Innovation and Technological Diffusion Literature

Subject	Constructs	Reference
ERP Assimilation	Mimetic forces; coercive forces; normative forces; top management	Liang et al., 2007
Organizational participation	Product characteristics; demand uncertainty; market volatility; mimetic pressures; coercive pressures; normative pressures	Son & Benbasat, 2007
Assimilation of metrics programs in software organizations	Institutional forces; management commitment; metrics adaptation; metrics acceptance	Gopal et al., 2005
Customer service	Technical skills of IT labor; generic	Ray et al.,

performance	information technology; shared knowledge; flexibility of IT infrastructure	2005
Web assimilation- e-commerce strategies and activities	Top management championship; strategic investment rationale; extent of coordination	Chatterjee et al., 2002
Organizational innovation with software process innovations	Learning-related scale; diversity; organizational knowledge; IT size; education; specialization	Fichman, 2001
Assimilation stage and consequences	Managerial intervention, subjective norms, facilitating conditions; individual adoption process	Gallivan, 2001
Assimilation of CASE	Management championship; knowledge embeddedness; current methodology used; prior methodology used; methodology compatibility	Purvis et al. 2001
IT assimilation	Senior leadership knowledge; systems of knowing; strategic IT vision; IT infrastructure sophistication	Armstrong & Sambamurthy, 1997
Assimilation stage	Learning-related scale; related knowledge; diversity	Fichman & Kemerer, 1997
EDI adoption, integration, impact	Benefits; readiness; external pressure	Iacovou et al., 1995
EDI implementation-adoption and infusion	Compatibility- task and technology characteristics	Cooper & Zmud, 1990

4.2.5 Extended Use of Information Technology

There are additional psychological models that address the adoption and usage of technology. The Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975) is a popular psychological model. TRA proposes that attitude for a technology has a significant role in determining behavior for that technology. The Technology Acceptance Model (TAM) (Davis, 1989; Davis et al., 1989) is an adaptation of TRA. TAM is a causal model that proposes acceptance and usage of a technology. TAM connects two attitudinal beliefs. These beliefs are perceived usefulness (PU) and perceived ease of use (PEOU). PU contends that the use of technology will enhance job performance. PU is considered the underlying belief and the greater effect of adoption and use of technology (Brosnan, 1999; Davis, 1989; Davis et al., 1989; Taylor and Todd, 1995a). TAM was applied on a dairy farm study in New Zealand (Flett et al., 2004). The farmers PU of a technology is more important than the PEOU. Prior TAM studies also suggest that PU has a greater influence on adoption and usage behavior (Davis et al., 1989; Szajna, 1996).

Post-adoptive behaviors for extended IT applications either increase overtime by intensification and routinization, decrease overtime by resistance, or treated with a lack of interest (Hartwick and Barki, 1994; Hiltz and Turoff, 1981; Kay and Thomas, 1995; Thompson et al. 1991, 1994). Potential IT applications are underutilized by users. Users apply a minimal amount of applications, operate at a low use level, and rarely initiate extended system components (Jasperson et al., 2005). Organizations need to accumulate collective intrinsic knowledge, and realize post-adoptive behavior over time within their organization to fully utilize implemented IT. Level of use can be equated to computer use success.

Applications of computer use success have been conducted in the classroom. The relationship between teacher engagement, teaching practice, and instruction of computer use has been investigated (Becker and Riel, 2000). Teachers that regularly interact and perform activities outside the classroom have a different set of teaching skills than teachers with minimal outside contact. Their use of computer skills while involving students was not limited to computer competence. Cognitive skills that encouraged the communication and presentation of ideas were also indicated as a factor. The students were able to assimilate the use of computers in the classroom better than teachers who lacked the appropriate skills. The success of a project depended on hands-on demonstration with user-friendly hardware and software (Mumtaz, 2000). Personal ownership and exclusive use over an extended period was indicated to be important (Berger and Hovav, forthcoming). Finally, equipment portability and a variety of support from external sources are important (Berger and Hovav, forthcoming). Extended use applications have also been investigated on dairy farms.

The small amount of time with teat or udder preparation in high capacity milking systems negatively affects milk ejection. The variation in udder preparation, cluster attachment, and milk frequency in automated milking systems (AMS) may have a negative effect on milk ejection (Hogeveen and Ouweltjes, 2003). Sensors should be extended to detect these negative effects. Sensors should also be extended to detect abnormal milk and udder inflammation (mastitis) disease. IS in livestock farming do not support important steps in the decision-making process for farmers. Most models support reproduction and replacement for dairy cattle and swine (Jaivingh, 1992). Models that extend the calculation of technical and economic consequences of decision and management strategies should be implemented. Existing models can also be extended by their available knowledge, rather than modifying or combining existing models. Streams of literature for agriculture appear more ambiguous than other sectors in spite of the numerous evidence of extended use of technology in the dairy sector. Multidisciplinary research teams of scientists and engineers developing biosensors, bioelectronics and micro-electromechanical systems were envisioned (Krutz and Schueller, 2000). There is little evidence that engineers had significantly contributed to the welfare of "resource-poor" farmers (Bunch, 2000). However, dairy farming is a highly industrial environment. Engineers can have a high impact on operational strategies and farm process automation.

4.2.6 Dairy Management Activities

Operational strategies and process automation can vary by farm in the dairy sector. A model for the strategic planning of an automated milking system (AMS) by integrating milking, feeding and cow traffic functions was developed (Devir et al., 1997). The five strategic considerations are the technology components, grazing (with or without indoor forage rationing), herd size or milking frequency, facilities and labor. The strategic goal is to achieve an optimal balance between milking frequency and feed supplements (technology components), and milk production cow body reserves (animal components). The operational challenge is to maintain an optimal balance between the operation and technology components, and animal performance within their given environment. Integrating milking, feeding and cow traffic functions are key factors in dairy management. A farmers strategic planning with AMS depends on their own needs, type of facility and managerial priorities. The dairy can range from a basic level of replacing the milkers' to fully-automated milking, feeding and cow traffic activities with minimal farmer and labor involvement (Devir et al., 1997). Categories for operational management functions in the dairy sector are shown in Table 4-6 (Brand et al., 1996; Pietersma et al., 1998).

Table 4-6 Dairy Farm Management and Activities

Activity	Strategic	Tactical	Operational	Regulatory
Breeding	Development of long-term goals	Planning of calving pattern; selection of sires for herd	Selection of sire per cow; culling and buying animals	Measurement of cow activity
Health	Development of disease prevention strategies	Development of treatment procedures	Diagnosis and treatment of disease	Measurement of body temperature
Nutrition	Choice of feeding system	Seasonal ration formulation based on available feeds	Ration formulation per cow; purchase of feed	Allocation and transportation of feed to cow
Environment	Choice of ventilation or manure system	Choice of bedding material	Adjustment of climate set-points	Climate control
Milk Production	Development of long-term goals	Development of milking procedures	Identification of cows with abnormal milk	Milking cluster detachment
Labor	Hiring permanent	Hiring seasonal	scheduling	timing of tasks
Fixed Assets	Investment in housing and equipment	development of maintenance schedules	Maintenance of fixed assets	Control of vacuum level in milking system
Finance	Long-term planning	Acquisition, investment, repayment funds	Cash flow management bookkeeping	Automatic payment

Adapted from Pietersma et al., 1998

Management can be divided into strategic, tactical and farm operation activities. Daily operations (operational), production planning (tactical) and herd health management (operational & regulatory) is adapted for this study.

Operational management functions have also been studied in dairy management. A framework emphasizes management support and the performance of automatic tasks from an operational management perspective was developed (Ouweltjes and Koning, 2004). Operational management strategy for dairy management from a function and sub-function approach is shown in Table 4-7. The operational management functions are nutrition, healthcare, animal reproduction, milk production, fixed assets and labor, and cash management.

Table 4-7 Operational Management Functions

Functions	Sub-functions
Nutrition	Grassland utilization, ration composition, control of feed supply, grazing/feeding, body condition scoring assessment
Healthcare	Observation, examination, prevention, treatment
Reproduction	Observation, insemination, examination/treatment, calving assistance
Milk production	Milking, storage, milk testing, assessment
Herd replacement	Sale, selection, purchase
Fixed assets/labor	Acquisition, maintenance, hiring
Cash management	Borrowing/investing, payments/receipts

Adapted from Ouweltjes and Koning, 2004

In addition, precision livestock farming (PLF) can monitor the change or trend in activity, rather than just the activity of the animal (see Chapters 2 & 3). This can help in the prediction of health disorders, disease incidence as well as comparing individual cow activity or yield for individual cows. Daily walking, cow activity and milk yields have been used as predictors of metabolic and digestive disorders (Edwards and Tozer, 2004). The management and control of biological processes is what differentiates IS used in PLF and typical business IS. For example, Enterprise Resource Planning (ERP) systems integrate internal and external information such as finance, accounting, manufacturing, sales and customer service throughout an organization. ERP automates these activities.[20] These differences show that PLF systems are unique for management and control of biological processes. Other industries have also adopted different levels of sophistication and automation in their production and distribution processes. For example, the automobile industry (Gorlach and Wessel, 2008) and the hardware and networking components of the hi-tech industry, (Marino and Dominguez, 1997) are highly automated. In contrast, the agriculture industry is well known to be technically inferior (Thomas and Callahan, 2002).

4.2.7 Dairy Farm Supply Chain

Figure 4-1 illustrates the overall supply-chain of milk production.

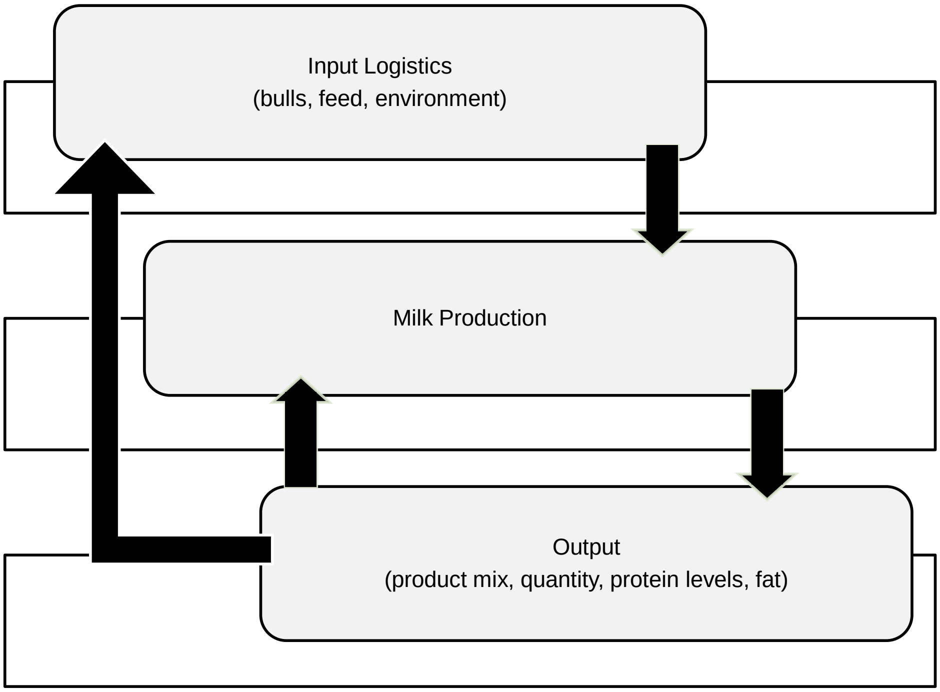

Figure 4-1 Dairy Farm Supply Chain
Adapted from Berger and Hovav, Forthcoming

[20] http://en.wikipedia.org/wiki/Enterprise_resource_planning [Last accessed 06/13/12]

The inputs for milk production such as the types of feed and the genetics of the bull used for insemination may vary. In addition, environmental conditions surrounding the cow such as the weather, temperature, spacing, and barn bedding can also influence milk production. Potential outputs and product mix are measured by yield and quality. Potential outputs may vary in fat, protein, somatic cell count, color, and calcium.

4.2.6 Milk Production Cycle

The cow production cycle traditionally begins with calving (Figure 4.2). However, from a business and manufacturing perspective, cow pregnancy is the key to an optimal milk production cycle. It is possible from a biological perspective that a cow would not get pregnant on the first try. This would result in delayed calving and lactation (i.e., loss of productivity). However, if the dairy farmer misses insemination during a heat period, twenty production days are lost until the next insemination window. Consequently, we suggest that insemination can be equated to inbound logistics. Much as having parts and material is a necessary but not sufficient condition to precision manufacturing, timely insemination is a necessary but not sufficient condition to optimal milk production. Therefore, we define “rest” as the time between the end of a lactation period and the next insemination window. Ideally, dairy farmers need to reduce wait time (time between the end of one lactation cycle and the beginning of the next one) and optimize the average of days in milk (DIM) of their overall herd (approximately 305 DIM), to maximize milk output (Ptak et al., 2004). The cow production life cycle is shown in Figure 4-2. Similar to other types of manufacturing, dairy farmers are concerned with product quality, supply, demand, product mix, operation efficiencies, and labor management.

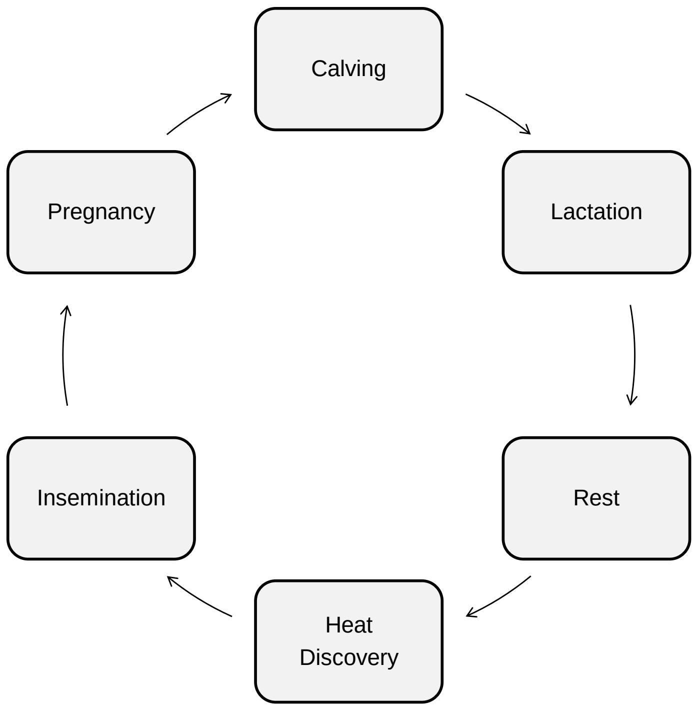

Figure 4-2 Milk Production Cycle
Adapted from Berger and Hovav, Forthcoming

4.3 Hypotheses and Model Development

The starting point for this research model is from a post-adoptive perspective. The study primarily follows the IT implementation model (Kwon and Zmud, 1987). The IT implementation model activities are based on six stages. These stages are initiation, adoption, adaptation, acceptance, routinization, and infusion. The fourth and fifth stages, acceptance and routinization, are the focus of this study. The TOE Framework begins at the acceptance stage after adoption. The assimilation and extended use activities, and the level of process automation are the routinization stage. The model investigates twenty-three hypotheses. The theoretical model (see

Figure 4-3) is based on the TOE Framework, assimilation and extended use activities, and the level of process automation. The assimilation and extended use of system components within farm operation activities is the focus of this study.

4.3.1 Theoretical Model

The theoretical model for this study has ten factors. System complexity, system compatibility, organization competence, perceived benefits, social influences, and cooperative support are measured at the acceptance stage (Cooper and Zmud, 1990; Sullivan, 1985). The system and the sum of its components are applied in the in the acceptance stage. The theoretical model for this study is shown in Figure 4-3.

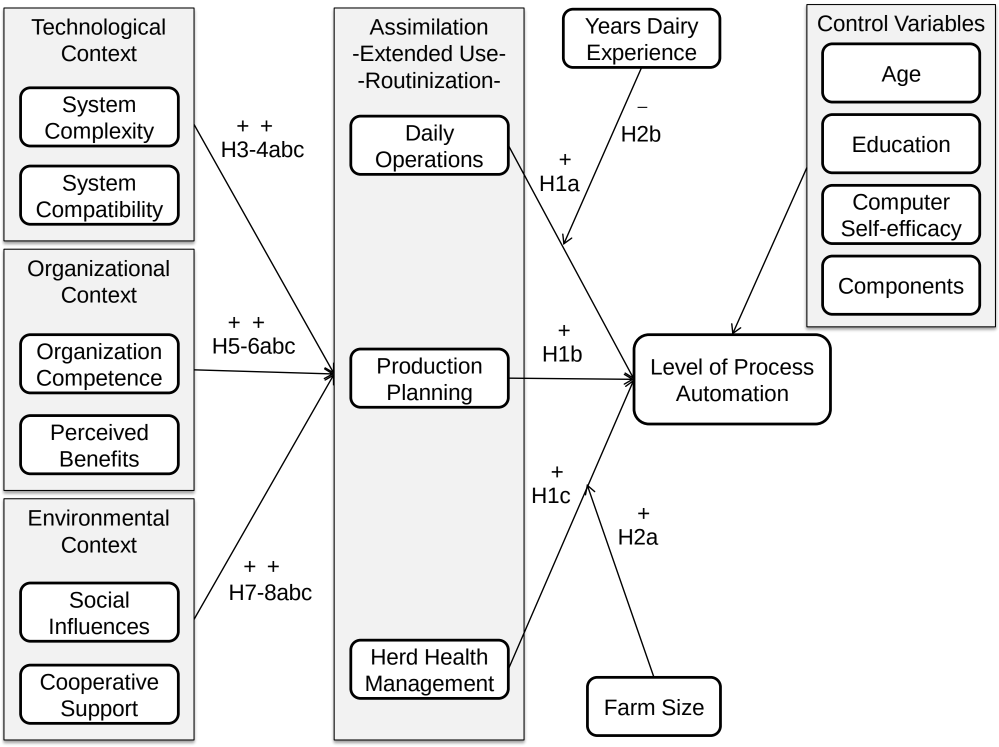

Figure 4-3 Theoretical Model

The theoretical model integrates TOE Framework constructs and three assimilation and extended use activities. Daily operations, production planning and herd health management are long and short term operations in the extended use and routinization stage. System components are applied to the activities in the routinized processes. The three activities are interrelated operational and management processes on the dairy farm. The assimilation stage is expanded to one further construct. This construct is called the level of processed automation and is also an extended use and routinized activity, however at a more advanced level. Components would need to be automated to its fullest potential to reach the infusion stage. The infusion stage is beyond the scope of this study.

Six independent variables (system complexity, system compatibility, organization competence, perceived benefits, social influences, and cooperative support) are applied to the TOE Framework (Tornatsky and Fleisher, 1990). The three dependent variables (daily operations, production planning and herd health management) are similar to farm operation activities. These activities have short and long term goals and strategies (Brand et al., 1996; Maltz, 2010; Ouweltjes and Koning, 2004; Pietersma et al., 1998). The three dependent variables (daily operations, production planning and herd health management) moderate when measuring for the more advance dependent variable (level of processed automation). The level of processed automation is just short of the infusion stage of full component adoption and automation (Kimm and Heyden, 2000; Ordolff, 1997; Rossing et al., 1997). Table 4-8 represents brief definitions for the model constructs. Definitions are based on the survey indicator variables.

Table 4-8 Model Construct Definitions

Variables	Definitions
Level of Process Automation	Degree of component level use and the component ability to replace manual labor for automated process applications
Daily Operations	Daily activities, identifying blood and contaminants, and feeding management
Production Planning	Productivity measurements such as measuring milk yield and

	flow rate, identifying cow health, detecting cows in heat, and identifying individual cows
Herd Health Management	Cow welfare measures such as tracking cow weight and directing cow traffic for veterinarian visits
System Complexity	Degree to which the system is perceived as easy/difficult to learn and use; satisfaction, skills needed and ability to integrate
System Compatibility	Degree to which the system is perceived as similar to a prior systems or system is similar to a past system
Organization Competence	Degree to which the organization can implement, adapt, comply and demonstrate the expertise to use the system
Perceived Benefits	Degree to which the system demonstrates quality and productivity improvements, change, saves time, family interest and replace labor
Social Influences	Degree to which others outside the organization affect future use and recommend the system; and how the system improves relationships and farm image
Cooperative Support	Degree to which technical and financial support is provided by the cooperative when implementing the system
Components	Degree of use for components and sub-components of the system
Farm Size	Total number of cows on a given facility; herd-size
Years Dairy Experience	Total number years of experience in the dairy sector
Education	Maximum level of education achieved in school
Computer Self-efficacy	Perception of level of computer knowledge
Age	Age of the system user, manager or owner

4.3.2 Level of Process Automation

Processed and automated packing activities are common in the food and manufacturing industries. Process automation is a strategy that automates processes to reduce costs by integrating various applications, restructuring labor and applying computer software.[21] The level of process automation for this study is referred to as the degree of component level use and the component ability to replace manual labor for automated process applications. Investigating the integration of process automation for a business is the intent of this study. A text book explanation views automation as “a form of production in which all manual intervention by the worker is eliminated, in some cases to be replaced by supervision, monitoring of

[21] http://en.wikipedia.org/wiki/Business_process_automation [Last accessed 06/13/12]

control by machinery … which concerns the operation of tools and machinery through sources independent of the workers manual dexterity" (Thompson, 1989). The level of process automation can vary by farm. A model for the strategic planning of an automated milking system (AMS) integrates milking, feeding and cow traffic functions (Devir et al., 1997). The dairy can range from a basic level of replacing the milkers' to fully-automated milking, feeding and cow traffic activities with minimal farmer and labor involvement. An objective of PLF is to monitor animals continuously throughout their life with online technology. PLF uses electronic information and applies it to control and optimize automatic processes that support biological production processes. The processes are feeding strategies, growth rate control, activity control (Morag et al., 2001; Halachmi et al., 2002; Aerts et al., 2003a, b), and body weight scales, milk composition analysis, behavior, digestion, and heart rate (Maltz, 2010). Therefore, an increased use of system components should increase the level of process automation while reducing the presence of manual labor.

Business process management (BPM) is defined as "using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents and other sources of information" (Van der Aalst et al., 2003). Management strategies can vary by dairy farm. A model for the strategic planning of an automated milking system (AMS) integrates milking, feeding and cow traffic functions (Devir et al., 1997). The five strategic management considerations are the technology components, grazing, herd size or milking frequency, facilities and labor. The strategic goal is to achieve an optimal balance between milking frequency and feed supplements (technology), and milk production, and cow body reserves (animal components). The intent is to integrate milking, feeding and cow traffic functions. A farmers strategic planning with AMS depends on their own needs, type of facility and managerial priorities. In general, management is divided into strategic, tactical and operational management. Daily operations (operational), production planning (tactical) and herd health management (operational & regulatory) are considered for this study. Daily operations can be defined as daily activity measures such as identifying blood and contaminants, and feeding management. The assimilation of the system in daily operations should have a direct effect and positive relationship for the level of process automation. Therefore, we hypothesize the following.

> Hypothesis 1a (H1a): *The assimilation of the system in daily operations is positively associated with the level of process automation.*

Production planning for this study can be defined within productivity measurements such as measuring milk yield and flow rate, identifying cow health, detecting cows in heat, and identifying individual cows. The assimilation of the system in production planning is a strategic activity of management. Production planning should have a direct effect and positive relationship on the level of process automation. Therefore, we hypothesize the following:

> Hypothesis 1b (H1b): *The assimilation of the system in production planning is positively associated with the level of process automation.*

For this study, herd health management can be defined as cow welfare measures such as tracking cow weight and directing cow traffic for veterinarian visits. The assimilation of the system in herd health management is a strategic part of the management that focuses on consumer and animal health and well-being issues. These issues have social and business implications. Herd health management should have a direct effect and positive relationship on the level of process automation. Therefore, we hypothesize the following:

> Hypothesis 1c (H1c): *The assimilation of the system in herd health management is positively associated with the level of process automation.*

4.3.3 Moderator Effects

Farm Size Effect on Herd Health Management and Process Automation

Firm size and executive characteristics are the most significant factors for adopters and non-adopters of IT (Thong and Yap, 1995). Large firms are more likely to adopt IT, small firms are slow to adopt, and executives that are more innovative and have a positive attitude for adoption, have greater IT knowledge. Small firms are more likely to adopt IS with innovative executives that have a high level of IS knowledge, and understand IS advantage, compatibility and complexity (Thong, 1999). However, innovation characteristics of executives from small firms do not affect the extent of IT adoption. Firm size and employee IS knowledge have a better effect on the extent of IT adoption. The Theory of Planned Behavior (TPB) was applied to explain and predict small firm executive decisions to adopt IT (Harrison et al., 1997). Potential adoption barriers decrease as firm-size increase. Firm size and executive characteristics are the most significant factors for adopters and non-adopters of IT. Large firms are more likely to adopt and small firms are slow to adopt IT (Thong and Yap, 1995). Therefore, we hypothesize the following:

> Hypothesis 2a (H2a): *The association between the assimilation of the system in herd health management and the level of process automation is moderated by farm size.*

Years Dairy Experience Effect on Daily Operations and Process Automation

Social norms influence on behavior will decrease as users gain more experience (Triandis, 1971). Inexperienced IT users are more influenced by social norms than experienced IT users, and the ease of use can influence inexperienced users more than experienced users (Thompson et al., 1994). In a study on adoption beliefs, it is assumed that pre-adoption beliefs are formed on indirect experience (i.e. cognition) and post-adoption beliefs are based on past experiences (Karahanna et al., 1999).

Social norms alone induce initial adoption and post-adoption usage. Therefore, initial adoption and post-adoption usage are based on the attitude of the user. Social norms also influenced adoption without prior knowledge of the IT. However, when experienced users have knowledge of the IT, perceived usefulness and image influenced attitude. Therefore, we hypothesize the following:

Hypothesis 2b (H2b): *The association between the assimilation of the system in daily operations and the level of process automation is moderated by years of dairy experience.*

4.3.4 System Complexity

Complexity can be defined as "the degree to which an innovation is perceived as relatively difficult to understand and use" (Thompson et al, 1991). System complexity for this study refers to the degree to which the system is perceived as easy or difficult to learn and use, and the satisfaction and skills needed, and ability to integrate the system. This is an inverse relationship. A meta-analysis indicated that complexity consistently related to adoption and utilization decisions (Tornatzky and Klein, 1982). A significant outcome of an individual or organization's decision whether to accept or reject a new technology is based on innovation diffusion theory. This decision is based on five key perceptions, which complexity is included (Rogers, 1995).

Adoption and implementation decisions are a "snapshot" of complexity (Prescott and Conger, 1995). Complexity is directly related to the adoption decision (Grover, 1993). Conversely, system complexity inhibited adoption. Technology complexity and task-technology compatibility were positively associated with MRP adoption (Cooper and Zmud, 1990 Grover, 1993). A positive relationship for complexity, information technology infrastructure and the adoption of open systems was suggested (Chau and Tam, 1997). A strategy to acquire information systems relates to the complexity of the system was also found (Iivari and Ervasti, 1992). However, an innovative person may have a stronger intention to use technology at the same level of perceived complexity as a less innovative individual. The less innovative person needs to be socially influenced about the complexity of the technology (Agarwal and Prasad, 1998).

