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THE IMPACT OF FOOD RECALL ON THIRD-PARTY CERTIFICATION ADOPTION

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THE IMPACT OF FOOD RECALL ON THIRD-PARTY CERTIFICATION ADOPTION

THESIS

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the College of Agriculture, Food and Environment at the University of Kentucky

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ABSTRACT OF THESIS

THE IMPACT OF FOOD RECALL ON THIRD PARTY CERTIFICATION ADOPTION

Food safety problems have gained national attention, and food recall is one of the most important indications of this concern. Third-party certifications have become a popular way to improve the safety and quality of products for consumers. Publications related to third-party certification usually focus on the motives and benefits of a particular certification. However, to date, no existing research investigates the effects of food recalls on certification adoption.

This study uses probit models with a binary endogenous explanatory variable to examine the relationship between food recalls and third-party certification, based on recalls occurring between January 1, 2015 and February 18, 2016. Marginal effects are used to interpret the impact of recalls and companies' annual net sales on third-party certification adoption. Results reveal that past recalls significantly effect a firm's likelihood of certification adoption.

KEYWORDS: Food recall, Third-party certifications, Probit model, Binary endogenous explanatory, Marginal effect.

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June 29, 2016

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This thesis work is dedicated to my parents, for their endless love, support and encouragement.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

In the last few decades, food safety concerns have grown significantly around the world due to the increasing incidence of food-related safety issues. The risk of foodborne illness is the most notable of these issues and, with nearly a quarter of the U.S. population currently highly at risk of contracting such an illness (Oliver et al., 2005), numerous meat recalls occur due to possible foodborne illnesses each year. From 2000 to 2007, in the United States alone, it is estimated that about 47.8 million people per year become ill as a direct result of 31 known foodborne illness (FoodNet data). To ensure food safety and prevent illnesses and deaths related to foodborne pathogens, facilities adopt various methods to more efficiently and safely manufacture, process, pack, and store food. One such method is the adoption of third-party certification, which can help a company develop a detailed scheme to identify any problems in the way they make, pack, or store their products that could be hazardous to consumers.

In recent years, major food safety events involving ground beef, ground turkey, egg, peanut butter, and spinach have resulted in thousands of illnesses, widespread media attention and hundreds of product recalls. Food recalls, as strong indicators of food safety problems, occur regularly for many reasons. The most dangerous and widely noted is microbiologic contamination, which can cause foodborne illnesses. An standard example of a food recall occured on July 3, 2015; according to the U.S. Department of Agriculture's Food Safety and Inspection Service. Denver's Lombardi Brothers Meats issued a recall of approximately 26,975 pounds of tenderized steak and ground beef products. These products may have been contaminated with E. coli O157:H7, and they had ben distributed to local hotels, restaurants and institutional customers throughout the southern and western United States. The company's sampling program received a positive E. coli test result on June 30 from a sample collected from the same source as the product already sold to the public. Due to the quick response, FSIS and the company received no reports of illnesses related to the consumption of these products. As this example shows, food recall is an important tool in responding to contamination incidents. However, when a company issues a recall, their reputation as well as consumer loyalty and intention to purchase is threatened. Individuals' willingness to pay decreases as a result of these foodborne illnesses. How companies can regain consumer confidence after incidents of food recall then becomes an important question.

As companies try to maintain their reputations for producing safe products, an important way for firms and plants to ensure controlled food safety processes is by obtaining third-party certification (TPC). TPC, as a governance mechanism, is becoming a popular component of the global agro-food system and is being accepted by larger consumers and retailers. Companies benefit by implementing TPC as a tool to monitor and enforce standards for food quality and safety (Hatanaka et al., 2008). Consumers' willingness to pay higher prices for certified products reflects their concern about food safety issues (Rozan et al., 2004). Certification standards are also implemented in order to regain consumer trust in product safety.