However, there are other studies that did not find an effect for complexity and technology adoption. No relationship for complexity was found for the adoption and use of database systems (Alexander et al., 1992). Another study did not find a relationship between complexity and the adoption and usage of technology (Karahana, 1999). Complexity was also not found to have an effect on Web and EDI adoption (Agarwal and Prasad, 1997; Prekumar et al., 1997). There was also no significance between the complexity of technology and information technology for three out of four studied technologies (Prekumar and Roberts, 1999). An organization may perceive the technology as simple if they have the IT expertise. Technology can set off change within an organization and there must be an understanding of the relationship between technology complexity and organization (DeSanctis and Poole, 1994). It is believe that “how to” knowledge increases as the complexity of the new technology increases (Prekumar and Roberts, 1999). A strong negative effect for complexity on adoption was found (Ramamurthy et al., 2008). New skill set and competency may be vital within a firm.

The effect of complexity and adoption on technology is multifaceted with positive and negative results. The dairy farm as an environment for adopting and assimilating technology is no exception. The agriculture and dairy sectors are slowly transitioning from traditional to precision type systems. Technological complexity is a challenge for an industry that has been neglected for so many years. This should negatively affect adoption and assimilation. Daily operations, production planning and herd health management activities have traditionally been manually performed on the dairy farm. Therefore, we hypothesize the following:

Hypothesis 3a (H3a): *System complexity is positively associated with the assimilation of the system in daily operations.*

Hypothesis 3b (H3b): *System complexity is positively associated with the assimilation of the system in production planning.*

Hypothesis 3c (H3c): *System complexity is positively associated with the assimilation of the system in herd health management.*

4.3.5 System Compatibility

System compatibility can be defined as "the degree to which an innovation is perceived as being consistent with the existing values, needs and past experiences of potential adopters" (Moore and Benbasat, 1991). Compatibility can also include the similarities with existing practices of adopters (Tornatzky and Klein, 1982). Compatibility consistently related to adoption and utilization. System compatibility for this study refers to the degree to which the system is perceived as similar to a prior system or the system is similar to a past system. Perceptions of compatibility may lead the decision to adopt technology (Grover, 1993). Positive associations have been found that link compatibility and adoption behaviors (Ettlie and Vallenga, 1979; Ettlie et al., 1984). Compatibility differences exist between adopters and non-adopters in the testing of software (Russo and Kumar, 1992). However, the role of compatibility and the intention to adopt is not definitive (Agarwal and Prasad, 1998). Compatibility for a less innovative group was not statistically significant. Nevertheless, other studies have shown a positive association for compatibility and the intention to adopt technology. Compatibility of organizational task and technology is positively associated with material requirements planning (MRP) adoption (Cooper and Zmud, 1990). Compatibility was used to demonstrate a fit of individual work style and use of the system as a driver for technology acceptance (Venkatesh et al, 2003). Firms that had longtime use of information technology were able to provide integrated accounts for their customers (Zhu et al., 2004). Furthermore, integrating dissimilar systems and reducing incompatibility between existing IS applications were investigated (Zhu and Kraemer 2005). Researchers have supported the need to coincide business opportunity and technology in the context of strategic systems (Huff and Munroe, 1985; Vitale et al., 1985). The system should be innovative and flexible enough to fit into an existing technology or fit into the traditional methods that already exist on the dairy farm. Every dairy farm has a unique set of conditions and environment. Daily operations, production planning and herd health management activities have traditionally been manually performed on the dairy farm. Therefore, we hypothesize the following:

Hypothesis 4a (H4a): *System compatibility is positively associated with the assimilation of the system in daily operations.*

Hypothesis 4b (H4b): *System compatibility is positively associated with the assimilation of the system in production planning.*

Hypothesis 4c (H4c): *System compatibility is positively associated with the assimilation of the system in herd health management.*

4.3.6 Organization Competence

Competence is defined as "generic knowledge, motive, trait, social role, or skill of a person linked to superior performance on the job" (Haynes, 1979). Organization competence is also defined as the "user's potential to apply technology to its fullest possible extent so as to maximize the user's performance on specific job tasks" (Marcolin et al., 2000). This definition uses the "skill-based" approach between a user's ability and the task. A grouped definition of competence integrates skill, personality trait, and knowledge (Bassellier et al., 2001). Organization competence for this study refers to the degree to which the organization can implement, adapt, comply and demonstrate expertise to use the system. Organization competence is a complex construct, which can involve technical skills, experience, knowledge, awareness, and beliefs. The differences between information technology competence and technical skills are vague. Practice and experience builds competence through knowledge which is also indistinct. Experience added to knowledge and skills build competitive advantage for businesses (Stoner, 1987; Webster and Martocchio, 1992). Personal beliefs that are within an individual's value system can create attitudes towards the technology. Information technology competence may reflect the individual's beliefs about the technology (Nonaka, 1994). IT competence can include explicit and tacit knowledge that enables a manager to show leadership for that technology (Bassellier et al., 2001). That leadership can lead to proactive behavior. A leadership role for IT users involves education and training (Rockart, 1996). An individual with a high level of skills and knowledge will implement practices that assume leadership roles (Sambamurthy and Zmud, 1997) and add business value (Gorsline, 1996). The complexity of competence revolves around the business value of the technology. Competence is a reflection of business value and the awareness of integrating business strategic planning and IT strategic planning (Sambamurthy and Zmud, 1994). Daily operations, production planning and herd health management are strategic activities that are highly integrated and overlapped. Therefore, we hypothesize the following:

Hypothesis 5a (H5a): *Organization competence is positively associated with the assimilation of the system in daily operations.*

Hypothesis 5b (H5b): *Organization competence is positively associated with the assimilation of the system in production planning.*

Hypothesis 5c (H5c): *Organization competence is positively associated with the assimilation of the system in herd health management.*

4.3.7 Perceived Benefits

Perceived benefits for this study refers to the degree to which the system demonstrates quality and productivity improvements, change, saves time, family interest and replace manual labor. *Have PLF systems saved farmers time and investment? Have the benefits of cow identification, feeding optimization, and cow health analysis yielded positive benefits for the farm?* The benefits of adopting technology could be considered the most important measure for a business. *What is the positive and negative impact for adopting this system?* Knowledge and awareness of information technology is an important indicator. Executives at small businesses in Singapore were shown to be lacking knowledge and awareness (Gable and Raman, 1992). Other studies have also shown that the lack of knowledge and awareness of information technology and its benefits may inhibit a business to adopt (Attewell, 1992; Yap et al., 1994). Positive attitudes will offset the risk if an organization has a better understanding of the system benefits (Thong and Yap, 1995). The embeddedeness of Electronic Data Interchange (EDI) has been studied from the context of strategic payoffs (Chatfield and Yetton, 2000). Embeddedness is defined as the degree to which individuals or firms are enmeshed in a social network (Granovetter, 1985). Firms that have established social links, mutual exchange of information and joint problem solving are more likely to gain strategic benefits. Both supplier and customers derived value from EDI order processing (Mukhopadhyay and Kekre, 2002). The customer obtains benefits from efficient procurement transaction processes. The supplier receives strategic benefits when the customer initiates and the supplier enhances the system. When suppliers had advanced electronic linkages, supplier and customer benefit from the order-processing system. EDI benefits may vary depending on how technology choices by customers are made. Information technology may provide operational and strategic benefits (Subramani, 1999). The value of information technology is dependent on internal and external factors, and the firms' organizational resources and customer (Melville et al., 2004). Potential benefits of MRP are realized more by production-oriented managers. Nonproduction managers have difficulty realizing higher levels of use. This reduces motivation by production managers to pursue extended use in the risk of challenging nonproduction managers (Cooper and Zmud, 1990). The benefits for adopting IT may depend on other factors such as farm size and awareness level. Smaller family-run operations may perceive saving time on the farm as a benefits for the family. Larger farms may see a reduction in manual labor and overall costs for production as a benefit. Therefore, we hypothesize the following:

Hypothesis 6a (H6a): *Perceived benefits are positively associated with the assimilation of the system in daily operations.*

Hypothesis 6b (H6b): *Perceived benefits are positively associated with the assimilation of the system in production planning.*

Hypothesis 6c (H6c): *Perceived benefits are positively associated with the assimilation of the system in herd health management.*

4.3.8 Social Influences

Social network effects have been used to explain behavioral events such as influence and power (Brass, 1984). Social influences for this study refer to the degree to which others outside the organization affect future use and recommend use, and how the system improves relationships and farm image. Influence by leaders in a social network can have an effect on other potential adopters because individuals adapt their attitudes, behavior and beliefs to their social context (Salancik and Pfeffer, 1978). Potential adopters fear uncertainty. They are uncomfortable with unforeseen consequences for adopting technology. They interact with the leaders in their social network for advice on adopting technology (Burkhardt and Brass, 1990; Katz and Tushman, 1979; Katz, 1980).

Social influences have also been associated with subjective norms by defining superior and peer influences, and people's opinions in TRA studies (Taylor and Todd, 1995a, b). However, the social influence construct is absent in the Technology Acceptance Model (TAM) research (Gefen and Straub 1997; Venkatesh and Morris, 2000). Subjective norm, image and voluntariness was later included in TAM. It was argued that normative influences are affected by identification such as image and social influences (Karahanna et al., 1999). Image is defined as the "extent to which the use of an in innovation is perceived as enhancement of one's status in a social system" (Lu et al., 2005; Moore and Benbasat, 1991). TAM was later investigated to reflect subjective norms, image and voluntariness as part of social influences for a potential adopter to accept or reject technology (Venkatesh and Davis, 2000). The daily operations, production planning and herd health management activities on the farm represent an image to neighboring dairy farms and other external influences. Therefore, we hypothesize the following:

Hypothesis 7a (H7a): *Social influences are positively associated with the assimilation of the system in daily operations.*

Hypothesis 7b (H7b): *Social influences are positively associated with the assimilation of the system in production planning.*

Hypothesis 7c (H7c): *Social influences are positively associated with the assimilation of the system in herd health management.*

4.3.9 Cooperative Support

A cooperative is a business that is organized and directly controlled by the people that it serves. Cooperatives have a unique culture based on shared social equality and equity (Locke and Schweiger, 1979). Cooperative support in this study refers to the degree to which technical and financial support is provided by the cooperative when implementing the system. Cooperatives can play an important role in the success of the farmer. IT adoption by farms within a cooperative may be different from non-cooperative farms. The adoption of new IT may be encouraged. However, democratic decision-making within the cooperative may slow down adoption because of the higher commitment within the cooperative (Bruqe et al., 2003). Evidence of IT adoption by cooperatives is lacking (Ogbonna and Harris, 2005). Yet, technology changes that modify member farms within a cooperative can be balanced by training that involves all farmers. Leaders within the cooperative may lead technology change as an example for other members. The cooperative can prevent unfavorable behavior from other farmers that may feel vulnerable by a change in technology, or in this case, the implementation of IT (Bruque and Moyano, 2007). Strategic value can be shared off the farm and within a cooperative surrounding. Daily operations, production planning and herd health management are three activities that can be achieved through community support. Therefore, we hypothesize the following:

Hypothesis 8a (H8a): *Cooperative support is positively associated with the assimilation of the system in daily operations.*

Hypothesis 8b (H8b): *Cooperative support is positively associated with the assimilation of the system in production planning.*

Hypothesis 8c (H8c): *Cooperative support is positively associated with the assimilation of the system in herd health management.*

4.3.10 Control Variables

Control variables are included because of their influence on organizational intent to adopt, assimilate and extended the use of IT. Research studies that investigate predictors of IT adoption include education and success at farming (Alvarez and Nuthall, 2001; Daberkow and McBride, 2003), education, computer self-efficacy, full-time farming and farm size (Daberkow and McBride, 2003), and analytical nature and commitment to life-long learning by the farmer (Doye et al., 2000). These factors have been used in agriculture research. A study on economic and subjective factors affecting technology adoption found that larger farms and more educated dairy farmers are more likely to adopt technology if they perceive yield increase and minimized costs (Saha et al., 1994). This study seeks to assess the impact of post-adoptive perceptions and assimilation for a dairy management information system and its eventual effect on the level of process automation. Therefore, age, years of dairy experience, education and farm size and computer self-efficacy are included as control variables for their effect on the level of process automation.

Firm size and executive characteristics are the most significant factors for adopters and non-adopters of IT (Thong and Yap, 1995). Large firms are more likely to adopt IT. Small firms are slow to adopt IT. Executives that are more innovative and have a positive attitude for adoption have greater IT knowledge. Small firms are more likely to adopt IS with innovative executives that have a high level of IS knowledge, and understand IS advantage, compatibility and complexity (Thong, 1999). However, the innovative characteristics of executives from small firms do not have the same affect on the extent of IT adoption. Instead, firm size and employee IS knowledge are better predictors for the extent of IT adoption. Adoption of IT relies heavily on individual executive qualities (Al-Qirim, 2007). However, a study that applied the Theory of Planned Behavior (TPB) indicates that as firm-size increased potential adoption barriers decreased (Harrison et al., 1997).

Experience in this study refers to dairy industry experience. However, the dairy farmer is the IT user. Inexperienced IT users are more influenced by social norms than experienced users and the ease of use influenced inexperienced users more than experienced users (Thompson et al., 1994). In a study on adoption beliefs, it is assumed that pre-adoption beliefs are formed on indirect experience (i.e. cognition) and post-adoption beliefs are based on past experiences (Karahanna et al., 1999). Therefore, without prior knowledge of the IT, social norms influenced adoption. However, when experienced users have knowledge of the IT, perceived usefulness and image influenced attitude. Firms that already have more IT experience or IT in use (post-adoption) are more likely to adopt IT (Yap et al., 1992; Fink, 1998).

Human capital and information about the technology are significant factors for the adoption of technology (Wozinak, 1987). Education and information about the technology improve the probability for adoption and have a greater impact over costs and uncertainty. Farmer education development and information accumulation can increase the probability that a farmer will adopt new irrigation technology (Koundouri et al., 2006). Education can certainly facilitate the implementation of IT (Chun, 2003). Farmers with a high level of education tend to adopt technology earlier than farmers with less education (Chun, 2003; Nelson and Phelps, 1966).

Younger workers that use technology were more influenced by attitude towards that technology. Older workers were more subjected to the influences of other people in their social environment. Older workers are also concerned with their perceived performance and the difficulty to use the technology (Morris and Venkatesh, 2000). Age can negatively affect PA technology adoption (Daberkow and McBride, 2003). A relationship between age and computer anxiety indicates that older users have less computer knowledge and training (Raub, 1981).

4.3.11 Study Hypotheses

Twenty-three hypotheses have been developed for this quantitative study. The hypotheses for this study are shown in Table 4-9.

Table 4-9 Study Hypotheses

	Hypotheses
	Assimilation (Extended Use and routinization)
H1a	The assimilation of the system in daily operations is positively associated with the level of process automation.
H1b	The assimilation of the system in production planning is positively associated with the level of process automation.
H1c	The assimilation of the system in herd health management is positively associated with the level of process automation.
	Moderator Variables
H2a	The association between the assimilation of the system in herd health management and the level of process automation is moderated by farm size.
H2b	The association between the assimilation of the system in daily operations and the level of process automation is moderated by years of dairy experience.
	Technological Context
H3a	System complexity is positively associated with the assimilation of the system in daily operations.
H3b	System complexity is positively associated with the assimilation of the system in production planning.
H3c	System complexity is positively associated with the assimilation of the system in herd health management.
H4a	System compatibility is positively associated with the assimilation of the system in daily operations.
H4b	System compatibility is positively associated with the assimilation of the system in production planning.
H4c	System compatibility is positively associated with the assimilation of the system in herd health management.
	Organizational Context
H5a	Organization competence is positively associated with the assimilation of the system in daily operations.
H5b	Organization competence is positively associated with the assimilation of the system in production planning.
H5c	Organization competence is positively associated with the assimilation of the system in herd health management.
H6a	Perceived benefits are positively associated with the assimilation of the system in daily operations.
H6b	Perceived benefits are positively associated with the assimilation of the system in production planning.
H6c	Perceived benefits are positively associated with the assimilation of the system in herd health management.
	Environmental Context
H7a	Social influences are positively associated with the assimilation of the system in daily operations.
H7b	Social influences are positively associated with the assimilation of the system in production planning.
H7c	Social influences are positively associated with the assimilation of the system in

	herd health management.
H8a	Cooperative support is positively associated with the assimilation of the system in daily operations.
H8b	Cooperative support is positively associated with the assimilation of the system in production planning.
H8c	Cooperative support is positively associated with the assimilation of the system in herd health management.

4.4 Research Methodology

4.4.1 Ethics of Survey Research

Responsibilities to Participants

Farm managers are the livelihood of this survey research. Their confidentially is protected from disclosure to third parties. The study does not discuss the collected identifiable data by the participant, and disclose identifiable information of the participant. The responses will be anonymous and kept in the strictest confidentiality. Collected survey questionnaire data used by the researcher have legitimate internal research purposes.

Privacy and the Avoidance of Harassment

The privacy of the survey participant has protection from unnecessary and unwanted personal harassment. The survey questionnaire is voluntary and asks for the cooperation of the participant. The top of the survey questionnaire asks the participant to take approximately 20 minutes to complete the survey. This study values the participants’ feedback and relies on their insights, comments and suggestions regarding the survey questionnaire, the system and its appeal to dairy farmers. The researcher respects the right of participants that refuse the survey questionnaire or terminate a survey questionnaire in progress. The researcher is responsible to minimize any discomfort to the survey participant

4.4.2 Study and Survey Permission

The doctoral thesis is partial requirements of a PhD in Economics in the Information Program, Department of Agricultural Economics and Rural Development, College of Agriculture and Life Sciences at Seoul National University in Seoul, Korea. The developer of the system has granted the thesis author to survey farmers that use the system. The thesis researcher developed and designed the survey questionnaire. The survey questionnaire was reviewed by the developers' research and development department and implemented in October 2011. The exact wording of the survey questions is in Appendices D1-3. Surveys will continue to be collected throughout the 2011-12 school terms.

4.4.3 Research Method

The sampling method for this study is quantitative survey research. Four research questions investigate farmer perception for the assimilation and post-adoption of an emerging DMIS and its effect on farm operation activities. Twenty-three hypotheses address the issue of what motivates farmers to assimilate the system and their perceptions of extended use. The survey research design is an interest or attitude questionnaire using Likert items. The primary intention of the survey questionnaire is to collect quantitative data that investigates farmer perception of system use.

4.4.4 Validity of Research Questions and Survey

"The goal of basic research is to understand and explain, to provide broad generalizations about how phenomena are related" (McMillan, 2004). The study intent is to extend the knowledge base and address specific research questions of farmer perception of assimilation and post-adoptive behavior of an emerging DMIS. The research questions follow a quantitative research design, data collection instrument, and conclude with data analysis and interpretations. A set of conclusions based on the survey questionnaire findings are discussed.

4.4.5 Survey Population

The participants in the quantitative dairy farm study were farmers, managers, owners and technicians from the U.S.A., Taiwan, South Africa, Korea, Mexico and Israel. Participants were male and female systems users with an unknown and unidentified socio-economic status. The dairy farms that participated are post-adopters of the system. The dairy farms are located in the U.S.A., Taiwan, South Africa, Korea, Mexico and Israel.

4.4.6 Sampling Method

The survey population consists of volunteer manager participants that are already using this DMIS. The sampling method is a non-probability and non-random convenience survey that utilizes volunteer participants. Volunteer participants are different from non-volunteer participants (McMillan, 2004). Volunteer participants "tend to be better educated, higher socio-economically, more intelligent, more in need of social approval, more sociable, more unconventional, less authoritarian, and less conforming than non-volunteers" (McMillan, 2004). However, the main focus and intent of this study is on users of this DMIS, therefore, post-adoption.

4.4.7 Sample Validity

There are potential weaknesses for using volunteer participants. "When conducting a survey the investigator typically sends questionnaires to a sample of individuals and tabulates the responses of those who return them. Often the percentage of the sample returning the questionnaire will be 50 to 60% or even lower" (McMillan, 2004). The survey sample results may not represent the target population that has adopted this information system.

4.4.8 Representative Sample

There is an unknown number of farms (organizations) benefiting from the DMIS for the dairy farm study. The study received 188 observations from an unknown target population from November 21, 2011 through April 30, 2012. The return rate is uncertain. It is assumed that the sampled population represents volunteer participants that use this information system.

4.4.9 The Survey Instrument

The data collection instrument for this study is an attitude questionnaire that indicates a degree of preference measured on a 7-point Likert scale. The Likert scale response range is from ‘strongly disagree’ to ‘strongly agree.’ The exact value descriptions are ‘strongly disagree’-1, ‘disagree’-2, ‘slightly disagree’-3, ‘neither’-4, ‘slightly agree’-5, ‘agree’-6, and ‘strongly agree’-7. The survey questionnaire consists of three parts. Part one provides a way for the participant to describe their current use of the system. Is it a new system? Does the system replace or co-exist with another older system? Is the system not used? Part two provides the participant a set of questions that are divided by several constructs. The constructs are based on a comprehensive model that explores farmer perceptions in a technological, organizational, and environmental context. The factors are technological (complexity and compatibility), organizational (competence and benefits) and environmental (social influences and cooperative support). These factors are independent variables leading to assimilation and extended use activities of the system. The survey questions provide data to evaluate how farmers perceive what drives assimilation and extended use of the system. Part three provides the participant an opportunity to select individual components of the system that they are presently using. The components are ranked for the level of use and ability to replace labor. Part four provides the participant an opportunity to express and add any comments and insights they may have regarding the survey, the system and its appeal to dairy farmers. Part five asks the participant to provide demographic information such as gender, position, age, level of education, where they grew up, years in the dairy industry, level of computer knowledge, and the herd-size or number of cows on their farm.

Pilot Survey and Survey Questionnaire Implementation

Sixty dealers that represent this information system participated in a pilot survey questionnaire at a March 2011 conference in Israel. Thirty of sixty survey questionnaires (50%) were returned. The pilot survey questionnaire conducted prior to data collection suggested the need for minor revisions. The final version of the survey questions are shown in Appendices D1-3. The survey questionnaire is written in three languages. Appendix D-1 is the survey questionnaire in English. Appendix D-2 is the survey questionnaire in Taiwanese/Chinese. And, Appendix D-3 is the survey questionnaire in Korean. The system representative distributed the survey to the manager by hard (paper) copy. An online link through the Internet was also provided. In the case of the USA, South Africa, Mexico and Israel, the survey was completed with an online link that leads to *Qualtrics*.[22] The participant had the option to complete the survey at their convenience. *Qualtrics* software enables researchers to create and conduct a web-based survey. *Qualtrics* software builds the database with completed responses as they are submitted by the participant. The data can be exported to Microsoft Excel and then imported to Statistical Package for Social Sciences (SPSS). The survey was completed by hard copy in the case of Taiwan and Korea. The participant had the option to complete the survey and return it directly to the system representative, or complete the survey at their convenience and send the survey questionnaire by mail directly to the system representative. The system representative sent the completed surveys to the thesis researcher.

[22] http://www.qualtrics.com/ [last accessed 06/13/12]

4.4.10 Dairy Management Information System

The case study company was founded in 1970s. They are considered a pioneer in introducing electronics into the milking parlor. The first electronic milk meter was developed by an inventor and visionary as a new philosophy of dairy farming. The system is a set of hardware and software components and sub-components custom designed for dairy management. The dairy farm system consists of milk meters, individual cow identification, pedometers, milk analyzer, management and analysis software, and sorting, weighing and automatic individual feeding. The system works for a variety of dairy animals such as cows, goats and sheep. The software package contains six components and four sub- components (see Appendix C), which enable herd farmers to monitor milk production, yield and quality in real time. In addition, the system provides cow welfare support (e.g., quality of bedding, feeding, and weather stress), early disease detection, and cow quality management (e.g., individual cow productivity, cow life-cycle from birth to culling, heat management, and health management). The system also enables automated herd management. This is especially important for large dairy or grazing farms. The modularity of the software package enables dairy managers to adopt the system in phases. The DMIS components and functions are shown in Table 4-10. The system has been installed in over fifty countries since February 2010. User interfaces have been translated in twenty-one languages.

Table 4-10 Components and Functions of the Dairy Management Information System

Activity	Code	Function	Module
Daily Operations	DOP1	Identify presence of blood and contaminants in the milk	Lab
	DOP2	Daily activities on state of the herd	Farm
	DOP3	Feeding management	Weigh
Production Planning	PPN1	Measure milk yield and flow rate	Meter
	PPN2	Identify cow health	Tag
	PPN3	Detect cows in heat	Act
	PPN4	Accurately identify each cow	Ideal
Herd Health Management	HHM1	Track cows' weight	Weigh
	HHM2	Direct the flow of cow traffic	Sort

4.4.11 Operationalization and Validation

Each factor or latent variable was measured using a 7-point Likert scale. The scale range was from 'strongly disagree' to 'strongly agree.' Table 4-11 provides a listing of scale items.

Table 4-11 Latent (LV) and Manifest Variables (MV), Indicator Coding, and Concept

LV	Coding	MV	Concept	References
Level of Automation	PAU1	Level of use	Level of use for each component using	Berger & Hovav, forthcoming
	PAU2	Replace labor	Ability to replace manual labor for each component using	
Daily Operations	DOP1	Identify blood	Identify the presence of blood and Identify contaminants in milk	Berger & Hovav, forthcoming;
	DOP2	Daily Activities	Provide a list of daily activities	
	DOP3	Improved feeding	Improve feeding management	
Production Planning	PPN1	Measure	Measure milk yield and flow rate	Berger & Hovav, forthcoming;
	PPN2	Health	Identify cow health	
	PPN3	Detect heat	Detect cows in heat	
	PPN4	Identify cow	Accurately identify each cow	
Herd Health Management	HHM1	Track weight	Track cows' weight	Berger and Hovav, forthcoming;
	HHM2	Direct traffic	Direct the flow of cow traffic	
System Complexity	SCX1	Learn	System is easy to learn	Ramamurthy et al., 2008; Venkatesh, 2008; Gefen et al., 2003; Prekumar & Roberts, 1999 Karahanna et al, 1999; Agarwal & Prassad, 1998; Moore & Benbasat, 1991
	SCX2	Understand	System is easy to understand	
	SCX3	Satisfy	Satisfied with the system	
	SCX4	Skills	Skills I need to use the system are simple	
	SCX5	Integrate	Integrating the system into our work routine has been easy	
System Compatibility	SCP1	Current similarity	System is similar to technology I already use	Berger & Hovav, forthcoming; Grover, 1993
	SCP2	Past similarity	System is similar to technology that I used in the past	

Organization Competence	OCP1	Implement	Sufficient skills to implement the system	Baily & Pearson, 1983; Zhu et al., 2003
	OCP2	Skills/expertise	Sufficient skills and expertise to use the system	
	OCP3	Adapt	Sufficient skills to adapt the milking process to the system	
	OCP4	Comply	Use the system to comply with government mandates	
Perceived Benefit	PBN1	Quality	System significantly improved quality of milk on my farm	Berger & Hovav, forthcoming; Torkzadeh & Doll, 1999; Grover et al., 1998
	PBN2	Productivity	System significantly improved productivity on my farm	
	PBN3	Change	System radically changed the milking process on my farm	
	PBN4	Saves time	System saves me time	
	PBN5	Family interest	Family more interested in managing the farm	
	PBN6	Replace labor	System has replaced all manual activities on the farm	
Social Influence	SIN1	Future use	I know other farmers that will use the system in the future	Berger & Hovav, forthcoming; Kuan & Chau, 2001
	SIN2	Recommend	System was recommended to me by other farmers	
	SIN3	Relationship	System improves my relationship with other farmers	
	SIN4	Image	System improves the image of my farm	
Cooperative Support	CSP1	Technical	Cooperative provides technical support when farmer adopts	Berger & Hovav, forthcoming
	CSP2	Training	Cooperative provides training/education when farmer adopts	
	CSP3	Financial	Cooperative provides financial support when farmer adopts	

The survey questions are measures that are referenced from prior studies. The scale items were phrased to specifically relate to DMIS use and a dairy farm context.

4.4.12 Descriptive Analysis

Descriptive statistics provides information on the distribution and frequencies of participant attitude. A descriptive analysis for mean, standard deviation and frequency can measure the questionnaire statements. Table 4-12 is a descriptive analysis about the survey questionnaire participants. Demographic characteristics such as gender, age, position, education level, origin, and years of dairy experience, computer self-efficacy, farm size, and representative country are measured for frequency, valid percent and cumulative percent.

Male participants (96.8%) overwhelmingly dominate the study. Nearly half of the users are in the 30-39 age range (46.3%) and the 40-59 age ranges (45.7%) are similar. Slightly over one-half of the users are owners (53.2%), and managers (31.9%) are just less than one-third of the participants. Two-thirds of the participants have university level education (66.0%) while the other one-third are either high school (20.7%) or technical college trained (13.3%). A significant number of participants grew up on a farm (84.6%) as a child. Less than three-quarters of the participants have 10 or more years of dairy experience (70.7%). One-quarter of the participants have 2-10 years of dairy experience (26.1%). Less than two-thirds consider themselves to have moderate to slightly high computer self-efficacy (62.7) while less than one-third consider themselves to have a high level of computer self-efficacy (30.3%). Farm size (herd-size or cows per farm) has a wide distribution. Two-thirds of the farms have a herd-size of 100-999 cows per farm (66.5%). Just under one-tenth have a herd size of 50-99 cows per farm (8.6%). This is similar to the herd-size of 1000-1999 cows per farm (9.7%). Over one-third of the participants are from the USA (39.4%) and less than one-half of the participants are from Taiwan (19.1%), South Africa (16.0%), and South Korea (19.1%).

Status for the use of the system is also measured for frequency, valid percent and cumulative percent. Over one-half of the participants are using a system for the first time (54.1%). And, just less than one-half of the participants have either replaced an older system (24.4%) or are using both old and new systems (21.5%). Table 4-12 is a descriptive statistic summary for the demographic survey questions.

Table 4-12 Descriptive Statistics (N=188)

Item	**Frequency**	**Valid Percent**	**Cum. Percent**
Gender			
Male	182	96.8	96.8
Female	6	3.2	100.0
Age			
less than 20	0	0	0
20-29	10	5.3	5.3
30-39	87	46.3	51.6
40-49	32	17.0	68.6
50-59	54	28.7	97.3
more than 59	5	2.7	100.0
Position			
Owner	100	53.2	53.2
Manager	60	31.9	85.1
Technician	8	4.3	89.4
Other	20	10.6	100.0
Education			
High School	39	20.7	20.7
Associate Degree	0	0	20.7
Technical College	25	13.3	34.0
University	124	66.0	100.0
Origin (farm)			
Yes	159	84.6	84.6
No	29	15.4	100.0
Years Dairy Industry			
less than 2	8	4.3	4.3
2-5	19	10.1	14.4
5-10	30	16.0	30.3
10-20	55	29.3	59.6
more than 20	76	40.4	100.0
Computer Self-Efficacy			
Very low	0	0	0
Low	0	0	0
Slightly low	5	2.7	2.7
Moderate	42	22.3	25.0

Slightly high	76	40.4	65.4
High	57	30.3	95.7
Very high	8	4.3	100.0
Farm Size (Cows per Farm)			
1-29	9	4.9	4.9
30-49	9	4.9	9.7
50-99	16	8.6	18.4
100-199	51	27.6	45.9
200-499	28	15.1	61.1
500-999	44	23.8	84.9
1000-1999	18	9.7	94.6
2000 and above	10	5.4	100
unanswered	3	1.6	
Country			
USA	74	39.4	39.4
Taiwan	36	19.1	58.5
South Africa	30	16.0	74.5
South Korea	36	19.1	93.6
Mexico	9	4.8	98.4
Israel	3	1.6	100.0
System Use-Status			
Not using system	0	0	0
Using old and new	37	21.5	21.5
Replaced old system	42	24.4	45.9
First system to use	93	54.1	100.0
Unanswered	16	8.5	

Farmer Comments

The questionnaire asked the participant to comment on the survey questionnaire and the information system. The participant was offered an opportunity to express their feelings towards the end of the survey questionnaire. Written comments provide freedom for the participant to express themselves on issues that may have not been covered. Appendix E. shows a selection of comments, suggestions and insights regarding the survey, the system, and the system's appeal to dairy farmers.

4.5 Analysis and Results

4.5.1 Statistical Tools

The data for the survey questionnaire was initially entered into Excel Microsoft software. The final data inputs from the Excel spreadsheet were imported into Statistical Package for Social Sciences (SPSS 19.0) for descriptive statistics. SPSS 19.0 was also used to conduct an exploratory factorial analysis (EFA) for the reflective indicators. Partial Least Squares (PLS) software was selected to examine and measure the proposed research model and hypotheses. This study used Smart PLS 2.0 to analyze relationships between latent variables (constructs) and measure items or indicator variables for factorial validity within the structural model. The Excel spreadsheet was converted to a "csv" format for importing to Smart PLS 2.0 for Structural Equation Modeling (SEM). SEM is a combination of EFA and multiple regressions (Ullman, 2001). SEM is variance-based and provides a better understanding when there are multiple observed variables within the model.

Exploratory factor Analysis

Factorial validity was first assessed by EFA. EFA identifies latent variables and explains correlations for a set of measurement items. The main objective of EFA is to establish an appropriate number of factors from the measure items by data reduction. Measurement items that load high on one factor are also established. The factor and measured items will hopefully relate to the latent variable (Gefen and Straub, 2005; SPSS, 2003). A loading coefficient above 0.60 is considered high. A loading coefficient below 0.40 is considered not high (Gefen and Straub, 2005; Hair et al., 1998). The researcher determines the number of factors based on a default setting, 'scree' test or theory.

Principal Components Analysis (PCA) was used in this study. PCA is a commonly used method used in information systems management research. PCA reduces the number of variables that are interrelated while maintaining variation within a data set. However, the reduction produces a new set of uncorrelated variables to retain variation of the original variables. The uncorrelated variables are converted by rotation. The uncorrelated variables could have possibly been correlated variables. A varimax rotation was used in this study. A varimax rotation was used to show how a set of measurement items (indicators) measure the same latent variable. A varimax rotation changes the coordinates of PCA and maximizes the variance of the squared factorial loadings.[23] This makes it possible to represent each measurement item in a linear arrangement.

Reflective and Formative Indicators

PLS is appropriate for assessing theories in the early stages of development. PLS is more tolerant on sample size for validating a model in comparison to other SEM techniques (Chin et al., 2003). PLS is the appropriate software for testing the proposed study model and for the data that was collected because there are minimal restrictions on sample size and residual distributions. This study has multiple-item constructs. The study implemented PLS as opposed to the limitations of covarianced-based SEM such as AMOS, EQS, and LISREL (Michael and Andreas, 2004). The indicator variables are designated a weight which reflects how the indicator positions with the composite score of the latent variable. Reflective indicators are a single underlying concept as opposed to formative indicators that are multi-dimensional (Jarvis et al., 2003). Factors that measure "personality and attitude" are viewed as "underlying factors" driven by an observation. These measures are considered as reflective (Diamantopoulos and Siguaw, 2006; Fornell and Bookstein, 1982). Factors that measure "socio-economic status" are viewed as combinations of education, income and occupation. These measures are considered as formative (Diamantopoulos and Siguaw, 2006; Hauser, 1971, 1973). Formative indicators are used to explain abstract or unobserved variance at the latent variable

[23] http://en.wikipedia.org/wiki/Varimax_rotation [Last accessed on 06/20/12]

level. Reflective indicators are used to explain variance among items or indicators (Diamantopoulos and Winklhofer, 2001). The item measures used in this study were modeled as reflective indicators as a result of the provided examples on reflective and formative indicators.

4.5.2 Measurement Model

Reliability and Convergent Validity

The reflective indicators (measurement items) are assessed by convergent validity, discriminant validity and reliability testing through Smart PLS 2.0. Convergent validity is determined by the composite reliability for each construct and the average variance extracted (AVE). Outer factor loadings or measurement items are assessed. Convergent validity is determined when the measurement item correlates strongly with its construct. It is recommended that the outer factor loadings should exceed 0.70 (Gefen and Straub, 2005). The outer factor loadings are correlation coefficients between the survey indicators or items. Factor loadings provide the basis for labeling factors. The AVE for each construct should exceed 0.50 (Baggozi, 1991; Gefen and Straub, 2005). AVE measures the variance of the construct in relation to the random measurement error. AVE can vary from 0 to 1, and represents the total variance of the latent variable. Most factor loadings for this model were above 0.70. The second item of herd health management (direct the flow of cow traffic) and the fourth item of organization competence (use the system to comply with government mandates) were slightly below the required minimum of 0.70. The factor loadings were 0.692 and 0.647, respectively. Factor loadings for all other items have met the 0.70 minimum requirements. The AVE for each construct exceeding 0.50 is met for all items. Factor loadings and AVE meet convergent reliability measures and are shown in Table 4-13.

Composite Reliability and Cronbach's Alpha

Table 4-13 Reliability and Convergent Validity of the Measurement Model

Construct	Item	Factor Loading	Cronbachs Alpha	AVE	Composite Reliability
Level of Process Automation	PAU1	0.902	0.786	0.823	0.903
	PAU2	0.913			
Herd Health Management	HHM1	0.975	0.866	0.715	0.936
	HHM2	0.692			
Production Planning	PPN1	0.805	0.719	0.544	0.826
	PPN2	0.790			
	PPN3	0.693			
	PPN4	0.703			
Daily Operations	DOP1	0.699	0.653	0.585	0.807
	DOP2	0.837			
	DOP3	0.795			
System Complexity	SCX1	0.964	0.899	0.709	0.924
	SCX2	0.840			
	SCX3	0.756			
	SCX4	0.768			
	SCX5	0.866			
System Compatibility	SCP1	0.915	0.829	0.853	0.921
	SCP2	0.933			
Organizational Competence	OCP1	0.885	0.861	0.713	0.907
	OCP2	0.930			
	OCP3	0.887			
	OCP4	0.647			
Perceived Benefits	PBN1	0.686	0.753	0.516	0.845
	PBN2	0.864			
	PBN3	0.863			
	PBN4	0.695			
	PBN5	0.750			
	PBN6	0.778			
Social Influences	SIN1	0.763	0.754	0.574	0.843
	SIN2	0.796			
	SIN3	0.774			
	SIN4	0.695			
Cooperative Support	CSP1	0.937	0.944	0.900	0.964
	CSP2	0.963			
	CSP3	0.946			

Reliability is also assessed by using composite reliability and Cronbach's Alpha. Composite reliability is a measure of overall reliability and internal consistency of heterogeneous, however similar items. Composite reliability for all constructs is above the recommended 0.70 threshold (Fornell and Larcker, 1981). Cronbach's Alpha is a set of items that measures a single construct or latent variable. The coefficient value for Cronbach's Alpha ranges from 0 to 1. Cronbach's Alpha for all constructs is above the recommended 0.70 threshold (Nunnaly, 1978). Composite reliability and Cronbach's Alpha measures are shown in Table 4-13.

Discriminant Validity

Construct validity is composed of convergent validity and discriminant validity (Gefen and Straub, 2005; Straub et al., 2004). Factorial validity is also divided into convergent validity and discriminant validity (Gefen and Straub, 2005). Discriminant validity tests whether the indicator items that are assumed unrelated are actually unrelated. A scale is derived for how much the indicator items differentiate between constructs. Discriminant validity is determined when the measurement item correlates weakly with all constructs except for the construct that it is associated with (Gefen and Straub, 2005). Discriminant validity is assessed by determining the square root of the AVE for each construct (Fornell and Larcker, 1981). The AVE for each construct should exceed 0.50 and is greater than the correlations between that and all other constructs. The AVE for each construct is shown in Table 4-14. The results indicate that items load more highly on their own construct than other constructs. Values of 1.000 appear on the correlations associated with the control variable and moderating variables (AGE, CSE, EDU, MOD and YRD). The correlations in most cases are low as shown in Table 4-13. Discriminant validity is met for most cases. However, there are high values for three exceptions. The correlations for age and years of dairy experience; system complexity and organization competence; and herd and health management and herd health management with farm size as a moderator were high. The reliability and interconstruct correlations are 0.689, 0.615, and 0.679, respectively.

Table 4-14 Discriminant Validity: Reliability and Interconstruct Correlations for Reflective Indicators

	AGE	PAU	SCP	OCP	SCX	CSP	CSE	EDU	HHM
AGE	1.000								
PAU	0.058	0.907							
SCP	-0.063	-0.111	0.924						
OCP	0.028	0.270	0.137	0.884					
SCX	-0.352	0.309	0.051	0.615	0.842				
CSP	-0.205	0.242	0.475	0.108	0.248	0.949			
CSE	0.147	-0.175	-0.088	0.243	0.170	-0.398	1.000		
EDU	0.095	-0.215	-0.360	0.094	0.000	-0.383	0.410	1.000	
HHM	-0.010	0.106	0.043	0.507	0.503	0.206	-0.039	0.052	0.938
H*S	0.229	0.284	-0.233	0.639	0.378	0.025	-0.056	0.142	0.679
MOD	0.045	-0.043	-0.038	0.005	0.012	-0.037	-0.012	0.070	0.037
DOP	-0.056	0.013	-0.334	0.081	0.206	-0.163	-0.085	-0.184	0.393
D*Y	0.497	-0.201	-0.122	0.250	-0.078	-0.254	0.125	-0.098	0.216
PBN	-0.192	0.240	-0.156	0.160	0.222	0.042	-0.136	-0.335	0.130
PPN	0.160	-0.102	-0.027	0.399	0.124	-0.346	0.374	0.122	0.205
SIN	0.203	0.042	-0.009	0.218	-0.012	-0.164	-0.009	-0.235	0.208
FSC	0.300	0.269	-0.253	0.547	0.158	-0.064	-0.023	0.220	0.167
YRD	0.689	-0.066	-0.026	0.355	-0.197	-0.347	0.200	0.134	0.114

	H*S	MOD	DOP	D*Y	PBN	PPN	SIN	FSC	YRD
AGE									
PAU									
SCP									
OCP									
SCX									
CSP									
CSE									
EDU									
HHM									
H*S	0.938								
MOD	0.077	1.000							
DOP	0.335	0.019	0.765						
D*Y	0.381	0.040	0,482	0.835					
PBN	0.209	0.003	0.520	0.065	0.718				
PPN	0.288	0.035	0.239	0.417	0.358	0.738			
SIN	0.197	-0.012	0.587	0.377	0.605	0.437	0.758		
FSC	0.800	0.061	-0.010	0.302	0.092	0.208	-0.008	1.000	
YRD	0.366	0.049	-0.051	0.692	-0.193	0.396	0.184	0.434	1.000

AGE–Age, **PAU**–Process Automation, **SCP**–System Compatibility, **OCP**–Organizational Competence, **SCX**–System Complexity, **CSP**–Cooperative Support, **CSE**–Computer Self-efficacy, **HHM**–Herd Health Management, **H*S**–Herd Health Management * Farm Size, **MOD**–System Components, **DOP**–Daily Operations, **D*Y**–Daily Operations * Years Dairy Experience, **PBN**–Perceived Benefits, **PPN**–Production Planning, **SIN**–Social influences, **FSC**–Farm Size, **YRD**–Years Dairy Experience

Table 4-15 Item-to-Construct Cross Loadings

	SCX	SCP	OCP	PBN	SIN	CSP	DOP	PPN	HHM	PAU
SCX1	**0.964**	0.083	0.601	0.169	-0.040	0.273	0.182	0.158	0.550	0.293
SCX2	**0.840**	-0.171	0.383	0.414	0.027	0.196	0.376	0.185	0.459	0.220
SCX3	**0.756**	0.209	0.547	-0.003	-0.016	0.150	0.015	0.098	0.374	0.192
SCX4	**0.768**	0.135	0.574	0.060	-0.014	0.248	-0.007	-0.071	0.351	0.426
SCX5	**0.866**	0.095	0.580	0.151	-0.013	0.164	0.148	0.038	0.286	0.224
SCP1	0.056	**0.915**	0.120	-0.077	-0.032	0.512	-0.293	-0.050	-0.005	-0.099
SCP2	0.040	**0.933**	0.132	-0.205	0.013	0.374	-0.322	-0.002	0.0790	-0.106
OCP1	0.607	0.056	**0.885**	0.129	0.143	0.010	0.035	0.318	0.431	0.261
OCP2	0.510	0.047	**0.930**	0.152	0.248	-0.010	0.104	0.432	0.481	0.187
OCP3	0.633	0.194	**0.887**	0.198	0.202	0.194	0.047	0.339	0.467	0.262
OCP4	0.288	0.203	**0.647**	0.031	0.120	0.225	0.089	0.225	0.312	0.218
PBN1	0.182	-0.083	0.098	**0.686**	0.322	0.273	0.249	0.159	0.079	0.160
PBN2	0.226	-0.073	0.153	**0.864**	0.462	0.043	0.443	0.305	0.198	0.092
PBN3	0.221	-0.218	0.122	**0.863**	0.525	0.009	0.566	0.197	0.194	0.247
PBN4	0.200	0.003	0.235	**0.635**	0.423	-0.223	0.241	0.592	0.008	0.091
PBN5	-0.011	-0.221	0.083	**0.750**	0.603	-0.020	0.394	0.311	-0.004	0.233
PBN6	0.202	-0.138	0.010	**0.778**	0.372	0.274	0.425	-0.018	0.110	0.311
SIN1	0.128	0.200	0.317	0.480	**0.763**	-0.069	0.436	0.376	0.284	-0.067
SIN2	-0.054	-0.050	0.080	0.403	**0.796**	-0.272	0.530	0.367	0.091	-0.095
SIN3	-0.176	-0.028	0.034	0.487	**0.774**	-0.101	0.388	0.257	0.079	0.109
SIN4	0.031	-0.182	0.205	0.479	**0.695**	-0.031	0.404	0.302	0.159	0.236
CSP1	0.275	0.466	0.060	0.069	-0.103	**0.937**	-0.091	-0.310	0.171	0.253
CSP2	0.210	0.407	0.101	0.020	-0.220	**0.963**	-0.198	-0.377	0.177	0.182
CSP3	0.229	0.487	0.142	0.037	-0.130	**0.946**	-0.165	-0.290	0.239	0.263
DOP1	0.119	-0.039	-0.056	0.307	0.301	0.081	**0.649**	0.141	0.0837	-0.172
DOP2	0.271	0.210	0.123	0.504	0.473	0.076	**0.837**	0.170	0.335	0.133
DOP3	0.081	0.429	0.073	0.365	0.529	0.291	**0.795**	0.225	0.403	-0.004
PPN1	0.174	0.031	0.357	0.356	0.471	0.235	0.259	**0.805**	0.300	-0.108
PPN2	0.195	0.084	0.303	0.208	0.227	0.216	0.215	**0.790**	0.263	-0.101
PPN3	-0.098	0.039	0.215	0.142	0.276	-0.397	0.062	**0.643**	-0.189	-0.078
PPN4	0.113	0.015	0.294	0.338	0.269	0.142	0.165	**0.703**	0.257	-0.005
HHM1	0.549	0.110	0.559	0.066	0.175	0.243	0.317	0.147	**0.975**	0.130
HHM2	0.156	0.191	0.144	0.286	0.232	0.005	0.486	0.312	**0.692**	-0.012
PAU1	0.370	-0.164	0.339	0.202	-0.010	0.219	0.017	-0.050	0.090	**0.902**
PAU2	0.196	-0.041	0.156	0.233	0.084	0.221	0.006	-0.134	0.103	**0.913**

SCX–System Complexity, **SCP**–System Compatibility, **OCP**–Organizational Competence, **PBN**–Perceived Benefits, **SIN**–Social influences, **CSP**–Cooperative Support, **DOP**–Daily Operations, **PPN**–Production Planning, **HHM**–Herd Health Management, **PAU**–Process Automation

Confirmatory factor analysis (CFA) was also conducted to demonstrate further evidence of discriminant validity among item-to-construct loadings. CFA was performed through Smart PLS 2.0. A pattern of factor loadings for the measurement items of the latent constructs are produced by the theoretical model. Procedures to establish construct validity and reliability for the measurement of the model are recommended (Gefen and Straub, 2005). Convergent and discriminant validities are examined for the model fit. Factorial validity demonstrates whether the pattern of factor loadings for the measurement items is compatible with the theoretical model factors. Factor loadings and item-to-construct cross-loadings are shown after refinement of the model in Table 4-15. Each items correlation with its own construct is higher than correlations for other constructs. Items that did not load properly were removed from the analysis for this study. Item factor loadings ranged from 0.643 to 0.975.

4.5.3 Hypotheses Testing

The hypotheses for the structural model are determined by estimating the path coefficients and the R^2 values. Path coefficients are the links between the latent variables in SEM. The path coefficient indicates the strength of the relationship between the independent and dependent variables in a multivariate model. The R^2 values are a predictor or a measure for the outcome of the model. The predictive power of the structural model and the variance of the independent variables are explained by the R^2 values (Chin, 1998). A bootstrapping re-sampling procedure of 200 cases and 500 samples was applied by PLS to determine the significance of the paths within the structural model. Bootstrapping is a re-sampling procedure that uses Monte Carlo sampling for estimating the distribution of data for independent observations. Monte Carlo sampling randomly draws samples from the population. The structural model analysis and results are shown in Figure 4-4. PLS analysis settings are provided below the figure.

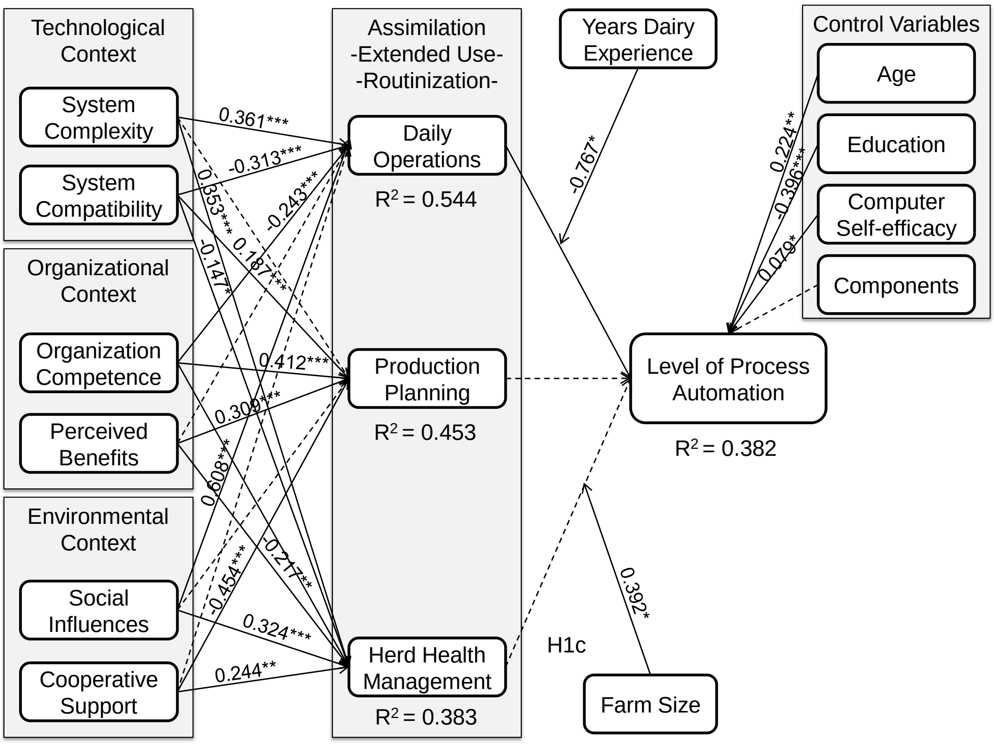

Figure 4-4 Results of PLS Structural Model Analysis

Paths in dashes are not significant (P>0.10) * p < 0.05, ** p < 0.01, *** p < 0.001
PLS Algorithm: Path Weighting Scheme: 500 Max Iterations, 1.0 Initial Weight
Bootstrapping: 200 cases, 500 samples

The R^2 Values

The structural model analysis and results are summarized in Table 4-16. The R^2 values are a predictor or a measure for the outcome of the model. The R^2 value for all constructs exceeds 0.10 or 10% as seen in Figure 4.4. A R^2 value above 10% implies an acceptable and significant model (Falk and Miller, 1992). Four measures, SCX, SCP, OCP, and SIN account for or predict 54.4 % of the variance in DOP. Four measures, SCP, OCP, PBN, and CSP account for or predict 45.3% of the variance in PPN. All six measures (SCX, SCP, OCP, PBN, SIN and CSP) account for or predict 38.3 % of the variance in HHM. The single measure of DOP and four control variables, AGE, EDU, CSE, and MOD, account for or predict 38.2% of the variance in the level of PAU. PPN and HHM were not significant measures for the level of PAU. PLS analysis settings and construct abbreviations are given below.