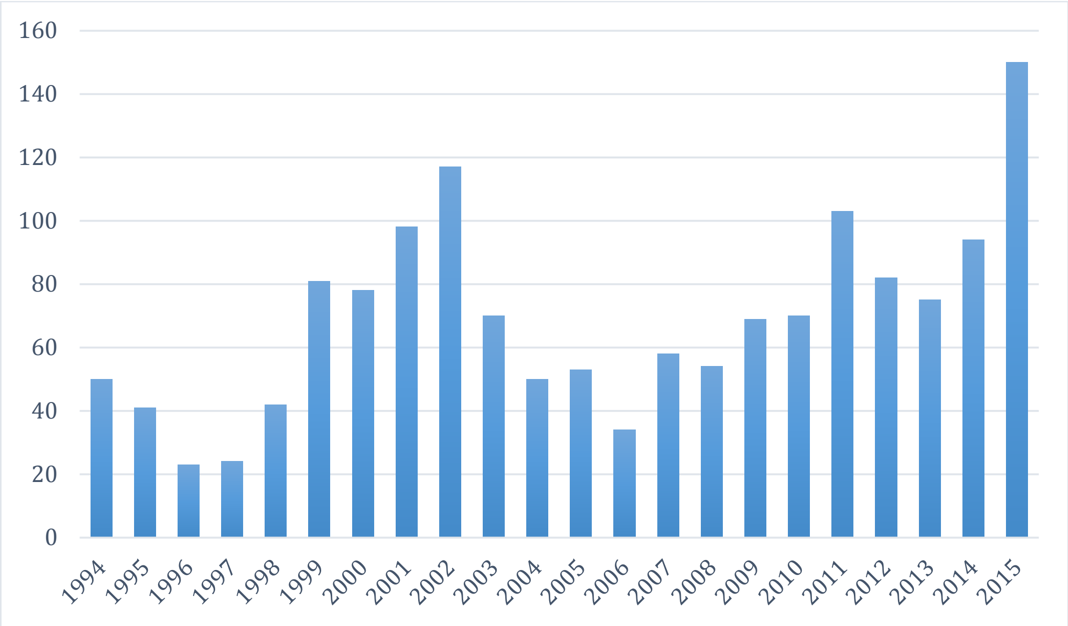
Governments and administrative offices devise and implement national-level food legislation and technical requirements for food processing, handling, and production processes. These laws and requirements provide incentives for firms to adopt appropriate production processes and methods. In addition to incentives driven by food and liability law, retailers, such as the SQF certification and Primus GFS, are also a major source for other motives that encourage firms to go beyond the basic adoption of approved practices meeting government requirements towards the adoption of third-party certification to meet market demand. These motives can be classified as either internal or external incentives for third-party certification adoption. Internal incentives are synonymous with internal forces that push the organization to seek TPC; they can be associated either with managerial performance (i.e. improving communication between the organization's employees) or with operational performance (i.e. improving the organization's quality system), both of which are directly affected by adoption. External incentives are largely related to motives associated with a company's external environment, such as customers, competitors, suppliers, and the government. The term "external environment" refers to elements that are outside an organization but still have the potential to affect all or part of it (Zaramdini, 2007). Although some research has looked at whether TPC is necessary and what motivates a company to apply for a particular certification, little is known, however, about the relationship between a company issuing a food recall and TPC adoption. This paper discusses how food recalls impact TPC, as well as which recall factor is most influential on TPC adoption.

Additionally, this paper contributes to the existing literature from several perspectives. Firstly, we have constructed a comprehensive dataset for recall information in the U.S. for the period of January 1, 2015 to February 18, 2016; this dataset provides an overview of all recall-related information occurring within this period. Secondly, we searched through each company's TPC adoption history. Six global third-party food safety certifications considered, all of which are recognized and popular around the world. Thirdly, we tested the effects of recall on TPC adoption, the results of which strongly support the real effects of food recall activities on TPC adoption. Lastly, we present an initial exploration of food recall as a TPC motivator; these findings may thus provide useful insights on the subject.