Table 4-16 Results of the Structural Model Analysis

H	Hypotheses Direction	Path Coefficient	t-statistic	p-value	Significance (one-tailed)	Support
H1a	DOP – PAU	0.267	1.507	0.0667	*p < 0.05	Yes
H1b	PPN – PAU	-0.060	1.074	0.1421	n/s	No
H1c	HHM – PAU	-0.108	0.570	0.2847	n/s	No
H2a	HHM * FSC – PAU	0.392	1.674	0.0479	* p < 0.05	Yes
H2b	DOP * YRD – PAU	-0.767	2.287	0.0117	*p < 0.05	Yes
H3a	SCX – DOP	0.361	4.591	<.0001	***p < 0.001	Yes
H3b	SCX – PPN	-0.093	1.038	0.1503	n/s	No
H3c	SCX – HHM	0.353	4.019	<.0001	***p < 0.001	Yes
H4a	SCP – DOP	-0.313	6.707	<.0001	***p < 0.001	No
H4b	SCP – PPN	0.187	3.519	0.0003	***p < 0.001	Yes
H4c	SCP – HHM	-0.147	1.684	0.0469	*p < 0.05	No
H5a	OCP – DOP	-0.243	3.259	0.0007	**p < 0.01	No
H5b	OCP – PPN	0.412	5.693	<.0001	***p < 0.001	Yes
H5c	OCP – HHM	0.250	2.531	0.0061	**p < 0.01	Yes
H6a	PBN – DOP	0.061	0.599	0.2749	n/s.	No
H6b	PBN – PPN	0.309	4.385	<.0001	***p < 0.001	Yes
H6c	PBN – HHM	-0.217	2.566	0.0055	**p < 0.01	No
H7a	SIN – DOP	0.608	5.778	<.0001	***p < 0.001	Yes
H7b	SIN – PPN	0.086	1.070	0.143	n/s	No
H7c	SIN – HHM	0.324	3.468	0.0003	***p < 0.001	Yes
H8a	CSP – DOP	0.019	0.245	0.4034	n/s	No
H8b	CSP – PPN	-0.454	6.716	<.0001	***p < 0.001	No
H8c	CSP – HHM	0.224	2.806	0.0028	**p < 0.01	Yes
	EDU	-0.396	7.516	<.0001	***p < 0.001	
	AGE	0.224	2.559	0.0056	** p < 0.01	
	CSE	0.079	2.097	0.0187	*p < 0.05	
	MOD	-0.042	0.702	0.2418	n/s	

AGE–Age, **PAU**–Process Automation, **SCP**–System Compatibility, **OCP**–Organizational Competence, **SCX** – System Complexity, **CSP**–Cooperative Support, **CSE**–Computer Self-efficacy, **HHM**–Herd Health Management, **MOD**–system components, **DOP**–Daily Operations, **PBN**–Perceived Benefits, **PPN**–Production Planning, **SIN**–Social influences, **FSC**–Farm Size, **YRD**–Years Dairy Experience

* $p < 0.05$ (one-tailed test); ** $p < 0.01$ (one-tailed test); *** $p < 0.001$ (one-tailed test)
PLS Algorithm: Path Weighting Scheme; 500 Max Iterations, 1.0 Initial Weight
Bootstrapping: 200 cases, 500 samples

Control Variables

EDU, CSE and AGE, were applied as control variables for PAU. EDU ($\beta = -0.396$, $p < 0.001$) was found significant. However, the relationship was negative. CSE ($\beta = 0.079$, $p < 0.05$) and AGE ($\beta = 0.224$, $p < 0.01$) were found significant with a positive effect. The path coefficients and significance for EDU, CSE and AGE indicate that these control variables can play a significant role in the level of PAU and should be considered in future adoption and assimilation research.

Level of Process Automation

Support for each hypothesis is determined by the positive or negative sign of the path coefficient, and the statistical significance for the t-statistic and calculated p-value for the respective path coefficient. The structural model path leading from assimilation and extended use (DOP, PPN and HHM) to the level of PAU is shown in Figure 4-4. The DOP to PAU ($\beta = 0.267$, $p < 0.05$) path is the only significant path. Therefore, H1a: *The assimilation of the system in daily operations is positively associated with the level of process automation* is supported. This single finding questions the role of assimilation and extended use of a DMIS as an antecedent of PAU. The results for the PPN and HHM to PAU paths were opposite to assumptions. The PPN to PAU interaction (H1b) and the HHM to PAU interaction (H1c) were not directionally consistent as DOP to PAU (H1a). The PPN to PAU and HHM to PAU paths were not significant. PPN and HHM both had a negative relationship to PAU. Therefore H1b: *The assimilation of the system in production planning is positively associated with the level of process automation* and H1c: *The assimilation of the system in herd health management is positively associated with the level of process automation* are not supported.

Moderator Variable (Farm Size)

The HHM to PAU interaction with FSC as a moderating variable ($\beta = 0.392$, $p < 0.05$) had a significant interaction. The relationship was positive. This may indicate that larger FSC can have a positive impact on HHM. Therefore, H2a: *The association between the assimilation of the system in herd health management and the level of process automation is moderated by farm size* is supported.

Moderator Variable (Years of Dairy Experience)

The DOP to PAU interaction with YRD as a moderating variable ($\beta = -0.767$, $p < 0.05$) was significant. However, the relationship was negative. This may indicate that the years of dairy experience may hinder the extended use of the system components for DOP activities. In other words, the farmer may want to operate under more traditional methods. It is the concept of art versus science. The more years of dairy experience is not the same as the number of years of information technology or computer experience. Therefore H2b: *The association between the assimilation of the system in daily operations and the level of process automation is moderated by years of dairy experience* is supported.

System Complexity

The interactions for SCX to DOP, PPN and HHM had varied results. The SCX to DOP interaction ($\beta = 0.361$, $p < 0.001$) and the SCX to HHM interaction ($\beta = 0.353$, $p < 0.001$) was significant. SCX to DOP and SCX to HHM were both positive. This may indicate that business operations that affect cow health and daily operation objectives such as identifying the presence of blood and contaminants, and feeding management are considered important activities to the farmer. Both DOP and HHM are involved with chemical, biological, and animal evaluations. Therefore, H3a: *System complexity is positively associated with the assimilation of the system in daily operations* and H3c: *System complexity is positively associated with the assimilation of the system in herd health management* are supported. The results for the SCX to PPN were opposite to assumptions. The SCX to PPN interaction ($\beta = -0.093$, p n/s) was not significant. However, the SCX to PPN had a negative relationship. This may indicate that farmers prefer to plan long term goals such as detecting cows in heat and identifying cow health in a more traditional method. Therefore, H3b: *System complexity is positively associated with the assimilation of the system in production planning* is not supported.

System Compatibility

The interactions for SCP to DOP, PPN and HHM showed the opposite results as the SCX to DOP, PPN and HHM interactions. The SCP to DOP interaction ($\beta = -0.313$, $p < 0.001$) and the SCP to HHM interaction ($\beta = -0.147$, $p < 0.05$) was significant. However, SCP to DOP interaction and the SCP to HHM interaction were both negative. This may indicate that the system is not as compatible to the methods that the farmer is more familiar with. The farmer may be more accustomed to traditional way of identifying blood contaminants, feeding management and tracking cow weight and directing the flow of cow traffic for veterinarian visits. An interesting statistic is that 54% of the respondents are using a DMIS for the first time. 46% are either replacing an older DMIS or using both old and new DMIS concurrently (see descriptive statistics, Table 4.12). This may indicate that there are other compatibility issues that can be considered for future research. Therefore, H4a: *System compatibility is positively associated with the assimilation of the system in daily operations* and H4c: *System compatibility is positively associated with the assimilation of the system in herd health management* are not supported. The results for the SCP to PPN were opposite to assumptions. The SCP to PPN interaction ($\beta = 0.187$, $p < 0.001$) was significant. The SCP to PPN had a positive relationship. This may indicate that using the DMIS for production functions such as measuring milk yield and flow rate, identifying cow health, detecting cows in heat and accurately identify each cow is trusted by the farmer. The risk and costs for failing to detect heat manually may be high. False insemination readings could be detrimental. Therefore, H4b: *System compatibility is positively associated with the assimilation of the system in production planning* is supported.

Organization Competence

The interactions for OCP to DOP, PPN and HHM also had varied results. The OCP to PPN interaction (β = 0.412, $p < 0.001$) and the OCP to HHM interaction (β = 0.250, $p < 0.01$) was significant. Both OCP to PPN and OCP to HHM had a positive relationship. This may indicate that the organizations that participated in this study feel competent using the system in identifying cows, measuring milk yields, detecting cows in heat, tracking cow weight, and sorting them out for veterinarian visits. Therefore, H5b: *Organization competence is positively associated with the assimilation of the system in production planning* and H5c: *Organization competence is positively associated with the assimilation of the system in herd health management* are supported. The results for the OCP to DOP were opposite to assumptions. The OCP to DOP interaction (β = -0.243, $p < 0.01$) was slightly significant. However, the relationship was slightly negative. This may indicate that identifying blood and contaminants, and feeding management are not routines dairy farmers feel so competent performing with the system. Therefore, H5a: *Organization competence is positively associated the assimilation of the system in daily operations* is not supported.

Perceived Benefits

The interactions for PBN to DOP, PPN and HHM also had varied results. The PBN to PPN interaction (β = 0.309, $p < 0.001$) was significant. The PBN to PPN relationship was positive. This may indicate that farmers perceive measuring milk yield and flow rate, identifying cow health, detecting cows in heat and accurately identifying each cow as having more beneficial value. Therefore, H6b: *Perceived benefits are positively associated with the assimilation of the system in production planning* is supported. However, the PBN to HHM interaction (β = -0.217, p <

0.01) was also significant. However, the relationship was negative. Detecting cows in heat and tracking cow weight and sorting them out for veterinarian visits are not as beneficial. Therefore, H6c: *Perceived benefits are positively associated with the assimilation of the system in herd health management* is not supported. The PBN to DOP interaction was opposite to assumptions. The PBN to DOP interaction (β = 0.061, *p* n/s) was not significant for this study. This may indicate that benefits for identify the presence of blood and contaminants in the milk, and feeding management have not been realized or achieved on the farm level. Therefore, H6a: *Perceived benefits are positively associated with the assimilation of the system in daily operations* is not supported

Social Influences

The interactions for SIN to DOP, PPN and HHM were the most consistent interactions. The SIN to DOP interaction ($\beta = 0.608$, $p < 0.001$) and the SIN to HHM interaction ($\beta = 0.324$, $p < 0.001$) were significant. Both SIN to DOP and SIN to HHM interactions was positive. This may indicate that social influences predominate more for short term daily operational objectives such as identifying the presence of blood and contaminants in the milk, and feeding management, track cows' weight, and directing the flow of cow traffic. Therefore, H7a: *Social influences are positively associated with the assimilation of the system in daily operations* and H7c: *Social influences are positively associated with the assimilation of the system in herd health management* are supported. The SIN to PPN interaction was opposite to assumptions. The SIN to PPN interaction (β = 0.086, *p* n/s) was not significant for this study. This may indicate that measuring milk yield and flow rates, identifying cow health, detecting cows in heat, and accurately identifying each cow are more farm specific and mostly influenced by those inside the organization. Therefore, H7b: *Social influences are positively associated with the assimilation of the system in production planning* is not supported.

Cooperative Support

The interactions for CSP to DOP, PPN and HHM also had varied results. The CSP to PPN interaction was opposite to assumptions. The CSP to PPN interaction (β = -0.454, $p < 0.001$) was significant, but negative. This may indicate that measuring milk yield and flow rate, identifying cow health, detecting cows in heat and accurately identifying each cow is not a technical and financial service that a cooperative would provide to farmers. Therefore, H8b: *Cooperative support is positively associated with the assimilation of the system in production planning* is not supported. However, the CSP to HHM interaction (β = 0.224, $p < 0.01$) was significant. The CSP to HHM interaction was positive. This may indicate that cooperative financial and technical support for tracking cows' weight, and directing the flow of cow traffic for health-related issues are functions supported by the cooperative. Therefore, H8c: *Cooperative support is positively associated with the assimilation of the system in herd health management* is supported. The CSP to DOP interaction was also opposite to assumptions. The CSP to DOP interaction (β = 0.019, *p* n/s) was not significant indicating that cooperatives do not get involved in technical training and financial support for identifying blood and contaminants, and feeding management. Therefore H8a: *Cooperative support is positively associated with the assimilation of the system in daily operations* is not supported

4.6 Discussion

The Technology-Organization-Environment Framework (Tornatzky and Fleischer, 1990) is extended and tested in the theoretical model as an initial starting part for this study. Research on post-adoptive approaches is illustrated by information technology implementation (Cooper and Zmud, 1990; Sullivan, 1985) and the assimilation process (Zhu et al., 2006). The theoretical model is extended to show the assimilation and extended use, and the level of process automation of a dairy management information system. The results indicate that there is a difference for factors that influence assimilation, extended use and the level of process automation of information technology by dairy farms. The path leading to assimilation and extended use was influenced by six factors. These factors are system complexity, system compatibility, organization competence, perceived benefits, social influences and cooperative support and follow the Technology-Organization-Environment Framework. Nine system components are also available for implementing into routinized and extended use activities. The system components are based on the farm environment, business strategy and organization ability. Dairy farms that have already adopted the dairy management information system have achieved benefits of the system based on three extended use activities. These activities are daily operations, production planning, and herd health management. Dairy farms will use some or all of the nine components of the dairy management information system according to internal and external or environmental pressures. The internal pressures may reflect the structure of the organization and the farm business strategy. External or environmental pressures such as social influences (farmer to farmer, farmer to dealer and vice versa), and cooperative support can also affect decisions for how dairy farms use information technology.

The proposed theoretical model effectively describes factors that influenced farmers to adopt the dairy management information system. The model also demonstrates how dairy farmers apply the use of system components in farm operation activities. However, there is unclear evidence to indicate why production planning, and herd health management activities were not significant interactions leading to the advanced assimilation stage represented in the level of process automation. Daily farm operation activities were the only significant path leading to the advanced assimilation stage in the level of process automation. The relative complexity of the theoretical model and subsequent hypotheses is a strength that could benefit researchers. Prior studies are more or less simplified and are primarily focused on adoption of information technology. The theoretical model for this study demonstrates that the assimilation and extended use of information technology in the level of process automation are important interactions that deserve recognition and further research. The theoretical model for this study is mostly supported by the data. The path analysis results from Figure 4.4 and Table 4.16 provide support for most of the hypotheses. The result for each hypothesis and associated pathway is summarized in Table 4-17. An abbreviation list for each construct is provided below the table.

Table 4-17 Hypotheses Results (R)

	Path	Hypotheses	Result
H1a	DOP – PAU	The assimilation of the system in daily operations is positively associated with the level of process automation.	yes
H1b	PPN – PAU	The assimilation of the system in production planning is positively associated with the level of process automation.	no
H1c	HHM – PAU	The assimilation of the system in herd health management is positively associated with the level of process automation.	no
H2a	HHM * FSC – PAU	The association between the assimilation of the system in herd health management and the level of process automation is moderated by farm size.	yes
H2b	DOP * YRD – PAU	The association between the assimilation of the system in daily operations and the level of process automation is moderated by years of dairy experience.	yes
H3a	SCX – DOP	System complexity is positively associated with the assimilation of the system in daily operations.	yes
H3b	SCX – PPN	System complexity is positively associated with the assimilation of the system in production planning.	no
H3c	SCX – HHM	System complexity is positively associated with the assimilation of the system in herd health management.	yes
H4a	SCP – DOP	System compatibility is positively associated with the assimilation of the system in daily operations.	no
H4b	SCP – PPN	System compatibility is positively associated with the assimilation of the system in production planning.	yes
H4c	SCP – HHM	System compatibility is positively associated with the assimilation of the system in herd health management.	no
H5a	OCP – DOP	Organization competence is positively associated with the assimilation of the system in daily operations.	no
H5b	OCP – PPN	Organization competence is positively associated with the assimilation of the system in production planning.	yes

H5c	OCP – HHM	Organization competence is positively associated with the assimilation of the system in herd health management.	yes
H6a	PBN – DOP	Perceived benefits are positively associated with the assimilation of the system in daily operations.	no
H6b	PBN – PPN	Perceived benefits are positively associated with the assimilation of the system in production planning.	yes
H6c	PBN – HHM	Perceived benefits are positively associated with the assimilation of the system in herd health management.	no
H7a	SIN – DOP	Social influences are positively associated with the assimilation of the system in daily operations.	yes
H7b	SIN – PPN	Social influences are positively associated with the assimilation of the system in production planning.	no
H7c	SIN – HHM	Social influences are positively associated with the assimilation of the system in herd health management.	yes
H8a	CSP – DOP	Cooperative support is positively associated with the assimilation of the system in daily operations.	no
H8b	CSP – PPN	Cooperative support is positively associated with the assimilation of the system in production planning.	no
H8c	CSP – HHM	Cooperative support is positively associated with the assimilation of the system in herd health management.	yes

PAU–Process Automation, **SCP**–System Compatibility, **OCP**–Organizational Competence, **SCX**–System Complexity, **CSP**–Cooperative Support, **HHM**–Herd Health Management, **DOP**–Daily Operations, **PBN**–Perceived Benefits, **PPN**–Production Planning, **SIN**–Social influences, **FSC**–Farm Size, **YRD**–Years Dairy Experience

4.6.1 Process Automation

Analysis of the research model indicates a clear, but complicated representation of information technology assimilation and extended use in the dairy sector. Farmers are using the dairy management information systems to automate daily operations. Daily operations are concerned with identifying the presence of blood and contaminants in the milk, and feeding management. Daily farm operation activities have an interesting finding and explanation. Daily farm operation activities (see Table 4.6) are the more important function represented in the center of the diagram for dairy farm activities (Pietersma et al., 1998). This study proposes that operational decision-making such as the purchase of feed and feed formulation, scheduling, and the identification of cows with abnormal milk are important and principal activities on the farm. This is a major finding that is backed by prior research. Farmers are not using the dairy management information system to automate production planning. It was assumed in our study that production planning activities such as measuring milk yield and flow rate, identifying cow health, detecting cows in heat, and accurately identifying each cow would be the primary objective and activity on a dairy farm.

4.6.2 Moderator Variables

Farm Size

Large herd-size farms rather than small herd-size farms are using the dairy management information system to automate herd health management. Analysis of the research model suggests that farm size is a key intervening variable that links herd health management and the level of process automation. These findings may have interesting and potential explanations. Adoption is slow or unlikely to occur for small-size operations according to the literature. Potential adoption barriers decreased as firm-size increased (Harrison et al., 1997). Firm size is the most significant factors for adopters and non-adopters of information technology (Thong and Yap, 1995). Large firms are more likely to adopt and small firms are slow to adopt information technology. Herd health management activities such as tracking cow weight and sorting-out unhealthy cows are a more advanced component of the dairy management information system. These activities appear beneficial for larger herd-size farms with a thousand or more cows. The significance of farm size is also another major finding that is confirmed by prior research.

Years of Dairy Experience

Years of dairy experience may be a barrier to automate daily operations. Dairy experience had a negative effect. This may suggest that more experienced farmers prefer traditional methods instead of trying something new. Analysis of the research model indicates that years of dairy experience is a key intervening variable that can hinder automation in daily operations. The level of industry experience can differentiate adopters from non adopters (Fichman, 1992). However, managers with information technology experience are more likely to adopt because they realize the benefits. They also have the knowledge to support adoption and assimilation of the system. However, years of information technology experience was not measured in this study. It can be assumed that the agriculture and dairy industry are more likely to have managers that are experienced in animal and plant sciences instead of information technology or computer sciences. This may suggest that managers with more years of dairy experience 'stick with what they know.' They are more inclined to traditional methods or the 'art versus science' of farming rather than venturing into something that they have little experience with in the past. Other examples can support this phenomenon. Reluctance to automate can be treated the same as the reluctance to adopt and use technology. Web-CoBRA was introduced to a small software company as a more accurate estimation process. A partial solution for cost estimations, poor usability of support tools, no technical support, and training and mode of use disconnect were cited as barriers for adoption (Keung et al., 2004). The main inhibitors for Internet adoption are the perceived lack of benefit, trust in the information technology industry, experience and knowledge of Internet technologies, internal expertise, expense to set up the technology and the lack of time (Van Akkeren and Cavaye, 1999). The value of information technology should be aligned with the organization from a business perspective. Human resource issues such as monetary compensation, training and career development of personnel, and the development of personnel who can adapt and configure information technology in their environment may be barriers for use (Segars and Hendrickson, 2000).

4.6.3 Daily Operations

Daily farm operation activities include identifying the presence of blood and contaminants in the milk, and feeding management and scheduling. These findings may have interesting and potential explanations. The ease of use of the system supports extended use and routinization of daily operations. The complexity (ease of use) and compatibility were the only factors affecting the adoption and implementation success of new technology (Karahanna et al., 1999; Tornatzky and Klein, 1982). Compatibility and complexity are important for continued use (Moore and Benbasat, 1996). Perceived benefits and competency did not facilitate the extended use and routinization of daily operations. The unexpected and non significance of perceived benefits in daily operations deserves attention because it may suggest that the traditional methods for performing daily farm operation activities, 'art versus science' concept or method may still exist. The dairy farm is a zero tolerance environment with no room for error. Social influences such as farmer to farmer, farmer to dealer and vice versa interactions also facilitate extended use and routinization of daily operations. The significance of the interaction of social influences and daily operations may suggest that farmers and other external influences share a common language and knowledge for these activities.

4.6.4 Production Planning

Production planning activities include measuring milk yield and flow rate, identifying cow health, and detecting cows in heat. These are activities that appear to be reliable and less risky for a dairy management information system application. The organization context appears to be the main factor driving the extended use and routinization of production planning. These findings may have interesting and potential explanations. Analysis of the research model indicates that the interactions of system compatibility was positively significant and supported for production planning. System compatibility and perceived benefits facilitate the routinization of production planning. Five perceptions are considered to influence the diffusion process. These perceptions are relative advantage, compatibility, complexity, trialability and observability of benefits (Rogers, 1995). Relative advantage and compatibility were the two more consistent factors determining adoption of Windows (Karahanna et al., 1999). Relative advantage and compatibility appeared to be distinct from each other in this study. However, the two may covariate and should be combined (Moore and Benbasat, 1991). Relative advantage is a significant factor for information technology adoption in small firms (Cragg and King, 1993). Organization competence also facilitates the extended use and routinization of production planning. Executives for small-size businesses are more likely to adopt technology when they are innovative, have a positive attitude for adoption and have greater information technology knowledge (Thong and Yap, 1995).

4.6.5 Herd Health Management

Herd health management activities include tracking the weight of the cow and sorting-out unhealthy cows for veterinarian visits. Herd health management had the most significant relationship with all variables that followed the Technology-Organization-Environment Framework. These findings may have interesting and potential explanations. Herd health management is an important function for animal well-being and consumer protection. System complexity facilitates the extended use and routinization of herd health management. This may suggest the system components are easy to use for herd health management activities. Organization competence also facilitates the extended use and routinization of herd health management. This may suggest that farmers have the knowledge to use the dairy management information system for herd health management activities. This may also suggest that the farmers feel socially responsible for cow health and well-being. Social influences also facilitate the extended use and routinization of herd health management. This may suggest that farmer to farmer, farmer to dealer and vice versa interactions have an influence on herd health management activities. In addition, cow health issues may be considered a norm or the right thing to do. Finally, cooperative support facilitates the extended use and routinization of herd health management. This may suggest that cooperatives can help and provide training and education for farmers to deal with regulations, policies and standards related to cow health. Herd health management activities may be influenced by regulatory pressures that require the tracking of cow activity, measuring body temperature, climate control for the animal, timing of the tasks, control of vacuum level of the milking system, and the transport and allocation of feed for the animal (Pietersma et al., 1998).

4.6.6 Control Variables

A number of adoption studies support that a higher level of education increases the likelihood of adoption (Daberkow and McBride, 2003; Wozinak, 1987; Cooper and Zmud, 1990). However, there are a number of studies that do not support the level of education as a determining factor for adoption (Bresnahan et al, 1999; Mawhinney and Lederer, 1990). Persons with lower levels of education typically use computers in the workplace in comparison to persons with more formal education. This supports the concept that computer self-efficacy and education can have opposing effects. The findings for this study suggest that education and computer self-efficacy had opposing effects. The findings also suggest that age and education together can play a major role for assimilating information technology in the dairy farm sector. Education has changed in the past twenty years. Younger users have developed advanced computer skills while in school as compared to older users (Morris and Venkatesh, 2000). The findings for this study also indicate that age and years of dairy experience are highly correlated. The correlation was 0.689. This may suggest that older users are reluctant to assimilate information technology on their dairy farm.

4.6.7 Implications

This study contributes to both theoretical research and practical applications in the assimilation and extended use of information systems. The study also contributes to the general concept of post-adoption of information technology in the agriculture and dairy sectors.

Implications for Research

First, the Technology-Organization-Environment Framework can be used to measure assimilation and extended use of information technology in precision dairy management. This is the first quantitative study to look at the assimilation of a dairy management information system from a three component framework. This research emphasizes the importance for the Technology-Organization-Environment Framework variables such as system complexity and compatibility, organization competence and benefits, and external sources such as social influence and cooperative support on farm operation activities. The overall model indicates that daily operations had the only direct interaction on the level of process automation. While daily operations had predictive power on the level of process automation, the extension of the Technology-Organization-Environment Framework by itself does not provide a complete understanding of assimilation for the three farm operation activities. Second, TAM and other adoption models correctly explain adoption from a technological context. However, social influences and cooperative support play a significant role in farmers' post-adoption behavior. This study provides evidence that environmental factors such as farmer to farmer and farmer to vendor relationships (social influences), and cooperative support can play a pivotal role as predictors in post-adoptive behavior and assimilation of information technology research. Third, daily farm operation activities (purchase of feed and feed formulation, scheduling, and the identification of cows with abnormal milk) are an important function for dairy farm activities. The research diagram suggested by Pietersma et al. (1998) supports the findings of this study. Daily farm operation activities (see Table 4.6) are the more important function represented in the center of the diagram. This study proposes that operational decision-making such as the purchase of feed and feed formulation, scheduling, and the identification of cows with abnormal milk are important and principal activities on the farm. Finally, additional factors external to the Technology-Organization-Environment Framework may likely provide future research insight for the assimilation of information technology within dairy farm activities.

Implications for Practice

First, the results of this study indicate that farmers are not fully automating routine dairy farm activities. The evidence from this study supports this implication. The level of system assimilation and extended use can be achieved by reducing the complexity of the system. Increasing the compatibility of the system to fit a particular dairy farm environment may also achieve assimilation and extended use. Second, education does not facilitate dairy management information system use to automate dairy farm activities. The education of the older farmers is more than likely emphasized in animal and biological sciences. While theoretically counter-intuitive, this finding may have potential value. The type of education may make it difficult for the dairy farm to increase the level of process automation. However, there is evidence that the younger generation is acquiring information technology and computer-related skills and knowledge (see case study, Chapter 3). Third, years of dairy experience does not facilitate dairy management information system use to automate daily operations. Most managers that have been in the dairy business for a long time prefer to follow known routines and manage the farm by traditional means. Although farmers adopted the technology, they still prefer to "observe" conditions manually on the farm. A number of farm processes remained somewhat of an "art." This appears theoretically counter-intuitive. However, the finding may also have potential value. This can also make it difficult for the dairy farm to increase the level of process automation. For example, the farmers may have a desire to use their own senses or feel over technology components such as sensors provided by radio frequency identification (RFID). The risk and uncertainty to change methods on the farm may have more impact for managers that have many years of industry experience. This topic can be considered for future research. Fourth, cooperative support and social influences facilitate dairy management information system use to automate herd health management. This is purely a matter of social responsibility. This has implications for animal health and well-being, and consumer protection. In an industry where milk standards vary by country, dairy farmers need to ensure that their product is free of contaminants, white blood cells, bacteria or drugs. According to USDA regulations, "a plant shall reject specific milk from a producer if the milk fails to meet the requirements for appearance and odor (§ 58.133(a)), if it is classified No. 4 for sediment content (§ 58.134), or if it tests positive for drug residue (§ 58.133(c))."[24] Finally, similar to other industries, product defects and spoilage is a major issue for dairy farmers (Jakobsen and Narvhus, 1996; Champagne et al., 1994). Dairy farms should allocate more efforts for animal and consumer protection. Training and education on product safety provided for the dairy farmer would be a very important benefit for animal and consumer protection.

4.7 Limitations and Future Research

This study has a number of limitations like most research. First, participants were farmers, managers, owners and technicians from several countries. These countries may not necessarily have anything culturally and regulatory in common with each other. Future research can address cultural, regulatory policies and government sponsorship and their impact on post-adoption behavior. Second, there were many social implications that were beyond the scope of this study. Dealer trust and relationship is an example. Future research can look at the affect of dealers' relationship with the dairy farmer. Future research can also look at the transfer of knowledge between farmer to farmer, farmer to dealer, and vice versa. Future

[24] http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3004788
[Last accessed 01/03/2010]

research can examine the social network of the farmer and its impact can be analyzed. Third, animal health and consumer protection is an important issue for developed and developing countries. Future research can examine the relationship between cow health concerns, consumer protection, government regulations and the use of dairy management information systems.

4.8 Conclusions

This study investigates the relationships between the Technology-Organization-Environment Framework and the assimilation and extended use of a dairy management information system. The assimilation and extended use are measured in farm operation activities and the level of process automation on a dairy farm. Results suggest that measures for daily operations have a significant effect on the level of process automation. This effect is negatively impacted by the years of dairy industry experience. There is also evidence that the farm size can facilitate dairy management system assimilation and extended use to automate herd health management. Social influences also facilitate the assimilation and extended use of the system in farm operation activities. These activities are daily operations, production planning and herd health management. The study introduces an information systems framework and demonstrates its applicability to extended farm activities from a theoretical perspective. The study also introduces a new component that involves biological/animal science mechanisms. This component is rarely seen in information technology adoption and assimilation research.

Chapter 4 provided a quantitative empirical study of a dairy management information system. The study adapts the Technology-Organization-Environment Framework by investigation of assimilation and extended use of the system through farm operation activities. The study also investigates the level of process automation on dairy farms. Chapter 5 provides final conclusions that draw together the exploratory case study (Chapter 3) and the quantitative assimilation study

(Chapter 4). An explanation for how they are related is provided and new integrate framework based on the two study results is developed. The final sections include the references and Appendices for Chapters 1-5. The Appendices consist of a list of abbreviations, interview questions for the case study (Chapter 3), description of the dairy management information system components, survey questionnaire for the quantitative study (Chapter 4), and selected farmer comments. The final section is a summary written in Korean.

Chapter 5

Conclusions

Please be good enough to put your conclusions and recommendations on one sheet of paper in the very beginning of your report, so I can even consider reading it.[25] –Winston Churchill

Chapter 1 provides an overview of the dissertation that includes a research background, problem statement, objectives and research questions. Small and Medium-sized Enterprises were discussed. The initial questions for the dissertation were simple. Why is it important to study the adoption and assimilation of information technology in agriculture and dairy management? Why has agriculture been slow to adopt and assimilate information technology? These simple questions lead to an investigation to a number of theoretical research questions:

1. *To what extent does the relationship of environmental, technological, and organizational factors drive/inhibit post-adoption of a dairy management information system in Korea?*

2. *To what extent does the assimilation of a dairy management information system in extended use activities drive the level of process automation on dairy farms?*

3. *To what extent does the relationship between technological, organizational, and environmental factors drive the assimilation of a dairy management information system in extended use activities on dairy farms?*

---

[25] http://thinkexist.com/quotes/with/keyword/conclusions/ [Last accessed 06/14/12]

Chapter 2 of the dissertation investigates literature for the adoption, potential functions and applications within precision agriculture, precision livestock farming, and automated systems in dairy management.

Chapter 3 is the first study and uses a qualitative case study approach to answer the first research question. Farmers in Korea have been slow to adopt information systems. Dairy farms in Korea are typically small-size operations. This is the first exploratory case study to look at a dairy management information system in Korea. Case studies should be linked to a theoretical framework (Tellis, 1997). The case study is linked to the technology-organization-environment Framework (Tornatsky and Fleisher, 1990). The case study examines adoption of the system by early adopters in the context of individual user characteristics and environmental, technological and organizational factors. Case studies may be used during the early stages of research or when little is known about a topic (Eisenhardt, 1989). We use this exploratory approach because little is known about adoption of an information system in the dairy sector. A set of propositions and an interview questionnaire were developed. Case studies derive propositions from the research question. The researcher has to make a speculation on the basis of the literature. In addition, other earlier evidence for what they expect the findings of the research to be should be inferred. The data collection and analysis can then be structured to support or refute the research propositions (Yin, 1994; Rowley, 2002). Four farms from Korea that are early adopters of a dairy management information system participated in the interviews. One non adopting farm from California was also interviewed as a control group. The result was a set of propositions and general framework. We were able to support eleven of sixteen propositions. Two of the propositions were varied and three were unclear. The case study findings suggest that environmental conditions appear more relevant than individual characteristics of the farmer. There was a general feeling that technology is a “good” thing rather than the bottom-line (trust versus economics). Although farmers adopted the technology, they still prefer to “observe” conditions on the farm manually. A number of farm processes remained somewhat of an “art”. Farmers prefer to follow known routines. The results for case study lead to Chapter 4.

Chapter 4 is the second study and uses a quantitative approach to answer the second and third research questions. This is the first quantitative study to investigate the assimilation and extended use of a dairy management information system from a three component model. A well established adoption-diffusion framework, the Technology-Organization-Environment Framework was extended to measure the assimilation extended use of the system in farm operation activities on the dairy farm. These farm operation activities are daily operations, production planning and herd health management. The assimilation and extended use of the system through farm operation activities was further investigated as a measure for the level of process automation. A set of hypotheses were developed. A survey questionnaire was also developed as a result of the case study in Chapter three. Farms that have adopted the dairy management information system from several countries participated in the survey. We were able to support twelve of twenty-three hypotheses. Results suggest that measures for daily operations have a significant effect on the level of process automation. This effect is negatively impacted by the years of dairy industry experience. There is also evidence that the farm size can facilitate dairy management system assimilation and extended use to automate herd health management. From the Technology-Organization-Environment Framework extension, social influences facilitated the assimilation and extended use of the system in farm operation activities. Social influences in this study are defined as the degree to which others outside the organization affect future use and recommend the system. Social influences also include how the system improves relationships and farm image. Cooperative support and social influences facilitate dairy management information system use to automate herd health management. The study introduces an information systems framework and demonstrates its applicability to extended farm activities from a theoretical perspective. The study also introduces a new component that involves biological/animal science mechanisms. This component is rarely seen in information technology adoption and assimilation research.

This dissertation is shaped by the exploratory case study and the quantitative study. The Technology-Organization-Environment Framework adapted in the case study is further developed in the quantitative study. In the quantitative study, we investigated assimilation and extended use in farm operation activities, and the level of process automation. We modeled the dynamics for the assimilation and extended use of a dairy management information system by extending a known framework already proven in adoption and diffusion research. This study is different from typical information systems research. The animal/biological mechanism or component is not typically found in information technology adoption and assimilation research. We achieved acceptable explanatory power (R^2) for the three constructs in farm operation activities and the one construct for the level of process automation. A new integrate framework is developed based on the findings for the exploratory case study and the quantitative study. Figure 5-1 represents an integrate model developed from the case and quantitative studies.

The integrate model represented in Figure 5-1 is suggestions for further research. The list of factors under the headings of 'environment', 'organization', 'user', 'assimilation', and 'animal and worker' are suggestions for future measures. The animal and worker category are abstract ideas that can be integrated into the model. Dairy management is labor intensive and animal centric. The common theme for both studies suggests that environmental factors such as social influences facilitate the assimilation and extended use of farm process activities. The findings in the exploratory case study supported individual user and technology characteristics, but the main conclusion was the impact of social influences and dealer support (environment). The case study interviewed early adopters of the system. Therefore, it is based on a post-adoption perspective. The findings in the quantitative study also support the environment pathway. The organization pathway is partially supported. However, technology constructs (system complexity and compatibility) do not appear as relevant as for what is commonly found in pre-adoption studies. Therefore, the consequent integrate model in Figure 5.1 does not incorporate the technology construct. Future research can further investigate the technology construct. Future research can also investigate the Technology-Organization-Environment Framework relationships with respect to the disparities between adoption and post-adoption behaviors.

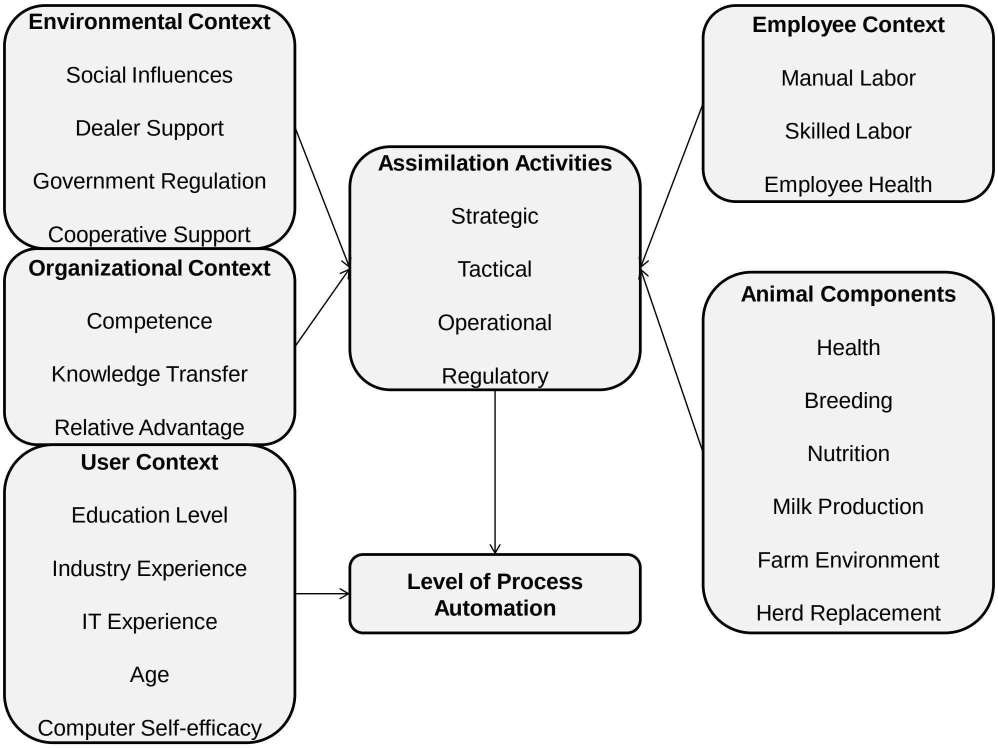

Figure 5-1 Integrate Model

References

Adesina, A. A., & Zinnah, M. M. (1993). Technology characteristics, farmers' perceptions and adoption decisions: A tobit model application in Sierra Leon. *Agricultural* Economics, 9, 297–311.

Aerts J.-M., Wathes C. M., & Berckmans D. (2003a). Dynamic data-based modelling of heat production and growth of broiler chickens: Development of an integrated management system. *Biosystems Engineering*, 84(3), 257–266.

Aerts J.-M., Van Buggenhout S., Lippens M., Buyse J., Decuypere E., Vranken E., & Berckmans D. (2003b). Active control of the growth trajectory of broiler chickens based on on-line animal responses. *Poultry Science*, 82(12), 1853–1862.

Agarwal, R., & Prasad, J. (1997). The role of innovation characteristics and perceived voluntariness in the acceptance of information technologies. *Decision Sciences*, 28(3), 557–582.

Agarwal, R., & Prasad, J (1998). The antecedents and consequents of user perceptions in information technology adoption. *Decision Support Systems*, 22, 15–29.

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Prentice-Hall, Englewood Cliffs, NJ.

Alexander, M., Elam, J., & Wasala, C. (1992). Multiple theoretical perspectives for studying the assimilation of emerging information technologies. *Proceedings of the 25th HICSS Conference*, January, IEEE Computer Society Press, Kauai, Hawaii, IV, 400–409.

Alvarez, J., & Nuthall, P. (2006). Adoption of computer based information systems: The case of dairy farmers in Canterbury. New Zealand, and Florida, Uruguay, *Computers and Electronics in Agriculture*, 50, 48–60.

Al-Qirim, N. (2007). The adoption of electronic commerce communications and applications technologies in small businesses in New Zealand. *Electronic Commerce Research and Applications*, 6(4), 462–473.

Anderson, S. T. & Newell, R. G. (2004). Information programs for technology adoption: The case of energy-efficiency audits. *Resource and Energy Economics*, 26, 27–50.

Arc Advisory Group (2007). Packaging execution systems benefit lean manufacturing initiatives. http://www.ARCweb.com. [Last accessed 04/25/12].

Armstrong, C. P. & Sambamurthy, V. (1997). Information technology assimilation in firms: the influence of senior leadership and IT infrastructures. *Information Systems Research*, 10(4), 304–327.

Arrow, K. (1962). The economic implication of learning by doing. *Review of Economic Studies*, 29, 166–170.

Arthur, W. B. (1988). Competing technologies: An overview. *Technical Change and Economic Theory*, Dosi, G. et al. (eds.), Pinter Publishers, London, 590–607.

Arthur, W. B. (1996). Increasing returns and the new world of business. *Harvard Business Review*, 74, 101–109.

Attewell P. (1992). Technology diffusion and organizational learning: The case of business computing. *Organization* Science, 3(1), 1–19.

Au, Y. A. & Kauffman, R. J. (2001). Should we wait? Network externalities and electronic billing adoption. *Proceedings of the 34th Hawaii International Conference on System Sciences*, 1–10.

Auernhammer, H., Spangler, A., & Demmel, M. (2000). Automatic process data acquisition with GPS and LBS. In Proceedings of Agricultural Engineering 2000 Conference, Warwick University, UK, 2-7 July, 267–268.

Bach, A., & Busto, I. (2005). Effects on milk yield of robotic milking interval regularity and teat cup attachment failures with robotic milking systems. *Journal of Dairy Research*, 72, 101–106.

Bailey, J. E. & Pearson, S. W. (1983). Development of a tool for measuring and analyzing computer user satisfaction. *Management Science*, 29(5), 530–545.

Bagozzi, R. P. (1991). Further thoughts on the validity of measures of elation, gladness, and joy. *Journal of Personality and Social Psychology*, 61, 98–104.

Bharadwaj, A. S. (2000). A resource-based perspective on information technology capability and firm performance: An empirical investigation. *MIS Quarterly*, 24(1), 169–196.

Baker, S. H. (1973). Risk, leverage and profitability: an industry analysis. *The Review of Economics and Statistics*, 55(4), 503–507.

Bandiera, O., & Rasul, I. (2006). Social networks and technology adoption in northern Mozambique. *The Economic Journal*, 116, 869–902.

Banhazi, T. (2005). Improved air quality measurement procedure – BASE-Q system. In *AAPV Conference,* Gold Coast, QLD, Australia, Fahy, T. (editor), 1, 71–75.

Banhazi, T., Dunn, M., Cook, P., Black, J., Durack, M., & Johnnson, I. (2007). Development of precision livestock farming (PLF) technologies for the Australian pig industry. In *Precision Livestock Farming ’07* (Ed. S. Cox), Wageningen, The Netherlands: Wageningen Academic Publishers, 219–228.

Banhazi, T. M., Aarnink, A., Thuy, H., Pedersen, S., Hartung, J., Payne, H., Mullan, B., & Berckmans, D. (2008). Review of issues related to heat stress in intensively housed pigs.” In *8th International Livestock Environment Symposium (ILES)*, Stowell, R. R., Wheeler, E. F. and Yanagi, T. (editor), Iguassu Fall, Brazil, ASABE, 1, 737–744.

Banhazi, T. M., & Black, J. L. (2009). Precision livestock farming: a suite of electronic systems to ensure the application of best practice management on livestock farms. *Australian Journal of Multi-disciplinary Engineering*, 70, 1.

Bassellier, G., Reich, B. H., & Benbasat, I. (2001). Information technology competence of business managers: A definition and research model. *Journal of Management Information* Systems, 17(4), 159–182.

Batte, M. T., & Arnholt, M. W. (2003). Precision farming adoption and use in

Ohio: Case studies of six leading-edge adopters. *Computers and Electronics in Agriculture*, 38, 125–139.

Batte, M. T., Jones, E., & Schnitkey, G. D. (1990). Computer use by Ohio commercial farmers. *American Journal of Agricultural Economics*, 72, 935–945.

Beamon, B. M. (1999). Measuring supply chain performance. *International Journal of Operations & Production Management*, 19(3), 275–292.

Becker, H. J., & Riel, M. M. (2000). Teacher professional engagement and constructivist-compatible computer use [on-line]. Centre for Research on Information Technology and Organizations, University of California, Irvine. Available at: http://www.crito.uci.edu/tic/findings.html

Bennett, A. (2003). Changing farming systems: Case studies assessing the financial implications. *International Farm management Congress*, Department of Agriculture, Western Australia, http://ifmaonline.org/pdf/congress/Bennett.pdf [Last accessed 05/09/12]

Berckmans, D. (2004). Automatic on-line Monitoring of Animals by Precision Livestock Farming. *International Society for Animal Hygiène* - Saint-Malo, 27–30.

Berger, R., & Hovav, A. (Forthcoming). Using a dairy management information system to facilitate precision agriculture: The case of the AfiMilk® system. *Information Systems Management*, Accepted October 2011.

Berger, R. (Forthcoming). Dealer perception of farmers' use of information technology in dairy management, Working Paper.

Berglund, I., Pettersson, G., & Svennersten-Sjaunja, K. (2002). Automatic milking: Effects on somatic cell count and teat end quality. *Livestock Production Science*, 78, 115–124.

Berkmans, D. (2008). Precision livestock farming (PLF). *Computers and Electronics in Agriculture*, 62, 1.

Bewley, J. M., & Russell, R. A. (2010). Reasons for slow adoption rates of precision dairy farming technologies: Evidence from a producer survey. *The First North American Conference on Precision Dairy Management*.

Bharadwaj, A. S. (2000). A resource-based perspective on information technology capability and firm performance: An empirical investigation, *MIS Quarterly*, 24(1), 169–196.

Bhattacherjee, A. (2001). Understanding information systems continuance: An expectation-confirmation model. *MIS Quarterly*, 25 (3), 351–370.

Blezinger, S. (2001). Many tools are available to help build a quality herd. *Cattle Today Online*, http://cattletoday.com/archive/2001/May/CT147.shtml [Last accessed 01/03/2010]

Brand, A., Noordhuizen, J. P. T. M., & Schukken, Y. H. (1996). Herd health and production management in dairy practice. Wageninigan Academic Publisher, 543.

Brass, D. J. (1984). Being in the right place: a structural analysis of individual influence in an organization. *Administrative Science Quarterly*, 29, 518–539.

Bresnahan, T. F., Brynjolfsson, E., & Hitt, E. (2002). Information technology, workplace organization and the demand for skilled labor: Firm-level evidence. *The Quarterly Journal of Economics*, February.

Brosnan, M. J. (1999). Modelling technophobia: A case for word processing. *Computers in Human Behavior*, 15, 105–121.

Bruckmaier, R. M., & Blum J. W. (1998). Oxytocin release and milk removal in ruminants. *Journal of Dairy Science*, 81, 939–949.

Bruque, S., Moyano, J., Vargas, A., & Hernandez, M. J. (2003). Ownership structure, technological endowment and competitive advantage: Do democracy and business fit? *Technology Analysis and Strategic Management*, 15, 65–79.

Bruque, S., & Moyano, J. (2007). Organizational determinants of information technology adoption and implementation in SMEs: The case of family and cooperative firms. *Technovation*, 27, 241–253.

Brynjolfsson, E., & Hitt, L. M. (2000). Beyond computation: information technology, organizational transformation and business performance. *The Journal of Economic Perspectives*, 14(4), 23–48.

Bulanon, D. M., & Kataoka T. (2010). A fruit detection system and an end effector for robotic harvesting of Fuji apples. *Agricultural Engineering International*: the CIGR E-journal, Manuscript 1285, XII, February.

Bunch, R. (2000). Keeping it simple: What resource poor farmers will need from agricultural engineers during the next decade. *Journal of Agricultural Engineering Research*, 76, 305–308.

Burkhardt, M. E., & Brass, D. J. (1990). Changing patterns or patterns of change: The effects of a change in technology on social network structure and power. *Administrative Science Quarterly*, 35, 104–127.

Cambra-Lopez, M., Aarnink, A. J. A., Zhao, Y., Calvet, S., & Torres, A. G. (2010). Airborne particulate matter from livestock production systems: A review of an air pollution problem. *Environmental Pollution*, 158, 1–17.

Campbell, D. (1975). Degrees of freedom and the case study. *Comparative Political Studies*, 8, 178-185.

Carter, F. J., Jambulingam, T., Gupta, V. K., & Melone, N. (2001). Technological innovations: A framework for communicating diffusion effects. *Information Management*, 38, 277–287.

Cassman, K. G. (1999). Ecological intensification of cereal production systems: Yield potential, soil quality, and precision agriculture. *Proceedings of the National Academy of Sciences, USA*, 96, Colloquium Paper, 5952–5959.

Champagne, C. P., Claude, P., Laing, R. R., Roy, D., Mafu, A. A., Griffiths, M. W., & White, C. (1994). Psychrotrophs in dairy products: Their effects and their control. *Critical Reviews in Food Science and Nutrition*, 34(1), 1–30.

Chatfield, A. T., & Yetton, P. (2000). Strategic payoff from EDI as a function of EDI embeddedness. *Journal of Management Information Systems*, 16(4), 195–224.

Chatterjee, D., Grewal, R., & Sambamurthy V. (2002). Shaping up for e-commerce:

Institutional enablers of the organizational assimilation of web technologies. *MIS Quarterly*, 26(2), 65–89.

Chau, P. Y. K., & Tam, K. Y. (1997). Factors affecting the adoption of open systems: An exploratory study. *MIS Quarterly*, 21(1), 1–24.

Chew, W. B. (1985). Productivity and change: The short-term effects of investment on factory level productivity. *Business Economics*, Harvard University, Cambridge, MA.

Chiles, T. H., & McMackin, J. F. (1996). Integrating variable risk preferences, trust, and transaction cost economics. *Academy of Management Review*, 21, 73–99.

Chin, W. W. (1998). Issues and opinion on structural equation modeling. *MIS Quarterly*, 22(1), vii–xvi.

Chin, W., Marcolin, B., & Newsted, P. (2003). A partial least squares latent variable modeling approach for measuring interaction effects: Results from a Monte Carlo simulation study and an electronic-mail emotion/adoption study. *Information Systems Research*, 14(2), 189–217.

Chong, S., & Pervan, G. (2007). Factors influencing the extent of deployment of electronic commerce for small- and medium-sized enterprises - An exploratory study. *Journal of Electronic Commerce in Organizations*, 5(1), 1–29.

Chun, H. (2003). Information technology and the demand for educated workers: Disentangling the impacts of adoption versus use. *The Review of Economics and Statistics*, 85(1), 1–8.

Conley, T., & Udry, C. (2001). Social learning through networks: The adoption of new agricultural technologies in Ghana American. *Journal of Agricultural Economics*, 83(3), 668–673.

Cooper, R. B., & Zmud, R. W. (1990). Information technology implementation research: A technological diffusion approach. *Management Science*, 36(2), 123–140.

Cox, S. (2002). Information technology: the global key to precision agriculture and sustainability. *Computers and Electronics in Agriculture*, 36, 93–111.

Cragg, P. B., & King, M. (1993). Small-firm computing: motivators and inhibitors. *MIS Quarterly*, 17(1), 47–60.

Crosby, L. A., Evans, K. R., & Cowles, D. (1990). Relationship quality in services selling: An interpersonal influence perspective. *Journal of Marketing*, 54, 68–81.

Crawford, H. K. Gray, D. I., Parker, J. W., & Edwards, N. (1989). Characteristics of seasonal dairy farms achieving high per cow production in the lower north island of New Zealand. In *Proceedings of the New Zealand Society of Animal Production*, 55, 71–75.

Daberkow, S. G., & McBride, W. D. (2003). Farm and operator characteristics affecting the awareness and adoption of precision agriculture technologies in the US. *Precision Agriculture*, 4, 163–177.

Darr, M., & Epperson, W. (2009). Embedded sensor technology for real time determination of animal lying time. *Computers and Electronics in Agriculture*, 66, 106–111.

Davenport, T. H. (1998). Putting the enterprise into the enterprise system. *Harvard Business Review*, 76(4), 121–131.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13, 319–339.

Davis, F. D., Bagozzi, R. P., Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, 35, 982–1002.

De Koning, K., Slaghuis, B., & Van der Vorst, Y. (2003). Robotic milking and milk quality: Effects on bacterial counts, somatic cell counts, freezing points and free fatty acids. *Italian Journal of Animal Science*, 2, 291–299.

De Koning, K., & Rodenburg, J. (2004). Automatic milking: state of the art in Europe and North America. [Last accessed 06/13/12] http://www.automaticmilking.nl/symposium/science/Papers/0.0-1.pdf

De Sanctis, G., & Poole, M. S. (1994). Capturing the complexity in advanced technology use: Adaptive structuration theory. *Organization Science*, 5(2), 121–147.

Deane, T. H. (1993). The relationship between milk fat production per hectare and economic farm surplus on New Zealand dairy farms. In *Proceedings of the New Zealand Society of Animal Production*, 53, 51–54.

Delgado, J. A., Shaffer, M. J., Lal, H., McKinney, S. P., Gross, C. M., & Cover, H. (2008). Assessment of nitrogen losses to the environment with a Nitrogen Trading Tool (NTT). *Computers and Electronics in Agriculture*, 63, 193–206.

Devir, S., Maltz, E., & Metz, J. H. M. (1997). Strategic management planning and implementation at the milking robot dairy farm. *Computers and Electronics in Agriculture*, 17, 95–110.

Devir, S., Renkema, J. A., Huirne, R. B. M., & Ipema, A. H. (1997). New dairy control and management system in the automatic milking farm: Basic concepts and components. *Journal of Dairy Science*, 76, 3607–3616.

Diamantopoulos, A., & Siguaw, J. A. (2006). Formative Versus reflective indicators in organizational measure development: A comparison and empirical illustration. *British Journal of Management*, 17, 263–282.

Diamantopoulos, A., & Winklhofer, H. M. (2001). Index construction with formative indicators: An alternative to scale development. *Journal of Marketing Research*, 38(2), 269–277.

Dijkhuizen, A. A., Huirne, R. B. M., Harsh, S. B., & Gardner, R. W. (1997). Economics of robotic application. *Computer Electronics in Agriculture*, 17(1), 111–121.

Dobos, R. C., Ashwood, A. M., Moore, K., & Youman, M. (2004). A decision tool to help in feed planning on dairy farms. *Environmental Modelling and Software*, 19(10), 967–974.

Dos Santos, B. L., & Peffers, K. (1998). Competitor and vendor influence on the adoption of innovative applications in electronic commerce. *Information & Management*, 34, 175–184.

Doye, D., Jolly, R., Hornbaker, R., Cross, T., King, R. P. Lazarus, W. F., & Yeboah, A. (2000). Case studies of farmer's use of information systems. *Review of Agricultural Economics*, (22)2, 566–585.

Durack, M. (2002). Precision pig farming: Where are your pigs and what are they up to? *National Centre for Engineering in Agriculture*, Toowoomba, 13.

Edwards, N., & Parker, W. J. (1994). Increasing per cow milk solids production in a pasture-based dairy system by manipulating the diet: A review. In *Proceedings of the New Zealand Society of Animal Production*, 54, 267–273.

Edwards, J. L., & Tozer, P. R. (2004). Using activity and milk yield as predictors of fresh cow disorders. *Journal of Dairy Science*, 87(2), 524–531.

Ein-Dor, P., & Segev, E. (1978). Organizational context and the success of management information systems. *Management Science*, (24), 1064–1077.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, 14(4), 532–550.

Eradus, W. J., & Jansen, M. B. (1999). Animal identification and monitoring. *Computers and Electronics in Agriculture*, 24, 91–98.