CHAPTER 2 BACKGROUND

Although the United States enjoys one of the world's safest food and water supplies, it still sees 76 million cases of foodborne illness each year, leading to billions of dollars in damages, unnecessary suffering, and nearly 5,000 deaths. The salmonella outbreak in 2008, caused by peanut butter manufactured by the Peanut Corporation of America, killed nine people and sickened 714 others across 46 states. In another example, the recall of over a half billion fresh eggs from Wright County Egg and Hillandale Farms resulted in heightened food safety problems and media coverage of food recalls that drew direct public attention. Foodborne illnesses, which are caused by 15 major pathogens, cost 1.9 billion dollars in 2013 alone (ERS). For meat and poultry recalls, the weight recalled increased from 6 million pounds in 1988 to 21 million pounds in 2015. Figure 2.1 shows the change in the number of recalls from 1994 to 2015.

Figure 2.1 Numbers of Meat and Poultry Recalls from 1994 to 2015



Since early this century, third-party certification has played a significant role in the global food-safety system. More companies have begun to select TPC, which is increasingly viewed as a tool for gaining a competitive advantage. Certifications chosen for study in this paper are leading and popular standards around the world; the aim of these certifications is to guarantee the standardization of quality, safety, and operational criteria, to ensure that manufacturers fulfill their legal obligations, and to provide protection for consumers. By jointly discussing recalls from within the last year and six TPC standards, this paper focuses on the implications of food recalls on TPC adoption.

2.1 Background information: Food Recall Statistics

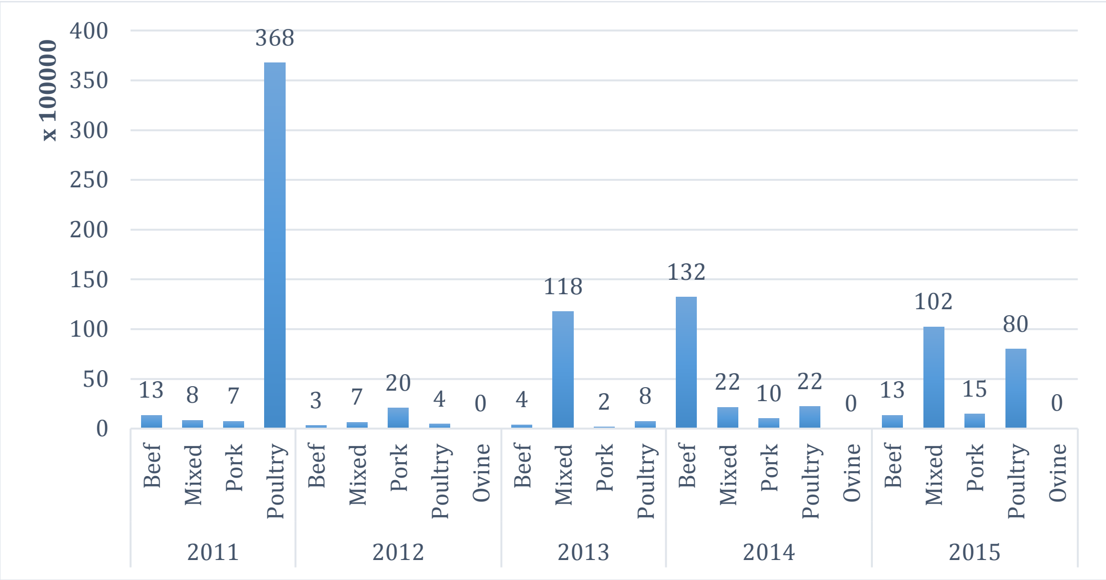
Food recalls are currently quite common. They are used as a means for improving food safety by removing faulty products from markets. If foods enter the market with the potential to cause serious adverse health effects, companies and government regulators will recall these products. There have been over 600 recalls in the U.S. and Canada in the past 12 months. Of these, 150 involved meat, poultry, egg, and mixed[1] products and were regulated by the Food Safety and Inspection Service (FSIS), a branch of the United States Department of Agriculture (USDA). As shown in Figure 2.2, poultry meat was recalled in the largest quantity in 2011. One reason for this difference was food producer and marketer Cargill issued a recall of 36 million pounds of ground turkey because it may have been contaminated with a drug-