Eradus, W. J., Rossing, W., Hogewerf, P. H., & Benders, E., (1992). Signal processing of activity data for oestrus detection in dairy cattle. In: Ipema, Lippus, Metz, Rossing, (Eds.), In *Proceedings of the International Symposium on Prospects for Automatic Milking*, Pudoc Scientific, Wageningen, The Netherlands, EAAP Publication 65, 360–369

Ettlie, J. E., & Vellenga, D. B. (1979). The adoption time period for some transportation innovation. *Management Science*, 25, 429–443.

Ettlie, J. E., Bridges, W. P., & O'Keefe, R. D. (1984). Organizational strategy and structural differences for radical versus incremental innovation. *Management* Science, 30(6), 682–695.

Falk, R. F., & Miller, N. B. (1992). *A primer for soft modeling*. University of Akron Press, Akron, OH.

Farrington, J., & Martin, A. M. (1998). Farmer Participatory Research: A Review of Concepts and Recent Fieldwork. *Agricultural Administration and Extension*, 29, 241–264.

Feder, G. (1980). Farm size, risk aversion and the adoption of new technology under uncertainty. *Oxford Economic Papers*, 32, 263–283.

Feder, G., Just, R. E., & Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change*, 33(2), 255–298.

Feder, G., & O'Mara, G. (1981). Farm size and the adoption of green revolution technology. *Economic Development and Cultural Change*, 30, 59–76.

Feder, G., & Slade, R. (1984). The acquisition of information and the adoption of new technology. *American Journal of Agricultural Economics*, 66(3), 312–320.

Fernando, R. S., Rindsig, R. B. & Spahr, S. L. (1982). Electrical conductivity of milk for detection of mastitis. *Journal of Dairy Science*, 65, 659–664.

Fichman, R. G. (1992). Information technology diffusion: A review of empirical research. http://tx.liberal.ntu.edu.tw/SilverJay/Literature/!Adoption/Fichman_1992_ICIS_IT_Diff_Review.pdf [Last accessed 06/17/12]

Fichman, R. G. (1999). The diffusion and assimilation of information technology innovations. R.W. Zmud (Ed.), *Framing the domains of IT management: Projecting the future through the past*. Cincinnati, OH: Pinnaflex Educational Resources, Inc.

Fichman, R. G. (2001). The role of aggregation in the measurement of IT-related organizational innovation. *MIS Quarterly*, 25(4), 201–429.

Fichman, R. G., & Kemerer, C. F. (1993). Adoption of software engineering process innovations: The case of object orientation. *Sloan Management Review*, (34), 7–22.

Fichman, R. G., & Kemerer, C. F. (1997). The assimilation of software process innovations: An organizational learning perspective. *Management Science*, 43(10), 1345–1363.

Fink, D. (1998). Guidelines for the successful adoption of information technology in small and medium enterprises. *International Journal of Information Management*, 18(4) 243–253.

Firk, R., Stamer, E., Junge, W., & Krieter J. (2002). Automation of oestrus detection in dairy cows: A review. *Livestock Production Science*, 75, 219–232.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: an introduction to theory and research*. Addison-Wesley, Reading, MA.

Flett, R., Alpass, F., Humphries, S., Massey, C., Morriss, S., & Long, N. (2004). The technology acceptance model and use of technology in New Zealand dairy farming. *Agricultural Systems*, 80, 199–211.

Forrell, J., & G. Saloner (1987). Competition, compatibility, and standards: The economics of horses, penguins and lemmings, *Product Standardization and Competitive Strategy*. 1–21, http://escholarship.org/uc/item/48v4g4q1. [Last accessed 09/19/2011].

Fornell, C., & Bookstein F. L. (1982). A comparative analysis of two structural equation models: LISREL and PLS applied to market data. In: Fornell, C. (ed.), *A second generation of multivariate analysis*, 1, 289–324. Praeger, New York.

Fornell, C., & Larcker, D. F. (1981). Structural equation models with unobservable variables and measurement errors. *Journal of Marketing Research*, 18(2), 39–50.

Forsberg, A.-M., Pettersson, G., & Wiktorsson, H. (2002). Comparison between free and forced cow traffic in an automatic milking system. In *NJF Report 337, Technology formilking and housing of dairy cows*. Hamar, Norway. Wageninen Pers, Wageningen, the Netherlands, 131–135.

Frambach, R. T., & Schillewaert, N. (2002). Organizational innovation adoption: A multi-level framework of determinants and opportunities for future research. *Journal of Business Research*, 55, 163–176.

Fuglie, K. O., & Kascak, C. A. (2001). Adoption and Diffusion of Natural-Resource-Conserving Agricultural Technology. *Review of Agricultural*

Economics, 23(2), 386–403.

Gable G. G., & Raman K. S. (1992). Government initiatives for IT adoption in small businesses. *International Information. Systems*, 1(1), 68–93.

Gallivan, M. J. (2001). Organizational adoption and assimilation of complex technological innovations: Development and application of a new framework. *The DATA BASE for Advances in Information Systems*, 32(3), 51–85.

Gefen, D., Karahanna, E., & Straub, D. W. (2003). Trust and TAM in online shopping: An integrated model. *MIS Quarterly*, 27(1), 51–90.

Gefen, D., & Straub, D. W. (1997). Gender differences in the perception and use of E-mail: An extension to the technology acceptance model. *MIS Quarterly*, 21(4), 389–400.

Gefen, D., & Straub, D. (2005). A practical guide to factorial validity using PLS-graph: Tutorial and annotated example. *Communications of AIS*, 16(5) 91–109.

Gelb, E., Parker, C., Wagner, P., & Rosskopf, K. (2001). Why is the ICT adoption rate by farmers still so slow? *Proceedings ICAST*, VI, Beijing, China, 40–48.

Gibbs, J. L., & Kramer, K. L. (2004). A cross-country investigation of the determinants of scope of e-commerce use: An institutional approach. *Electronic Markets*, 14(2), 124–137.

Gopal, A., Mukhopadhyay, T., & Krishnan, M. S. (2005). The impact of institutional forces on software metrics programs. *IEEE Transactions on Software Engineering*, 31(8), 679–694.

Gorlach, I., & Wessel, O. (2008). Optimal level of automation in the automotive industry. *Engineering Letter*s. 16(1), Advance online publication: 19 February.

Gorsline, K. A. (1996). Competency profile for human resources: No more shoemaker’s children. *Human Resource Management*, 35(1), 53–66.

Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology*, 91(3), 481–510.

Grift, T., Zhang, Q., Kondo, N., & Ting, K. C. (2008). A review of automation and robotics for the bioindustry. *Journal of Biomechatronics Engineering*, 1(1), 37–

54.

Grigori, D., Casati, F., Dayal, U., & Shan, M. C. (2001). Improving business process quality through exception understanding, prediction, and prevention. In *Proceedings of the 27th VLDB Conference*, Roma, Italy, September 11–14.

Grover, V. (1993). An empirically derived model for the adoption of customer-based interorganizational systems. *Decision Sciences*, 24(3), 603–640.

Grover, V., Teng, J., Segars, A.H., & Fiedler, K. (1998). The influence of information technology diffusion and business process change on perceived productivity: The IS executive's perspective. *Information & Management*, 34, 141–159.

Guerrin, F. (2004). Simulation of stock control policies in a two-stage production system: Application to pig slurry management involving multiple farms. *Computers and Electronics in Agriculture*, 45(1-3), 27–50.

Guerin, L. J., & Guerin, T. F. (1994). Constraints to the adoption of innovations in agricultural research and environmental management: A review. *Australian Journal of Experimental Agriculture*, 34, 549–571.

Hagen, K., Langbein, J., Schmied, C., Lexer, D., & Waiblinger, S. (2005). Heart rate variability in dairy cows: Influences of breed and milking system. *Physiology* & *Behavior*, 85, 195–204.

Hair, J. F., Anderson, R. E Jr., Tatham, R. L., & Black W. C. (1998). *Multivariate data analysis with readings*. 5th Edition, Englewood Cliffs, NJ: Prentice Hall.

Halachmi, I., Metz, J. H. M., Van Land, A., Halachmi, A. S., & Kleijnen, J. P .C. (2002). Case study: Optimal facility allocation in a robotic milking barn. *Transactions of the ASAE*, 45(5), 1539–1546.

Han, D. H. (2004). Globalization and the Quality of Life of Korean Farmers. *The Review of Korean Studies*, 7(1), 187–205.

Hannan, M. W., & Burks, T. F. (2004). Current developments in automated citrus harvesting. *ASAE Paper No. 04-3087*, St. Joseph, MI.

Harms, J. (2004). Untersuchungen zum Einsatz verschiedener Varianten des

Tierumtriebs bei automatischen Melksystemen (Einboxenanlagen). *PhD Dissertation*, Institute of Agricultural Engineering, Technical University of Munich, Germany.

Harrison, D. A., Mykytyn, P. P. Jr., & Riemenschneider, C. K. (1997). Executive decisions about adoption of information technology in small business: *Theory and Empirical Tests Information Systems Research*, 8, 171–195.

Hartwick, J., & Barki, H. (1994). Explaining the role of user participation in information system use. *Management Science*, 40(4), 440–465.

Hayashi, S., Ganno, K., Ishii, Y., & Tanaka, I. (2002). Robotic harvesting system for eggplants. *Japan Agricultural Research Quarterly*, 36(3), 163-168, http://www.jircas.affrc.go.jp.

Haynes, J. L. (1979). A new look at managerial competence: The AMA model of worthy performance. *Management* Review, 2–3.

Hauser, R. M. (1971). Socioeconomic background and educational performance. *Rose Monograph Series American Sociological Association*, Washington DC.

Hauser, R. M. (1973). Disaggregating a social-psychological model of educational attainment. In: A. S. Goldberger and O. D. Duncan (eds.), *Structural equation models in the social sciences*, Seminar Press, New York.

Heinonen, M., Grohn, Y. T., Saloniemi, H., Eskola, E., & Tuovinen, V. K. (2001). The effects of health classification and housing and management of feeder pigs on performance and meat inspection findings of all-in-all-out swine-finishing herds. *Preventive Veterinary Medicine*, 49(1-2), 41–54.

Hendricks, K. B., & Singhal, V. R. (1997). Does implementing an effective TQM program actually improve operating performance? Empirical evidence from firms that have won quality awards. *Management Science*, 43(9), 1258–1274.

Hemmat, A., & Adamchuk V. I. (2008). Sensor systems for measuring soil compaction: Review and analysis. *Computers and Electronics in Agriculture*, 6(3), 89–103.

Hieronymus, P. (2000). Automatic steering for cereal harvesters. *Proceedings in*

Agriculture Engineering Conference, Warwick University, UK, 2-7 July, 240–241.

Hillerton, J. E., Pankey, J. W., & Pankey, P. (2002). Effect of overmilking on teat condition. *Journal of Dairy Research*, 69, 81–84.

Hiltz, S. R., & Turoff, M. (1981). The evolution of user behavior in a computerized conferencing center. *Communications of the ACM*, 24(11), 739–751.

Hofstede, G. (2009). Geert Hofstede Cultural Dimensions. *Itim International*, http://www.geert-hofstede.com/hofstede_south_korea. [Last accessed 09/20/2011].

Hogeveen, H., & Ouweltjes, W. (2003) Sensors and management support in high-technology milking, *Journal of Animal Science*, 81, 1–10.

Holst, P. J. (1999). Recording and on-farm evaluations and monitoring: Breeding and selection. *Small Ruminant Research*, 34(3), 197–202.

Hopster, H., Bruckmaier, R. M., Van der Werf, J. T. N., Korte, S. M., Macuhova, J., Korte-Bouws, G., & Van Reenen, C. G. (2002) Stress responses during milking: Comparing conventional and automatic milking in primiparous dairy cows. *Journal of Dairy Science*, 85, 3206–3216.

Hovav, A., & Gray, P. (2001). Managing academic electronic publishing: Six case studies. Global Co-Operation in the New Millennium. *The 9th European Conference on Information Systems*, Bled, Slovenia, June 27–29.

Hovav, A., Patnayakuni, R., & Schuff, D. (2004). A model of Internet standards adoption: The case of IPv6. *Journal of Information Systems*, 14, 265–294.

Howell, J. M., & Higgins, C. A. (1990). Champions of technological innovation. *Administrative Science Quarterly*, 35, 317–341.

Huang, Z., Janz, B. D., & Frolick, M. N. (2008). A Comprehensive examination of Internet- EDI adoption. *Information Systems Management*, 25(3), 273–286.

Huff, S., & Munro, M. (1985). Information technology assessment and adoption: A field study. *MIS Quarterly*, 19(4), 327–340.

Huirne, R. B. M., Harsh, S. B., & Dijkhuizen. A. A. (1997). Critical success factors and information needs on dairy farms: The farmer's opinion. *Livestock Production Science*, 48(3), 229–238.

Hurnik, J. F. (1992). Ethology and technology: The role of ethology in automation of animal production processes. In *Proceedings of the International Symposium on Prospects for Automatic Milking*. EAAP Publication No. 65, Pudoc, Wageningen, The Netherlands, 401.

Iacovou, C. L., Benbasat, I., & Dexter, A. S. (1995). Electronic data interchange and small organizations: Adoption and impact of technology. *MIS Quarterly*, 19(4), 465–485.

Isgin, T., Bilgic, A., Forster, D. L., Batte, M. T. (2008). Using count data models to determine the factors affecting farmers' quantity decisions of precision farming technology adoption. *Computers and Electronics in Agriculture,* 62, 231–242.

livari, J., & Ervasti, I. (1992). The Impact of Alternative IS Acquisition Strategies upon IS Success. *Computer Personnel,* 14(l-2), 45–59.

Jakobsen, M., & Narvhus, J. (1996). Yeasts and their possible beneficial and negative effects on the quality of dairy products. *International Dairy Journal*, 6, 8-9, August-September, 755–768.

Jaivingh, A. W. (1992). The possible role of existing models in on-farm decision support in dairy cattle and swine production. *Livestock Production* Science, 3, 351–365.

Jarvenpaa, S. L., & Staples, D. S. (2000). The use of collaborative electronic media for information sharing: An exploratory study of determinants. *Journal of Strategic Information Systems*, 9, 129–154.

Jarvis, C. B., Mackenzie, P. M., & Podsakoff, P. M. (2003). A critical review of construct indicators and measurement model misspecification in marketing and consumer research. *Journal of Consumer Research*, 30(2), 199–218.

Jasperson, S., Carter, P. E., & Zmud, R. W. (2005). A comprehensive conceptualization of post-adoptive behaviors associated with information technology enabled work systems. *MIS Quarterly*, 29(3), 525–557

Jensen, R. (1982). Adoption and diffusion of an innovation of uncertain profitability. *Journal of Economic Theory*, 27, 182–193.

Justesen, P., & Rasmussen, M. D. (2000). Improvements of milk quality by the Danish AMS self monitoring programme. In *Proceedings of the International Symposium on Robotic* Milking, Lelystad, the Netherlands. Wageninen Pers, Wageningen, the Netherlands, 83–88.

Kaae, S., Søndergaard, B., Haugbølle, L. S., & Traulsen, J. M. (2010). Development of a qualitative exploratory case study research method to explore sustained delivery of cognitive services. *Pharmaceutical World & Science*, 32, 36–42.

Karahanna, E., Straub, D. W., & Chervany, N. L. (1999). Information technology adoption across time: A cross-sectional comparison of pre-adoption and post-adoption beliefs. *MIS Quarterly*, 23(2), 183–213.

Kassler, M. (2001). Agricultural automation in the new millennium. *Computers and Electronics in Agriculture*, 30, 237–240.

Katz, R. (1980). Time and work: Toward an integrative perspective. In Staw, B. M., & Cummings, L. L (Eds.), *Research in Organizational Behavior*, 2, Greenwich, CT: JAI Press, 81–127.

Katz, M. L., & Shapiro, C. (1986). Technology adoption in the presence of network externalities. *Journal of Political Economics*, 94(4), 822–841.

Katz, R., & Tushman, M. (1979). Communication patterns, project performance, and task characteristics: An empirical evaluation and integration in an R&D setting. *Organizational Behavior and Human Performance*, 23(2), 139–162.

Kay, J., & Thomas, R. C. (1995). Studying long-term system use. *Communications of the ACM*, 38(7), 61–69.

Ketelaar-de-Lauwere, C. C., Hendriks, M. M. W. B., Metz, J. H. M., & Schouten, W. G. P. (1998). Behaviour of dairy cows under free or forced cow traffic in a simulated automatic milking system. *Applied Animal Behaviour Science*, 56, 13–28.

Keung, J., Jeffery, R., & Kitchenham, B. (2004). The challenge of introducing a new software cost estimation technology into a small software organization. *Proceedings of the 2004 Australian Software Engineering Conference*, (ASWEC'04).

Kimberly, J. R., & Evanisko, M. J. (1981). Organizational innovation: The influence of individual, organizational, and contextual factors on hospital adoption of technological and administrative innovations. *The Academy of Management Journal*, 24(4), 689–713.

Kimm, K., & Heyden, I. (2000). Automatic milking system, Leonardo- hanging on of the teat-cups. *Proceedings in Agriculture Engineering Conference*, Warwick University, UK, 2–7, 246–247.

King, J. L., Gurbaxani, V., Kraemer, K. L., McFarlan, F. W., Raman, K. S., & Yap, C. S. (1994). Institutional factors in information technology innovation. *Information Systems Research*, (5)2, 139–169.

Klungel, G. H., Slaghuis, B. A., & Hogeveen, H. (2000). The effect of the introduction of automatic milking systems on milk quality. *Journal of Dairy Science* 83, 1998–2003.

Kollis, K., Phang, C. S., Banhazi, T. M., & Searle, S. J. (2007). Weight estimation using image analysis and statistical modelling: A preliminary study. *Applied Engineering in Agriculture*, 23(1), 91–96.

Komiak, S. X., & Benbasat, I. (2004). Understanding customer trust in agent-mediated electronic commerce, web-mediated electronic commerce, and traditional commerce. *Information Technology and Management*, 5, 181–207.

Kondo, N., Monta, M., & Fujiura, T. (1996). Fruit harvesting robots in Japan. *Advances in Space Research*, 18, 181–184.

Koundouri, P., Nauges, C´ E., & Tzouvelekas, V. (2006). Technology adoption under production uncertainty: Theory and application to irrigation technology. *American Journal of Agricultural Economics*, 88(3), 657–670.

Kristensen H. H., Aerts J. M., Leroy T., Berckmans D., & Wathes, C. M. (2004).

Using light to control activity in broiler chickens. *British Poultry Science*, 45 (Suppl. 1): S30.

Krutz, G. W., & Schueller, J. K. (2000). Advanced engineering: Future directions for the agricultural and biological engineering professions. *Journal of Agricultural Engineering Research*, 76, 251–265.

Kuan, K. K. Y., & Chau, Y. K (2001). A perception-based model for EDI adoption in small businesses using a techhnology-organization-environment framework. *Information and Management*, 38, 507–521.

Kwon, T. H., & Zmud, R. W. (1987). Unifying the fragmented models of information systems implementation. In Boland and Hirschheim (Eds.), *Critical issues in information systems research*, John Wiley, New York.

Lal, K. (1999). Determinants of the adoption of information technology: A case study of electrical and electronic goods manufacturing firms in India. *Research Policy*, 28, 667–680.

Lefebvre, L. A., Lefebvre, E., & Harvey, J. (1996). Intangible assets as determinants of advanced manufacturing technology adoption in SME's: Toward an evolutionary model. *IEEE Transactions on Engineering* Management, 43(3), 307–322.

Lehrer, A. R., Lewis G. S., & Aiziubud E. (1992). Oestrus detection in cattle: Recent develop. *Animal Reproduction Science*, 28, 355–361.

Levidow, L., & Bijman, J. (2002). Farm inputs under pressure from the European food industry. *Food Policy*, 27(1), 31–45.

Lewis, T. (1998). Evolution of farm management information systems. *Computers and Electronics in Agriculture*, 19, 233–248.

Liang, H., Saraf, N., & Hu, Q. (2007). Assimilation of enterprise systems: The effect of institutional pressures and the mediating role of top management. *MIS Quarterly*, 31(1), 59–87.

Lin, H-F. (2008). Determinants of successful virtual communities: Contributions from system characteristics and social factors. *Information & Management*, 45, 522–527.

Lippert, S. K., & Davis, M. (2006). A conceptual model integrating trust into planned change activities to enhance technology adoption behavior. *Journal of Information Science*, 32(5), 434–448.

Locke, E., & Schweiger, D. M. (1979). Participation in decision-making: One more look. In: Cummings, L. L., Staw, B. M. (Eds.), *Research in Organizational Behavior*, Greenwich, 265–339.

Lopes, D. C., Martins, J. H., Filho, A. F. L., Melo, E. C., Monteiro, P. M. B., & Queiroz, D. M. (2008). Aeration strategy for controlling grain storage based on simulation and on real data acquisition. *Computers and Electronics in Agriculture*, 63, 140–146.

López, C. P., & Requena, J. C. (2005). Factors related to the adoption of organic farming in Spanish olive orchards. *Spanish Journal of Agricultural Research*, 3(1), 5–16.

Lu, J., Yao, J. E. and Yu, C. S. (2005). Personal innovativeness, social influences and adoption of wireless internet services via mobile technology. *Journal of Strategic Information Systems*, (14), 245–268.

Lyytinen, K., & Hirschheim, R. A. (1987). Information systems failures: A survey and classification of the empirical literature. In *Oxford Surveys in Information Technology*, P. I. Zorkoczy (Ed.), Oxford UK, 257–309.

Maatje, K., De Mol, R. M., & Rossing, W. (1997). Cow status monitoring (health and oestrus) using detection sensors. *Computers and Electronics in Agriculture*, 16(3), 245–254.

Mabert, V. A., Soni, A., & Venkataramanan, M. A. (2001). Enterprise resource planning: common myths versus evolving reality. *Business Horizons*, 44(3), 69–76.

MacDonald, J. M., O'Donoghue, E. J., McBride, W. D., Nehring, R. F., Sandretto, C. L., & Mosheim, R. (2007). Profits, costs, and the changing structure of dairy farming. United States Department of Agriculture, Economic Research Service, *Economic Research Report Number 47*, http://www.ers.usda.gov/publications/err47/err47.pdf [Last accessed 04/17/12]

Madsen, T. N., & Kristensen, A. R. (2005). A model for monitoring the condition of young pigs by their drinking behavior. *Computers and Electronics in Agriculture*, 48(2), 138–154.

Madsen, T. N., Andersen, S., & Kristensen, A. R. (2005). Modelling the drinking patterns of young pigs using a state space model. *Computers and Electronics in Agriculture*, 48(1), 39–61.

Maltz, E. (2010). Novel technologies: Sensors, data and precision dairy farming. *The First North American Conference on Precision Dairy Management*, http://precisiondairy.com/proceedings/s9maltz.pdf [Last accessed 06/22/12]

Marcolin, B., Compeau, D. R., Munro, M. C., & Huff, S. L. (2000). Assessing user competence: conceptualization and measurement. *Information Systems Research*, 11(1), 37–60.

Marino P., & Dominguez, M. A. (1997). Artificial vision for automated manufacturing systems in communications industry. In *Proceedings of the 6th International Conference on Emerging Technologies and factory automation*, Los Angeles, California, September 9–12, 1997.

Markus, M. L. (1984). *Systems in Organizations: Bugs and Features*, Boston, MA: Pitman.

Marra, M., Pannell, D. J., & Ghadim, A. A. (2003). The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: Where are we on the learning curve? *Agricultural Systems*, 75, 215–234.

Mawhinney, C. H., & Lederer, A. L. (1990). A study of personal computer utilization by managers. *Information & Management*, 18, 43–253.

McBratney, A., Whelan, B., & Ancev, T. (2005). Future directions of precision agriculture. *Precision Agriculture*, 6, 7–23.

McAfee, A. (2002). The impact of enterprise information technology adoption on operational performance: An empirical investigation. *Production and*

Operations Management, 11(1), 33–53.

McCardle, K. F. (1985). Information acquisition and the adoption of new technology. *Management Science*, 31(11), 1372–1389.

McDonough, J., & McDonough, S. (1997). *Research Methods for English Language Teachers*, London: Arnold.

McMillan, J. H. (2004). *Educational Research*, Boston, MA: Allyn and Bacon.

Meade, L. M., & Sarkis, J. (1999). Analyzing organizational project alternatives for agile manufacturing processes: An analytical network approach. *International Journal of Production Research*, 37(2), 241–261.

Mehrtens, J., Cragg, P. B., & Mills, A. M. (2001). A model of Internet adoption by SMEs. *Information & Management*, 39, 165–176.

Melin, M. (2005). Optimizing cow traffic in automatic milking systems – with emphasis on, feeding patterns, cow welfare and productivity. *PhD Dissertation*, No 2005:63, Swedish University of Agricultural Sciences, Uppsala Sweden.

Melville, N., Kraemer, K., & Gurbaxani, V. (2004). Information technology and organizational performance: An integrative model of it business value. *MIS Quarterly*, 28(2), 283–322.

Mertens, K., Decuypere, E., De Baerdemaeker, J., & De Ketelaere, B. (2011). Modelling animal systems review: Statistical control charts as a support tool for the management of livestock production. *Journal of Agricultural Science*, 149, 369–384.

Michael, H., & Andreas, M. K. (2004). A beginner’s guide to partial least squares analysis. *Understanding Statistics*, 3(4), 283–297.

Moore, G. C., Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systems Research*, 2(3), 192–222.

Moore, G. C. and Benbasat, I. (1996). Integrating diffusion of innovations and theory of reasoned action models to predict utilization of information technology by end-users. *Diffusion and Adoption of Information Technology*, K.

Kautz and J. Pries-Heje (eds.), Chapman and Hall, London, 132–146.

Morag I, Edan Y., & Maltz E. (2001). An individual feed allocation decision support system for the dairy farm. *Journal of Agricultural Engineering Research*, 79(2), 167–176.

Morris, C., Loveridge, A., & Fairweather, J. (1995). Understanding why farmers change their farming practices: The role of orienting principles in technology transfer. *AERU Research Report 232*, Lincoln University, Canterbury, New Zealand.

Morris, M. G., & Venkatesh, V. (2000). Age differences in technology adoption decisions: Implications for a Changing Workforce. *Personnel Psychology*, 5, 375–403.

Morris, M. G., Venkatesh, V., & Ackerman, P. L. (2005). Gender and age differences in employee decisions about new technology: An extension to the theory of planned behavior. *IEEE Transactions on Engineering Management*, 52(1), 69–84.

Mottram, T. (1997). Automatic monitoring of the health and metabolic status of dairy cows. *Livestock Production Science*, 48, 209–217.

Mukhopadhyay, T., & Kekre, S. (2002). Strategic and operational benefits of electronic integration in B2B procurement processes. *Management Science*, 48(10), 1301–1313.

Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: A review of the literature. *Journal of Information Technology for Teacher Education*, 9(3), 319–342.

Naas, I. A. (2001). Precision Animal Production. *Agricultural Engineering International: the CIGR Journal of Scientific Research and Development*, 3.

Naas, I. A. (2002). Application of mechatronics to animal production. *Agricultural Engineering International: the CIGR Journal of Scientific Research and Development*, 4.

Nambisan, S., & Wang, Y. M. (1999). Roadblocks to web technology adoption?

Communications of the ACM, 42(1), 98–101.

Nash, E., Dreger, F., Schwarz, J., Bill, R., & Werner, A. (2009). Development of a model of data-flows for precision agriculture based on a collaborative research project. *Computers and Electronics in Agriculture*, 66, 25–37.

Nedović-Budić, Z., & Godschalk, D. R. (1996). Human factors in adoption of geographic information systems: A local government case study. *Public Administration Review*, 56(6), 554–567.

Nelson, R. R., & Phelps, E. S. (1966). Investment in humans, technological diffusion and economic growth. *American Economic Review*, 56(2), 69–75.

Nemenyi, M., Mesterhazi, P. A., Pecze, Zs., & Stepan, Zs. (2003). The role of GIS and GPS in precision farming. *Computers and Electronics in Agriculture*, 40, 45–55.

Niederhauser, N., Oberthur, T., Kattnig, S., & Cock, J. (2008). Information and its management for differentiation of agricultural products: The example of specialty coffee. *Computers and Electronics in Agriculture*, 61, 241–253.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, 5(1), 14–37.

Nwana, H. S., Rosenschein, J., Sandholm, T., Sierra, C., Maes, P., & Guttmann, R. (1998). Agent-mediated electronic commerce: issues, challenges and some viewpoints. *The 2nd International Conference on Autonomous Agents*, Minneapolis, MN.

OECD (2000). Small and medium-sized enterprises: Local strength, global reach. http://www.oecd.org/dataoecd/3/30/1918307.pdf [Last accessed 04/28/12]

Ogbonna, E., & Harris, L. C. (2005). The adoption and use of information technology: A longitudinal study of a mature family firm. *New Technology, Work and Employment*, 20(1), 1–18.

Okali, C., & Knipscheer, H. C. (1985). Small ruminant production in mixed farming systems: Case studies in research design. Paper for FSSP 5th Annual Research and Extension Symposium, http://pdf.usaid.gov/pdf_docs/pnaav944.pdf [Last accessed 06/13/12]

Oliveira, T., & Martins, M. F. (2011). Literature review of information technology adoption models at firm level. *The Electronic Journal Information Systems Evaluation*, 1, www.ejise.com, 110–121. [Last accessed 06/13/12].

Onder, H., Cam, M. A., & Soydan, E. (2009). Automation of flock management and establishment of decision support systems for small ruminant production. *Asian Journal of Animal and Veterinary Advances*, 1–6.

Ordolff, D. (Ed.), (1997). Special Issue: Robotic milking. *Computers and Electronics in Agriculture*, 17, 1–137.

Osterland, A. (2000). Blaming ERP. *CFO*, 16(1), 89-92.

Ouweltjes, W., & De Koning, K. (2004). Demands and opportunities for operational management support, In Automatic milking: A better understanding. Meijering, A. and Hogeveen, H. and de Koning C. J. A. M. (Eds), Wageninigan Academic Publisher, 443–449.

Painter, M. J. (2007). A comparison of the dairy industries in Canada and New Zealand. *Journal of International Farm Management*, 4(1), 1–19.

Palvia P., Means, D. B., & Jackson, W. M. (1994). Determinants of computing in very small businesses. *Information and Management*, 27, 161–174.

Persson-Waller, K., Westermark, T., Ekman, T., & Svennersten- Sjaunja, K. (2003). Milk leakage–An increased risk in automatic milking systems. *Journal of Dairy Science*, 86, 3488–3497.

Petersen, B., Knura-Deszczka, S., Ponsgen-Schmidt, E., & Gymnich, S. (2002). Computerized food safety monitoring in animal production. *Livestock Production Science*, 76, 3, 207–213.

Pietersma, D. Lacroix, R., & Wade, K. M. (1998). A framework for the development of computerized management and control systems for use in dairy farming. *Journal of Dairy Science*, 81, 2962–2972.

Pomar, J., & Pomar, C. (2005). A knowledge-based decision support system to improve sow farm productivity. *Expert Systems with Applications*, 29(1), 33–40.

Premkumar, G. P. (2000). Interorganization systems and supply chain management: An information processing perspective. *Information Systems Management*, 17(3), 1–14.

Premkumar, G., & Potter, M. (1995). Adoption of computer aided software engineering (case) technology: An innovation adoption perspective. *Data Base Advances*, 26(2/3), 105–124.

Prekumar, G., & Ramamurthy, K. (1995). The role of interorganizational and organizational factors on the decision mode for the adoption of interorganizational systems. *Decision Science*, 26(3), 303–336.

Premkumar, G., Ramamurthy, K., & Crum, M. (1997). Determinants of EDI adoption in the transportation industry. *European Journal of Information Systems*, 6(2) 107–121.

Premkumar, G., & Roberts, M. (1999). Adoption of new information technologies in rural small businesses. *Omega International Journal of Management Science*, 27(4), Elsevier, 467–484.

Prescott, M. B., & Conger, S. A. (1995). Information technology innovations: A classification by it locus of impact and research approach. *Data Base Advances*, 26(2/3), 20–41.

Ptak, E., Satoła, A., & Hanna, C. (2004). Prediction of 305-day lactation milk, fat and protein yields using legendre polynomials and test-day yields from different parts of lactation. *Animal Science Papers and Reports*, 22(2), 173–183.

Purvis, R. L., Sambamurthy, V., & and Zmud, R. W. (2001). The assimilation of knowledge platforms in organizations: An empirical investigation. *Organization Science*, 12(2), 117–135.

Putt, A. (2006). *Putt's law and the successful technocrat: How to win in the information age*. Wiley-IEEE Press, ISBN 0-471-71422-4, 7.

Ramamurthy, K., Sen, A., & Sinha, A. P. (2008). An empirical investigation of the key determinants of data warehouse adoption. *Decision Support Systems*, 44, 817–841.

Rasmussen, M. D., Bjerring, M., Justesen, P., & Jepsen, L. (2002). Milk quality on Danish farms with automatic milking systems. *Journal of Dairy Science*, 85, 2869–2878.

Raub, A. C. (1981). Correlates of computer anxiety in college students. *Unpublished Doctoral Dissertation*, University of Pennsylvania.

Ray, G., Muhanna, W. A., Barney, J. B. (2005). Information technology and the performance of the customer service process: A resource-based analysis. *MIS Quarterly*, 29(4), 625–652.

Reed, J. N., Miles, S. J., Butler, J., Baldwin, M., & Noble R. (2001). Automatic mushroom harvester development, *Journal of Agriculture Engineering Research*, 78(1), 15–23.

Rider, A., (1998). Private-public sector co-operation can be key to research. *Landwards*, 53(3), 2–8.

Rigby, D. K., Reichheld, F. F., & Schefter, P. (2002). Avoid the four perils of CRM. *Harvard Business Review*, 80(2), 101–109.

Rockart, J. F., Earl, M. J., & Ross, J. W. (1996). Eight imperatives for the new IT organization. *Sloan Management Review*, 43–55.

Robert, P. C. (2002). Precision agriculture: A challenge for crop nutrition management. *Plant and Soil*, 247, 143–149.

Rogers, E. M. (1991). The ‘critical mass’ in the diffusion of interactive technologies in organizations. Kraemer KL, editor, *The information systems research challenge: Survey research methods*, 3, Boston: Harvard Business School Press, 245–63.

Rogers, E. M. (1995). *Diffusion of Innovations*, New York, Free Press.

Roelofs, J. B., Van Eerdenburg, F. J. C. M., Soede, N. M., & Kemp, B. (2005). Pedometer readings for estrous detection and as predictor for time of ovulation in dairy cattle. *Theriogenology*, 64, 1690–1703.

Rosenburg, N. (1982). *Inside the black box: Technology and economics*, Cambridge University Press, Cambridge, United Kingdom.

Ross, J. W., & Weill, P. (2002). Six IT decisions your IT people shouldn't make. *Harvard Business Review,* 80(11), November, 84–91.

Rossing, W., Hogewerf, P. H., Ipema, A. H., Ketelaar-de Lauwere, C. C., & De Koning, C. J. A. M. (1997). Robotic milking in dairy farming. *Netherlands Journal of Agricultural Sciences,* 45, 15–31.

Rowley, J. (2002). Using case studies in research. *Management Research News*, 25(1), 16–27.

Russo, N. L., & Kumar, K. (1992). Studying the impact of information technology innovations in organizations: The influence of individual characteristics, innovation characteristics, and the innovation introduction process. In K.E. Kendall et al. (Ed.), *The impact of computer-supported technologies on information systems development.* Minneapolis, MN: Elsevier Science Publications, B. V.

Saha, A., Love, H. A., & Schwart, R. (1994). Adoption of emerging technologies under output uncertainty. *American Journal of Agricultural Economics*, 76(4), 836–846.

Salancik, G. R., & Pfeffer, J. (1978). A social information processing approach to job attitudes and task design. *Administrative Science Quarterly*, 23, 224–253.

Sambamurthy, V., & Zmud, R. W. (1994*). IT management competency assessment: A tool for creating business value through IT*. Morristown, NJ: Financial Executives Research Foundation.

Sambamurthy, V., & Zmud, R. W. (1997). At the heart of success: Organization-wide management competencies. In C. Sauer and P.W. Yetton (eds.), *Steps to the Future: Fresh Thinking on the Management of IT-Based Organizational Transformation.* San Francisco: Jossey-Bass, 143–163.

Samuelsson, B., Wahlberg, E., & Svennersten, K. (1993). The effect of feeding during milking on milk production and milk flow. *Swedish Journal of Agricultural Research*, 23, 101–106.

Sapru, A., Barbano, D. M., Yun, J. J., Klei, L. R., Oltenacu, P. A., & Bandler D. K.

(1997). Cheddar cheese: Influence of milking frequency and stage of lactation on composition and yield, *Journal of Dairy Science*, 80, 437–446.

Scapens, R. W. (1990). Researching management accounting practice: The role of case study methods. *British Accounting Review*, 22, 259–281.

Schmidt, D., Rockwell, S. K., Bitney, L., & Sarno, E. A. (1994). Farmers adopt microcomputers in the 1980s: Educational needs surface for the 1990s. *Journal of Extension*, 32(1), http://www.joe.org/joe/1994june/a9.html [Last accessed 01/03/2010]

Schulze, C., Spilke, J., & Lehner, W. (2007). Data modeling for precision dairy farming within the competitive field of operational and analytical tasks. *Computers and Electronics in Agriculture*, 59, 39–55.

Scupola, A. (2003). The adoption of internet commerce by SMEs in the south of Italy: An environmental, technological and organizational perspective, *Journal of Global Information Technology Management*, 6(1), 51–71.

Segars, A. H., & Hendrickson, A. R. (2000). Value, knowledge, and the human equation: Evolution of the information technology function in modern organizations. *Journal of Labor Research*, 21(3), 431–445.

Shao, B., & Xin, H. (2008). A real-time computer vision assessment and control of thermal comfort for grouphoused pigs. *Computers and Electronics in Agriculture*, 62(1), 15–21.

Sliva, E., Banhazi, T., & Tonkin, M. (2007). Development of a prototype sensor for measuring feed disappearance in livestock buildings, in *SEAg 2007*, Banhazi, T. & Saunders, C. (editors), Adelaide, Australia, SEAg, 1, 221-225.

Son, J. Y., & Benbasat, I. (2007). Organizational buyers' adoption and use of B2B electronic marketplaces: efficiency and legitimacy-oriented perspectives. *Journal of Management Information* Systems, 24(1), 55–99.

SPSS (2003). *SPSS 12 help manual*. Chicago, Illinois: SPSS.

Stantiall, J. D. & Parker, W. J. (1997). Adoption of technology and information on New Zealand dairy farms, *Report on a Dairy Industry Exchange Forum*, Massey University, Palmerstion North.

Stefanowska, J., Tiliopoulus, N. S., Ipema, A. H., & Hendriks, M. M. W .B. (1999). Dairy cow interactions with an automatic milking system starting with "walk-through" selection, *Applied Animal Behaviour Science*, 63, 177–193.

Stefanowska, J., Plavsic, M., Ipema, A. H., & Hendriks, M. M. W. B. (2000). The effect of omitted milking on the behaviour of cows in the context of cluster attachment failure during automatic milking. *Applied Animal Behaviour Science*, 67, 277–291.

Steinberger, G., Rothmund, M., & Auernhammer, H. (2009). Mobile farm equipment as a data source in an agricultural service architecture. *Computers and Electronics in Agriculture*, 65, 238–246.

Stoner, C. R. (1987). Distinctive competence and competitive advantage. *Journal of Small Business Management*, April, 33–39.

Subramani, M. R. (1999). Linking IT use to benefits in interorganizational networks: The mediating role of relationship-specific intangible investments. In *Proceedings of the 20th International Conference on Information Systems*, Association for Information Systems Atlanta, GA, USA, 358–363.

Sullivan, C. (1985). Systems planning in the information age. *Sloan Management Review*, Winter, 3–12.

Svennersten-Sjaunja, K., Berglund, I., & Pettersson, G.. (2000). The milking process in an automated milking system, evaluation of milk yield, teat condition and udder health. In *Proceedings of the International Symposium on Prospects for Automatic Milking*, Lelystad, the Netherlands. Wageningen Pers, Wageningen, the Netherlands, 277–287.

Svennersten-Sjaunja K. M., & Pettersson G. (2007). Pros and cons of automatic milking in Europe, http://jas.fass.org/content/86/13_suppl/37. [Last accessed 04/26/12].

Swanson, E. B. and Ramiller, N. C. (2004). Innovating mindfully with information technology. *MIS Quarterly*, 28(4), 553–583.

Szajna, B. (1996). Empirical evaluation of the revised technology acceptance model. *Management Science*, 42, 85–92.

Tanigaki, K., Fujiura, T., Akase, A., & Imagawa, J. (2008). Cherry-harvesting robot. *Computers and Electronics in Agriculture*, 63, 65–72.

Taylor, S., & Todd, P. A. (1995a). Understanding information technology usage: A test of competing models. *Information Systems Research* 6(2), 144–174.

Taylor, S., & Todd, P. A. (1995b). Assessing IT usage: The role of prior experience. *MIS Quarterly*, 19(4), 561–571.

Tellis, W. (1997). Introduction to case study. *The Qualitative Report*, 3(2), July, http://www.nova.edu/ssss/QR/QR3-2/tellis1.html [Last accessed 05/09/12]

Teo, T. S. H., Ranganathan, C., & Dhaliwal, J. (2006). Key dimensions of inhibitors for the deployment of web-based business-to-business electronic commerce. *IEEE Transactions on Engineering Management*, 53(3), 395–411.

Teo, T. S. H., Lin, S., & Lai, K-H. (2009). Adopters and non-adopters of e-procurement in Singapore: An empirical study. Omega, 37, 972-987.

Thomas, D., & Callahan, D. (2002). Information technology adoption in agricultural operations: A progression path. *Ideas at Work*, December, 40, 6, http://www.joe.org/joe/2002december/iw1.php. [Last accessed 01/03/2010].

Thompson, P. (1989). *The Nature of Work: An Introduction to Debates on the Labour Process*. Second edition, MacMillan Education LTD, Hampshire, London.

Thompson, R. L., Higgins, C. A., & Howell, J. M. (1991). Personal computing: toward a conceptual model of utilization. *MIS Quarterly*, 15(1), 124–143.

Thompson, R. L., Higgins, C. A., & Howell, J. M. (1994). Influence of experience on personal computer utilization: Testing a conceptual model. *Journal of Management Information Systems*, 11(1), 167–187.

Thong, J. Y. L. (1999). An integrated model of information systems adoption in small businesses. *Journal of Management Information Systems*, 15(4), 187–214.

Thong, J. Y. L., & Yap, C. S. (1995). CEO characteristics, organizational characteristics and information technology adoption in small businesses. *Omega International Journal of Management Science*, 23(4), 429–442.

Thong, J. Y. L., Hong, S-J., & Tam, K. Y. (2006). The effects of post-adoption beliefs on the expectation-confirmation model for information technology continuance. *International Journal of Human-Computer Studies*, 64, 799–810.

Tian, L. (2002). Development of a sensor-based precision herbicide application system. *Computers and Electronics in Agriculture*, 36, 133–149.

Timmermans, A. J. M., & Hulzebosch, A. A. (1996). Computer vision system for on-line sorting of pot plants using an artificial neural network classifier. *Computers and Electronics in Agriculture*, 15, 41–55.

Torbett, J. C., Roberts, R. K., Larson, J. A., & English, B. C. (2008). Perceived improvements in nitrogen fertilizer efficiency from cotton precision farming. *Computers and Electronics in Agriculture*, 64, 140–148.

Torkzadeh, G., & Doll, W. J. (1999). The development of a tool for measuring the perceived impact of information technology on work. *Omega, International Journal of Management Science*, 27, 327–339.

Tornatzky, L. G., & Fleischer M. (1990). *The processes of technological innovation*. Lexington Books, Lexington, Massachusetts, Toronto, 152–154.

Tornatzky, L. G., & Klein, K. J. (1982). Innovation characteristics and innovation adoption-implementation: A meta-analysis of findings. *IEEE Transactions on Engineering Management*, 29(1), 28–45.

Tothill, I. E. (2001). Biosensors: Developments and potential applications in the agricultural diagnosis sector. In: Cox, S.W.R., Schmoldt, D.L. (Eds.). Millennium Special Issue. *Computers and Electronics in Agriculture,* 30, 205–218.

Triandis, H. C. (1971). *Attitude and Attitude Change*. New York, John Wiley.

Tukey, J. (1997). More honest foundations for data analysis. *Journal of Statistical Planning and Inference*, 57(1), 21–28.

Tuckey, S. L., & Stadhouders, J. (1967). Increase in sensitivity of organoleptic detection of lipolysis in cow's milk by culturing or direct acidification. *Netherlands Milk* and *Dairy Journal*, 21, 158–162.

Ullman, J. B. (2001). Structural equation modeling. In B. G. Tabachnick & L. S. Fidell (Eds.). *Using multivariate statistics* (4th ed.), Needham Heights, MA: Allyn & Bacon.

USDA, (2002). Part III: References of dairy cattle health and health management practices in the United States. APHIS: VS CEAH. National Animal Health Monitoring System, Fort Collins, CO.

Van der Aalst, W. M. P., ter Hofstede, A. H. M., & Weske, M. (2003). Business process management: A survey. W. M. P. Van der Aalst et al. (Eds.): *BPM 2003*, LNCS 2678, 1–12.

Van Asseldonk, M. A. P. M. (1999). Economic evaluation of information technology applications on dairy farms. *Doctoral Dissertation*, Wageningen Agricultural University.

Van Akkeren, J., & Cavaye, A. L. M. (1999). Factors affecting entry-level internet technology adoption by small business in Australia: An empirical study. *Proceedings of the 10th Australasian Conference on Information Systems*, 1071–1083.

Van Henten, E. J., Hemming, J.,Van Tuijl, B. A. J., Kornet, J. G., Meuleman, J., Bontsema J., & Van Os, E. A. (2002). An autonomous robot for harvesting cucumbers in greenhouses. *Autonomous Robots*, 13, 241–258.

Venkatesh, V., & Morris, M. G. (2000). Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage. *MIS Quarterly*, 24(1), 115–139.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field. *Management Science*, 46(2), 186–204.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425–

478

Vitale, M. R., Ives, B., & Beath, C. M. (1985). Linking information technology and corporate strategy: An organizational view. *Proceedings of* the *6th International Conference on Information Systems*, 265–276.

Wang, N., Zhang, N., & Wang, M. (2006). Wireless sensors in agriculture and food industry–Recent development and future perspective. *Computers and Electronics in Agriculture*, 50, 1–14.

Wathes, C. M., Kristensen, H. H., Aerts, J.-M., & Berckmans, D. (2008). Is precision livestock farming an engineer's daydream or nightmare, an animal's friend or foe, and a farmer's panacea or pitfall? C*omputers and Electronics in Agriculture*, 64, 2–10.

Watt, A. C., Aziz, S. M., & Banhazi, T. M. (2010). Air pollution and livestock production. *XVIIth World Congress of the International Commission of Agricultural and Biosystems Engineering (CIGR)*, Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB) Québec City, Canada, June 13–17.

Webster, J., & Martocchio, J. (1992). Microcomputer playfulness: development of a measure with workplace implications. *MIS Quarterly*, 16(2), 201–226.

Weiss, D., Helmreich, S., Mo¨stl, E., Dzidic, A., & Bruckmaier, R. M. (2004). Coping capacity of dairy cows during the change from conventional to automatic milking. *Journal of Animal* Science, 82, 563–570.

Woolford, M. W., Williamson J. H., & Henderson, H. V. (1998). Changes in electrical conductivity and somatic cell count between milk fractions from quarters subclinically infected with particular mastitis pathogens. *Journal of Dairy Research*, 65, 187–198.

Wong, F. (2006). Why we protest the world trade organization. *The Mission Magazine of the United Methodist Church*.

Wozniak, G. D. (1987). Human capital, information, and the early adoption of new technology. *The Journal of Human Resources*, 22(1), 101–112.

Xiong, B., Fu, R., Lin, Z., Luo, Q., & Yang, L. (2009). A solution on identification and rearing files in smallhold pig farming. In IFIP International Federation for Information Processing, eds. D. Li, Z. Chunjiang, (Boston: Springer), *Computer and Computing Technologies in Agriculture II*, 295(*3)*, 2249–2258.

Yap, C. S., Soh, C. P. P., & Raman, K. S. (1992). Information systems success factors in small business. *Omega International Journal of Management Science*, 5(6), 597–-609.

Yap C. S., Thong J. Y. L., & Raman, K. S. (1994). Effect of government incentives on computerization in small business. *European journal of Information Systems*, 3, 191–206.

Yin, R. K. (2003). *Case Study Research Design and Methods*. 2nd Ed. Thousand Oaks, CA: Sage Publications.

Yin, R., & Moore, G. (1987). The use of advanced technologies in special education. *Journal of Learning Disabilities*, 20(1), 60.

Zack, M. H., & McKenney, J. L. (1995). Social context and interaction in ongoing computer-supported management groups, *Organization Science*, 6(4), 394–422.

Zairi, M. (1997). Business process management: A boundaryless approach to modern competitiveness. *Business Process Management Journal*, 3(1), 64–80.

Zecconi, A., Piccini, R., Casirani, G., Binda, E., & Migliorati, L. (2003). Effects of automatic milking system on teat tissues, intramammary infections and somatic cell count. *Italian Journal of Animal Science*, 2, 275–282.

Zhang, N., Wang, M., & Wang, N. (2002). Precision agriculture – A worldwide overview, *Computers and Electronics in Agriculture*, 36(2/3), 113–132.

Zhu, K., & Kraemer, K. L. (2005). Post-adoption variations in usage and value of e-business by organizations: Cross-country evidence from the retail industry. *Information Systems Research*, 16(1), 61–84.

Zhu, K., Kraemer, K. L., & Xu, S. (2003). Electronic business adoption by European firms: a cross-country assessment of the facilitators and inhibitors. *Center for Research on Information Technology and Organizations*, University of California, Irvine, www.crito.uci.edu

Zhu, K., Kraemer, K. L., & Xu, S. (2006). The process of innovation assimilation by firms in different countries: A technology diffusion perspective on e-business. *Management Science*, 52(10), 1557–1576.

Zhu, K., Kraemer, K. L., Xu, S., & Dedrick, J. (2004). Information technology payoff in e-business environments: An international perspective on value creation of e-business in the financial services industry. *Journal of Management Information Systems*, 21(1), 17–54.

Zilberman, D., Khanna, M., & Lipper, L. (1997). Economics of new technologies for sustainable agriculture. *Australian Journal of Agricultural and Resource Economics*, 41(1), 63–80.

Zolla Jr., G. A. (1999). Information technology diffusion: A comparative case study of intranet adoption, management of engineering and technology. *Technology and Innovation Management*, PICMET '99, Portland International.

Appendices

Appendix A: List of Abbreviations

	Study Abbreviations		Study Abbreviations
AMS	Automated Milking System	PU	Perceived Usefulness
AMT	Advanced Manufacturing Technologies	RFID	Radio frequency identification
AgIS	Agricultural Information System	SCM	Supply Chain Management
AVE	Average Variance Extracted	SEM	Structural Equation Modeling
BPM	Business Process Management	SMEs	Small And Medium-Size Enterprises
CFA	Confirmatory factor analysis	SPSS	Statistical Package for Social Sciences
CINFO	Internet-based coffee information system	TAM	Technology Acceptance Model
CMS	Conventional Milking System	TOE	Technology-Organization-Environment
DIM	Days in Milk	TPB	Theory Of Planned Behavior
DMIS	Dairy Management Information System	TRA	Theory of Reasoned Behavior
EDI	Electronic Data Interchange		**Model Abbreviations**
EFA	exploratory factor analysis	AGE	Age
FMIS	Farm Management Information System	CSE	Computer Self-efficacy
FRS	Farm Records System	CSP	Cooperative Support
IDT	Innovation Diffusion Theory	DOP	Daily Operations
IOS	Inter-organizational Systems	FSC	Farm Size
IS	Information Systems	HHM	Herd Health Management
IT	Information Technology	MOD	System Components
JIT	Just-in-Time	OCP	Organization Competence
MRP	Material Requirements Planning	PAU	Process Automation
PA	Precision Agriculture	PBN	Perceived Benefits
PCA	Principal Components Analysis	PPN	Production Planning
PDF	Precision Dairy Farming	SCP	System Compatibility
PEOU	Perceived Ease of Use	SCX	System Complexity
PLF	Precision Livestock Farming	SIN	Social Influences
PLS	Partial Least Squares	YRD	Years of Dairy Experience

Appendix B: Case Study Open-Ended Interview Questions

Area	Questions
Demographics	Name, location, size of farm (herd-size), years in dairy industry, age, education, place of birth, and grow up on a farm
How does farmer feel about …	Dairy farm automation, food safety and processing, maximizing profits
Adoption	What is the farmer using? What is the farmer not using? Has the farmer partially adopted certain modules? Does the farmer know other farmers using the dairy management information systems modules?
Factors affecting adoption (Positive)	Reliability of technology, knowledge of technology, additional learning to knowledge base, flexibility, profitability perceptions, improves or enhances learning, compatibility to business and personal goals, planning tool, saving time (resolve problems), others are using (social network)
Barriers for adoption (Negative)	Complexity of technology, difficulty in using, difficult in learning to use, bank requirements and cash flow issues, capital outlay; resources , to adopt and survive; high risk loans, uncertainty and risk (assurance that technology will benefit them), conflicting information, lack of social infrastructure (network) and access to knowledge
Other discussion	Veterinarian, area dealer, farm labor, milk quality, government support, SCC, heat detection, R, economics, Korea statistics, social networks

Appendix C: Dairy Management Information System Components

Module	Description
System	Composed of four sub-components. Its main function is to collect detailed information about every cow, store and process the data, and present it in a user friendly format. The system consists of the following main components.
Meter	Milk meter that measures yield, conductivity[26], flow rate, and milking times. The module analyzes milking pattern and provides automated cluster removal to optimize yield and milking parlor optimization. *Meter* also helps prevent contaminated milk from entering the milk tank, alerts the farmer if a cow has mastitis and faulty milking equipment.
Lab	Real-time on-line milk analyzer. It collects data on individual cows in every milking session. *Lab* collects milk component information (e.g., fat content, protein and lactose) and measures blood and SCC quantity. The system provides real time analysis and alerts. A critical component of *Lab* is its ability to identify the presence of blood in the milk in real time, allowing the discontinuation of the milking and minimizing the contamination of "milk in the tank."
Tag and	Sensor-based. The *Tag* is a transponder/pedometer that is attached to the cow's

[26] Conductivity is measured as a screening test for mastitis (Fernando et.al. 1982) and is used for tracking udder health (Woolford, 1998).

Ideal	leg and measures its activities and rest behavior. At present, the data is downloaded at milking time. The data collected helps the farmer in "heat detection" and cow welfare. The system alerts the farmer if environmental conditions such as bedding, group density, weather stress and access to food and water are suboptimal. The *Ideal* system is used to ensure accurate identification of each cow.

The dairy management information system also includes the following sub-components for farm and herd management.

Sub	Description
Farm	HM software used with all modules. The system automates daily operational routine activities traditionally carried out by herdsmen. The Farm system relies on data collected by Milk, Weigh and Act. The system can be customized by the user to fit individual farming style, select reports, and daily activities. Farm provides the farm manager with a list of daily activities based on the state of the herd on a given day. The activities are related to cow fertility (e.g., breeding list, open cows, dry-off schedule, calving schedule), cow health (e.g., cows suspected as having health problems, veterinary visits), equipment (e.g., efficiency of milking machines and milkers' work, over milking, average milk curve, equipment malfunction), and production (e.g., milk production by group, day, session, deviation from the standard). Farm enables the manager to plan the herd structure, quota management and yield optimization.
Act	Uses the pedometers described above to monitor and detect cows in heat for optimal breeding and lactation. Due to the critical function of heat detection, Act is often the first module installed by farmers. Other modules can be added as needed. Act is also used by large grazing farms to identify cows in need regardless of their location.
Weight	Module that enables the automatic identification and weighing of cows without manual intervention. Tracking cows' weight is one way to detect potential metabolic disorders and other health problems. Thus, Weigh enables early detection and treatment of unhealthy cows, which contributes to the overall welfare of the herd and reduced loss due to downtime of unhealthy cows. Tracking cow's weight also enables improved feeding management and the precision feeding of individual cows.
Sort	Computerized gate control that directs cow traffic. Farmers have to perform numerous checks, examinations and treatments daily. Sort tracks, selects and monitors the cows that need special attention and directs them to the proper location. For example, cows that are due for a veterinary check are selected and directed to a hospital/treatment pen. This is done automatically as cows move from the milking area back to their pen.
2GO	PDA type device used by the farmer while in the field. 2GO is a complementary accessory to the Milk system. The system includes RFID capabilities, enabling the herdsman a quick and accurate identification of cows. As of Feb 2010, the synchronization of data between the 2GO and the Milk systems is done off-line.

Appendix D-1: Quantitative Study English Survey Questionnaire

Part I: Use of the System

Which one of the following statements best describes use of the DMIS by you (SST1):

- ☐ I am not currently using the DMIS
- ☐ I use the DMIS by maintaining both old and new system for an extended period of time
- ☐ I have used the DMIS by replacing an existing system with DMIS modules
- ☐ I am currently using the DMIS exclusively, and I did not have to replace an existing system

Part II: Perception of the DMIS

Please rate your level of agreement from 1-7 (strongly disagree, disagree, slightly disagree, neither, slightly agree, agree, strongly agree) with the following statements

SCX1	the system is easy to learn
SCX2	the system is easy to understand
SCX3	I am satisfied with the system
SCX4	the skills I need to use the system are simple
SCX5	integrating the system into our work routine has been easy
OCP1	I have sufficient skills to implement the system
OCP2	I have sufficient skills and expertise to use the system
OCP3	I have sufficient skills to adapt the milking process to the system
SCP1	the system is similar to technology I already use
SCP2	the system is similar to technology that I used in the past
SIN1	I know other farmers that will use the system in the future
SIN2	the system was recommended to me by other farmers
SIN3	the system improves my relationship with other farmers
SIN4	the system improves the image of my farm
OCP4	I use the system to comply with government mandates
CSP1	the cooperative provides technical support when a farmer adopts the system
CSP2	the cooperative provides training and education when a farmer adopts the system
CSP3	the cooperative provides financial support when a farmer adopts the system
PBN1	the system has significantly improved the quality of milk on my farm
PBN2	the system has significantly improved productivity on my farm
PBN3	the system has radically changed the milking process on my farm
PBN4	the system saves me time
PBN5	my family is more interested in managing the farm because of the system
PBN6	the system has replaced all manual activities on the farm

Please rate your level of agreement from 1-7 (strongly unimportant, unimportant, slightly unimportant, neither, slightly important, important, strongly important) with the following statements

PPN1	I use the system to measure milk yield and flow rate
DOP1	I use the system to identify the presence of blood and contaminants in the milk
PPN2	I use the system to detect cows in heat
PPN3	I use the system to identify cow health
DOP2	I use the system to provide me with a list of daily activities based on the state of the herd on a given day
PPN4	I use the system to accurately identify each cow
HHM1	I use the system to track cows' weight
DOP3	I use the system to improve feeding management
HHM2	I use the system to direct the flow of cow traffic

Part III: Questions about the DMIS

Please rank your level of use for each component that you are using.
0 = not using module; 1 = lowest; 7 = highest

___	Meter	___	Ideal	___	Weigh
___	Lab	___	Farm	___	Sort
___	Tag	___	Act	___	2GO

Please rank your ability to replace manual labor for each component that you are using. *0 = not using module; 1 = lowest; 7 = highest*

___	Meter	___	Ideal	___	Weigh
___	Lab	___	Farm	___	Sort
___	Tag	___	Act	___	2GO

Part IV: Suggestions and Insights

In the lines below, please add any comments and insights you may have regarding this survey, the DMIS and its appeal to dairy farmers (optional):

Part V: Demographics

Which one of the following statements best describes you (Mark one for each statement)
Gender (GNR): ☐ Male ☐ Female
Position (POS): ☐ Owner ☐ Manager ☐ Technician ☐ Other: __________
Age (AGE): ☐ less than 20 ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60 and over
Level of education (EDU): ☐ High School ☐ Associate Degree ☐ Technical College ☐ University

Origin (ORG): Did you grow up on a farm? ☐ Yes ☐ No
Years in the dairy industry (YRD): ☐ 0-2 ☐ 2-5 ☐ 5-10 ☐ 10-20 ☐ 20+
Please rate your level of computer knowledge (CKL):
Lowest ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 Highest
Please indicate the number of cows that you have on your farm (FSC): ___1-29 ___30-49 ___50-99 ___100-199 ___200-499 ___500-999 ___1000-1999 ___2000 and over

Appendix D-2: Quantitative Study Taiwanese/Chinese Survey Questionnaire

第一部分： 阿菲金® 系统的使用

以下选项中哪一个最好的描述了您对AfiMilk® 阿菲金® 系统的使用情况：

☐	我目前并没有使用AfiMilk® 阿菲金® 系统
☐	我已经采用了AfiMilk® 阿菲金® 系统，并且同时使用AfiMilk® 阿菲金® 系统和其他之前使用过的系统很久了
☐	我已经采用AfiMilk® 阿菲金® 系统代替了我之前使用的其他系统
☐	我目前只使用AfiMilk® 阿菲金® 系统，而且没有必要替换目前的系统

从 1 到 7，请您为您对以下关于 ***阿菲金® 系统****描述的同意程度进行打分*

SCX1	这个系统很容易学习
SCX2	这个系统很容易明白
SCX3	我对这个系统很满意
SCX4	学习这个系统所需要的技能很简单
SCX5	把这个系统整合到我们的工作流程中很容易
OCP1	我掌握了足够的技能来使用这个系统
OCP2	我拥有足够的技能和经验来使用这个系统
OCP3	我有足够的技能来根据系统的要求来调整挤奶的过程
SCP1	这个系统和我已经在使用的技术相似
SCP2	这个系统和我以前曾经用过的技术相似
SIN1	我知道其他农户打算在未来使用这个系统
SIN2	这个系统是被其他农户推荐给我的
SIN3	这个系统使我和其他农户的关系更好了
SIN4	这个系统提升了我的农场的形象
OCP4	我用这个系统是为了迎合政府的强制性规定
CSP1	如果一个农户采用了这个系统，合作伙伴会提供技术支持
CSP2	如果一个农户采用了这个系统，合作伙伴会提供培训
CSP3	如果一个农户采用了这个系统，合作伙伴会提供资金支持
PBN1	这个系统很显著的提高了我农场生产的牛奶的质量

PBN2	这个系统显著的提高了我农场的生产效率
PBN3	这个系统彻底的改变了我农场的生产过程
PBN4	这个系统节省了我的时间
PBN5	因为这个系统我的家人对管理农场更感兴趣了
PBN6	系统已经取代了农场上所有的人工劳动/人力劳动

从1到7，请您对以下关于AfiMilk® 阿菲金® 系统功能描述的重要程度进行打分

PPN1	我使用这个系统来测量牛奶生产和流量/流速
DOP1	我用这个系统来检测（牛奶中）是否有血或者污染物I
PPN2	我用这个系统来检测奶牛的温度
PPN3	我用这个系统来检测奶牛的健康情况
DOP2	我用这个系统来生成一个给予牛群情况的每日需要进行活动的清单
PPN4	我用这个系统来精确识别每一只奶牛
HHM1	我用这个系统来检测和追踪奶牛的重量
DOP3	我用这个系统来优化喂食管理
HHM2	我用这个系统来指挥奶牛群的移动和出入

第三部分：关于AfiMilk® 阿菲金® 系统的问题

宁为您目前对每个组件/模块的使用情况进行评分
0 = 没有使用这个模块; 1 = 最低分; 7 = 最高分

___ Meter乳量计	___ Ideal	___ Weigh自动称重系统
___ Lab魔盒	___ Farm阿菲牧	___ Sort 分群管理统
___ Tag辨识系统	___ Act活动量测量统	___ 2GO

请您为您用以下每个组件/模块代替人工/人力劳动的能力评分.
0 = 没有使用这个模块; 1 = 最低分; 7 = 最高分

___ Meter乳量计	___ Ideal	___ Weigh自动称重统
___ Lab魔盒	___ Farm阿菲牧	___ Sort 分群管理统
___ Tag辨识系统	___ Act活动量测量统	___ 2GO

第四部分：建议和想法

请在下面的横线部分填写任何您对本次调研，AfiMilk® 阿菲金® 系统以及它对奶农的吸引力的建议和想法：（选做题）

第五部分：基本资料

下面的描述中哪一个是对您的最好描述（请在每道题目中选择一个选项）

性别: ☐ 男 ☐ 女
职务/职位: ☐ 农场主 ☐ 农场经理 ☐ 技术人员 ☐ 其他: ____________

年龄: ☐ <20岁 ☐ 20-29岁 ☐ 30-39岁 ☐ 40-49岁 ☐ 50-59岁 ☐ 60岁以上
教育背景: ☐ 高中 ☐ 专科学院 ☐ 技术学校 ☐ 大学
出身: 请问您是否有在农场成长的经历? ☐ 有 ☐ 没有
从事乳业/奶行业的时间: ☐ 0-2年 ☐ 2-5年 ☐ 5-10年 ☐ 10-20年 ☐ 20年以上
请为您的电脑操作水平评分: 最低 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 最高
请选择您农场上目前奶牛的数量: ___1-29 ___30-49 ___50-99 ___100-199 ___200-499 ___500-999 ___1000-1999 ___2000以上

Appendix D-3: Quantitative Study Korean Survey Questionnaire

파트 1: 아피밀크® 시스템 사용

다음 중 귀하의 아피밀크® 시스템 사용에 관해 가장 적절하게 기술한 항목은 무엇입니까?

☐	나는 현재 아피밀크® 시스템을 사용하고 있지 않다.
☐	나는 이전 시스템과 새로운 시스템을 둘 다 장기간 유지하며 아피밀크® 시스템을 사용한다.
☐	나는 기존 시스템을 아피밀크® 시스템 모듈로 교체하여 아피밀크® 시스템을 사용해왔다.
☐	나는 현재 아피밀크® 시스템만 사용하고 있으며, 기존 시스템을 교체할 필요가 없었다.

파트 2: 아피밀크® 시스템에 관한 인식
다음 항목들에 귀하가 동의하는 정도를 1부터 7까지 숫자로 표시해 주십시오.
아피밀크® 시스템과 관련된 다음 항목들에 귀하가 동의하는 정도를 1부터 7까지 숫자로 표시해 주십시오.

SCX1	시스템을 배우기가 쉽다.
SCX2	시스템을 이해하기가 쉽다.
SCX3	나는 이 시스템에 만족한다.
SCX4	시스템을 사용하는 데 필요한 기술이 간단하다.
SCX5	일상 작업에 시스템을 통합하기가 수월했다.
OCP1	나는 시스템 실행 기술을 충분히 갖추고 있다.
OCP2	나는 시스템 사용에 필요한 기술과 전문성을 충분히 갖추고 있다.
OCP3	나는 착유공정을 시스템에 맞게 조정하는 기술을 충분히 갖추고 있다.
SCP1	시스템이 내가 이미 사용하고 있는 기술장비와 비슷하다.
SCP2	시스템이 과거 내가 사용했던 기술장비와 비슷하다.
SIN1	나는 장차 이 시스템을 사용하려고 하는 다른 농장주들을 알고 있다.
SIN2	나는 다른 농장주들로부터 이 시스템을 추천받았다.
SIN3	시스템 덕분에 나와 다른 농장주들의 관계가 향상되었다.

SIN4	시스템 덕분에 우리 농장의 이미지가 향상되었다.
OCP4	나는 정부 지시에 따르기 위해 이 시스템을 사용한다.
CSP1	농장주가 이 시스템을 채택할 때 조합이 기술 지원을 해준다.
CSP2	농장주가 시스템을 채택할 때 조합이 훈련과 교육을 제공한다.
CSP3	농장주가 시스템을 채택할 때 조합이 재정 지원을 해준다.
PBN1	시스템이 우리 농장의 우유 품질을 크게 향상시켰다.
PBN2	시스템이 우리 농장의 생산성을 크게 향상시켰다.
PBN3	시스템이 우리 농장의 착유공정을 획기적으로 변화시켰다.
PBN4	시스템 덕분에 내 시간이 절약된다.
PBN5	시스템 때문에 우리 가족이 농장 운영에 더 많은 관심을 갖는다.
PBN6	시스템이 농장의 모든 수작업 활동을 대체했다.

아피밀크® 시스템과 관련된 다음 항목들에 귀하가 동의하는 정도를 1부터 7까지 숫자로 표시해 주십시오.

PPN1	나는 시스템을 활용하여 산유량과 착유속도를 측정한다.
DOP1	나는 시스템을 활용하여 우유에 혼입된 혈액과 오염물질을 확인한다.
PPN2	나는 시스템을 활용하여 젖소의 발정을 감지한다.
PPN3	나는 시스템을 활용하여 젖소의 건강을 확인한다.
DOP2	나는 시스템을 활용하여 특정일의 젖소군 상태에 따라 일일 활동 목록을 제공받는다.
PPN4	나는 시스템을 사용하여 각각의 젖소를 정확히 식별한다.
HHM1	나는 시스템을 활용하여 젖소의 무게를 기록한다.
DOP3	나는 시스템을 활용하여 사료급여 관리를 개선한다.
HHM2	나는 시스템을 활용하여 젖소의 이동 흐름을 감독한다.

<u>파트3: 아피밀크® 시스템에 관한 질문</u>

귀하가 사용 중인 각 구성제품에 대한 귀하의 사용 수준이 어느 정도인지 평가해 주십시오. *0 = 사용하지 않는 모듈; 1 = 최저; 7 = 최고*

___ 아피라이트(Meter)	___ 아이디얼 (Ideal)	___ 아피웨이 (Weigh)
___ 아피랩 (Lab)	___ 아피팜 (Farm)	___ 아피소트 (Sort)
___ 아피태그 (Tag)	___ 아피액트 (Act)	___ 아피투고 (2GO)

귀하가 사용 중인 각 구성제품으로 귀하가 수작업을 어느 정도나 대체할 수 있는지 평가해 주십시오. *0 = 사용하지 않는 모듈; 1 = 최저; 7 = 최고*

___ 아피라이트(Meter)	___ 아이디얼 (Ideal)	___ 아피웨이 (Weigh)
___ 아피랩 (Lab)	___ 아피팜 (Farm)	___ 아피소트 (Sort)
___ 아피태그 (Tag)	___ 아피액트 (Act)	___ 아피투고 (2GO)

파트 4: 제안 및 의견

아래 빈칸에 본 설문과 아키밀크® 시스템, 그리고 낙농인들의 관심을 끌 만한 해당 시스템의매력과 관련하여 귀하의 의견이나 통찰을 적어 주십시오. (선택 기재 사항)

파트 V: 인적 사항

다음 항목들 중 귀하에게 해당되는 사항은 무엇입니까? (각 항목에서 한 개씩만 표시하십시오.)

성별: ☐ 남자 ☐ 여자
직위: ☐ 소유주 ☐ 관리자 ☐ 기술자 ☐ 기타: ___________
나이: ☐ 20세 미만 ☐ 20-29세 ☐ 30-39세 ☐ 40-49세 ☐ 50-59세 ☐ 60-69세 ☐ 69세 이상
교육 수준: ☐ 고등학교 졸업 ☐ 준학사 ☐ 기술대학 ☐ 종합대학
출신지: 귀하는 농촌에서 자랐습니까? ☐ 그렇다 ☐ 아니다
낙농업 종사 햇수: ☐ 0-2년 ☐ 2-5년 ☐ 5-10년 ☐ 10-20년 ☐ 20년 이상
귀하의 컴퓨터 지식 수준을 평가해 주십시오:
최하 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 최고
귀하의 농장에 있는 젖소의 수를 표시해 주십시오: ___1-29두___30-49두 ___50-99두 ___100-199두 ___200-499두 ___500-999 ___1,000-1,999두 ___2,000두 이상

Appendix E. Farmers Comments for the Quantitative Study

USA
This survey is too long.
I would like to see a system setup where there is not a antenna at every station.
When will the program meet the Canadian Quality Milk Program (CQM) requirements for Canada?
The system is too complex with too much technical failure, too expensive to maintain, and transponder life to short- 25% didn't work after 2years and 50% didn't work after 3 years
All of my answers are based on the fact that DeLaval has been the dealer installing and maintaining the system for the past few years. You have to take into account that DeLaval is a competitor of in the rest of the world, so it is probably not in their best interest to train people and maintain the system, although it shouldn't be like that. This has changed, so we hope things will improve.
The pedometers are essential to reproductive performance. Lab is huge in monitoring fresh

cows.
South Africa
South Africa has currently had a change of dealership - there have been some handover issues - but they are trying hard to get up to speed. South Africa farmers receive no support from Government at all and the co-op system is no longer present - so questions related to these are not relevant to this market.
Passive ID still needs work - improve the antenna.
Taiwan
AfiMilk e-generation management system, in my perception is easily and efficient system for pasture. But I don’t understand about the part of the analysis of system, it need to retrain. Milk scale and activity amount , these two is considered satisfactory, conductivity still have a gap. Attractive to dairy farmers, in my view is that promotion from the point to the surface is the right way. In short: Easy to manage and high efficiency capacity is the way to attract dairy farmers. You have strong and powerful point that can have a extensive surface. Thank you.
Except of milk scale, identification system, active measurement system, you can enhance the understanding and implementation of other systems.
The most important is to observe the estrus, lactation and mammitis. This is the attraction.
We should arrange for more time to teach dairy farmers to use AfiMilk management system function make dairy farmers more facility. In order to attract more dairy farmers we need to develop system function.
The price is cost consideration, paid recovery is hard to estimate. Hope to provide cost compensation calculation
Korea
Promoting (advertising) milking machine and estrus sensing machine is needed; education for dairy farmers should be offered more
Program is too massive to understand; because manure is stuck within Tag, cows feel uncomfortable
Need some government support to be used in more farms; Dairy farmers should improve their computer literacy
It is good to see all the traceability of cow by computer at a glance
It is effective for managing a farm (with the level of system efficiency; there are some difference in efficiency with their level of computer skills

Abstract in Korean 국문초록

낙농업에서 정보 기술 적용의 결정 요인에 관한 연구

- 탐색적 고찰 -

Ronald S. Berger
농경제사회학부 지역정보전공
서울대학교 대학원

낙농 경영의 정보 관리는 가축 관리, 높은 품질의 제품에 대한 소비자의 수요, 그리고 정부 규제 등에 관한 지식의 증가와 정보 시스템 강화 때문에 더 복잡하다. 정밀 농업이라고 불리는 (Wang et al., 2006), 효과적인 유효한 실시간 데이터를 얻는 것을 (Zhang et al., 2002) 과학기술은 가능하게 한다. 정밀 축산업은 가축 관리를 지원하는 정보기술 사용의 증가 (Banhazi et al., 2007; Mertens et al., 2011) 와 낙농 경영 활동으로부터 유래된 비교적 새로운 학문이다. 그러나 농산물에 대한 정보 기술 적용에 대한 연구는 거의 이뤄지고 있지 않다 (Thomas and Callahan, 2002). 농부들은 1980년대와 1990년대를 거치는 동안 정보 기술을 거의 이용하지 못했다 (Schmidt et al., 1994). 또한 농부들은 정보 기술을 도입하여 적용하는 비율이 낮았다 (Morris et al., 1995). 뉴질랜드의 연구들은 낙농 농장이 그들의 유제품 생산에 혜택을 줄 새로운 기술을 도입하는 것이 늦거나 하지 않는 것을 보여준다 (Crawford et

al., 1989; Deane, 1993; Edwards and Parker, 1994; Stantiall and Parker, 1997). 일반적으로 기업들도 정보 기술 적용과 역량을 충분히 활용하지 않는다 (Jasperson et al., 2005). 사용자들은 일반적으로 기술의 특징적인 부분만 낮은 수준에서 이용하며, 기술이 제공하는 더 많은 확장된 다양한 부분들은 거의 사용하지 않는다 (Davenport, 1998; Lyytinen and Hirschheim, 1987; Mabert et al., 2001; Osterland, 2000; Rigby et al., 2002; and Ross and Weill 2002).

제 2 장에서 정밀 농업과 정밀 축산업에 관한 채택, 잠재적 기능과 적용에 대한 문헌들을 보여주고 있으며, 낙농 경영의 자동화된 시스템에 대해서도 검토했다. 이 연구의 목적은 크게 두 가지이다. 첫째는 한국의 낙농 경영 정보 시스템의 후(後) 채택을 위한 요인을 설명하고 식별하는 것이다. 두 번째 목표는 한국 낙농 경영 정보 시스템의 동화(기술 적용)에 대한 요인을 조사하는 것이다. 3 장과 4 장에서는 이 연구의 대상인 후(後) 채택과 동화(기술 적용)에 초점을 맞추고 있다.

제 3장에서, 첫 번째 연구인 한국에서 낙농 경영 정보 시스템의 후(後) 채택을 실시한 경험적 사례가 논의된다. 초기 기술 이용자들 기술을 채택하는데 끼친 영향에 대해 알아보기 위해서 사례 연구를 발전시켰다. 개별 기술 이용자들과 환경적, 기술적, 그리고 조직적 요소들이 연구 되었다. 연구의 결과는 낙농 경영 정보 시스템과 농업 정보 시스템의 도입이 한국과 다른 지역에서 늦어지는 원인과 좀 더 나은 전망을 제시한다. 이미 이러한 시스템을 시행하고 있는 낙농업의 농장의 매니저를 대상으로 한 현장 인터뷰를 통해 수집된 질적 데이터를 사용하여 평가되었고, 농부의 개별적인 특성보다는 환경 조건이 더 관련성이 크다라는 것을 보여준다. 이에 득실을 따지는 것(신뢰 대 경제) 보다는 오히려 기술이 “좋은”것이라는 일반적인 생각들이 있었다. 농부들이 기술을 경영에 도입하지만, 그들은 여전히 수동으로 농장에서 상황들을 “관찰”하려

는 것을 선호한다. 대부분의 농장 과정에서 이러한 것은 다소 요령으로 남아있으며, 농부들은 전통적인 관행들을 따라 하는 것을 선호한다. 이러한 관계는 이러한 새로운 기술을 도입하는데 기여하거나 방해가 된다. 사례의 경우 기술 - 조직 - 환경 프레임 워크 (Tornatsky and Fleisher, 1990)를 따르거나 깊게 관련되는 것을 보여줬다. 이러한 결과는 제 4장으로 이어질 일반적인 프레임 워크와 일련의 가설들이다. 결과는 16개의 가설들 중에서 11개를 증명했다. 이 연구는 한국의 낙농 경영 정보 시스템을 조사한 최초의 실험적인 다양한 방법론을 사용한 사례연구이다. 이 연구는 낙농 매니저와 공급 업체 지원의 관계에 대한 더 나은 이해를 제공한다. 제 4장에서 이러한 기술의 적용에 영향을 미치는 요인들과 확장된 낙농 경영 정보 시스템의 사용에 대해 알아보고 있다.

제 4 장에서는 두 번째 주제인, 낙농 경영 정보 시스템을 적용하는 과정을 알아보는 양적 연구이다. 이러한 낙농 경영 정보의 적용 과정은 기술-조직-환경 프레임워크를 통해 조사되고, 과정 자동화의 수준과 확장된 사용에 의해 제시된 동화 단계를 통해 진행된다. 이론적 모델은 두 가지의 동화과정과 확장된 사용 단계를 통해 진행된다. 이러한 단계들은 농장 운영 활동들, 즉 과정 자동화의 수준에 따라 나뉜다. 정보기술의 채택과 관련된 많은 기존의 연구들이 있지만 농업과 낙농의 맥락으로부터 정보 기술의 흡수(동화)에 대한 연구는 거의 없었다. 연구에서 리커트 타입의 설문(a Likert-type survey)을 통해 얻어진 자료를 활용했다. 가설을 확인하기 위해서 확인적 요인 분석과 최소 제곱 법(PLS: partial least square)을 하였으며, 결론적으로 일상 업무에 대한 측정은 과정 자동화의 수준에 큰 긍정적인 영향이 있으며, 이 효과는 낙농 산업의 경험과 연령에 부정적인 영향이 있다는 것을 보여준다. 또한 농장 크기가 가축 건강 관리를 자동화 하는 시스템 사용을 용이 하게하는 것으로 나타났으며, 농부들과 외부 조직 사람들이 앞으로의 사용에 영향을

미칠 수 있으며, 시스템은 외부와의 관계와 농장의 이미지를 향상 할 수 있는 것으로 나타났다. 일상 업무나 생산 계획, 그리고 가축들의 건강 관리와 같은 일들이 농장 운영에서 시스템의 적용과정과 확장된 시스템의 사용을 촉진한다. 이 연구는 정보 시스템 프레임 워크를 소개하고, 이론적인 관점에서 확장된 농장 업무에도 적용 가능함을 보여준다. 연구의 결과는 또한 낙농장 환경에서 가축들의 생물학적 시기와 관련된 새로운 요인들을 제시하며 이러한 요인들은 정보 기술의 채택이나 동화 과정 연구에서 잘 보여지지 않는 것들이다.

주제어: 동화, 낙농 경영 정보 시스템, 확장된 사용, 사후 채택, 정밀 농업, 정밀 축산업, 기술-조직-환경(TOE) 체제