[1] "Mixed" refers to cases in which more than one type of meat or poultry species is included.

resistant strain of salmonella. And in 2014, beef was recalled far more than poultry or mixed meat products for a California-based Rancho Feeding Corporation was solely responsible for a recall of approximately 8,742,700 pounds of beef product: the company had processed diseased and unsound animals and had done so without the benefit or full benefit of a federal inspection. Products had then been shipped to distribution centers and retail establishments in California, Florida, Illinois, Oregon, Texas, and Washington. Both of these two cases were a Class I food recall case.

Figure 2.2 Recalled Weights by Species from 2011 to 2015

(Units: in 100,000 Pounds)



Source: FSIS, USDA, 2011-2015

Depending on the degree of the health hazard posed, food recalls can be organized into three different classes, defined by the USDA as follows:

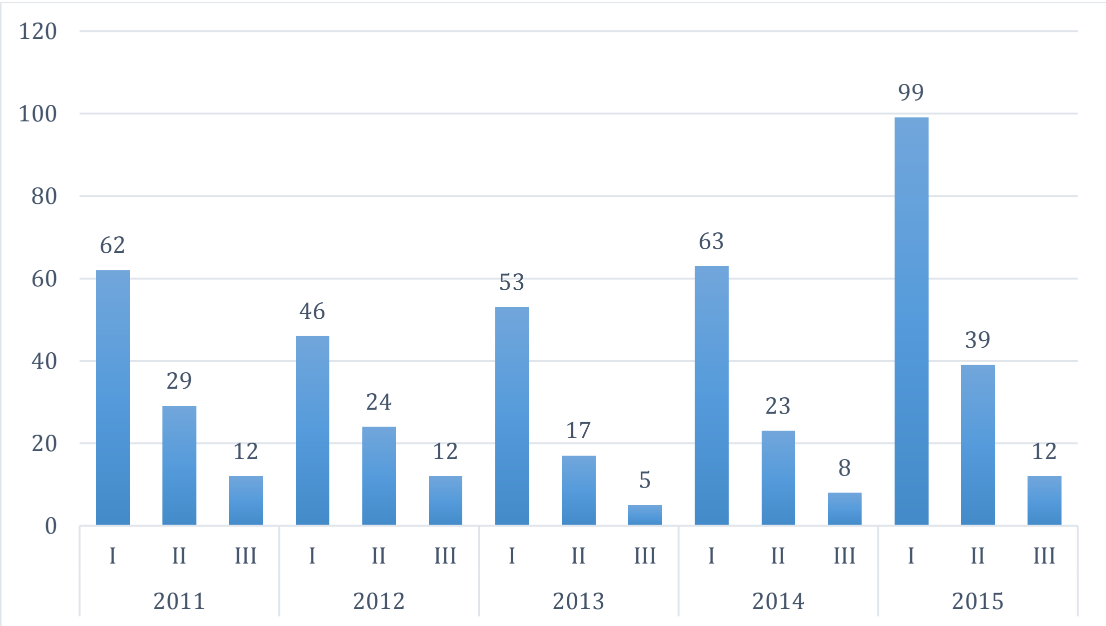
Class I – involving a health hazard situation in which there is a reasonable probability that eating the food will cause health problems or death;

Class II –involving a potential health hazard situation in which there is a remote probability of adverse health consequences from eating the food; and

Class III –involving a situation in which eating the food will not cause adverse health consequences.

As we can see from the above the definition, a Class I recall refers to dangerous or defective products that could predictably cause serious health problems or even death. However, as shown in Figure 2.3, the majority of recall cases from 2012 to 2015 were Class I, a rate which is still gradually increasing each year. For this reason, I have chosen to focus on Class I cases in this paper.

Figure 2.3 Recalled Cases by Class from 2011 to 2015



Source: FSIS, USDA, 2011-2015

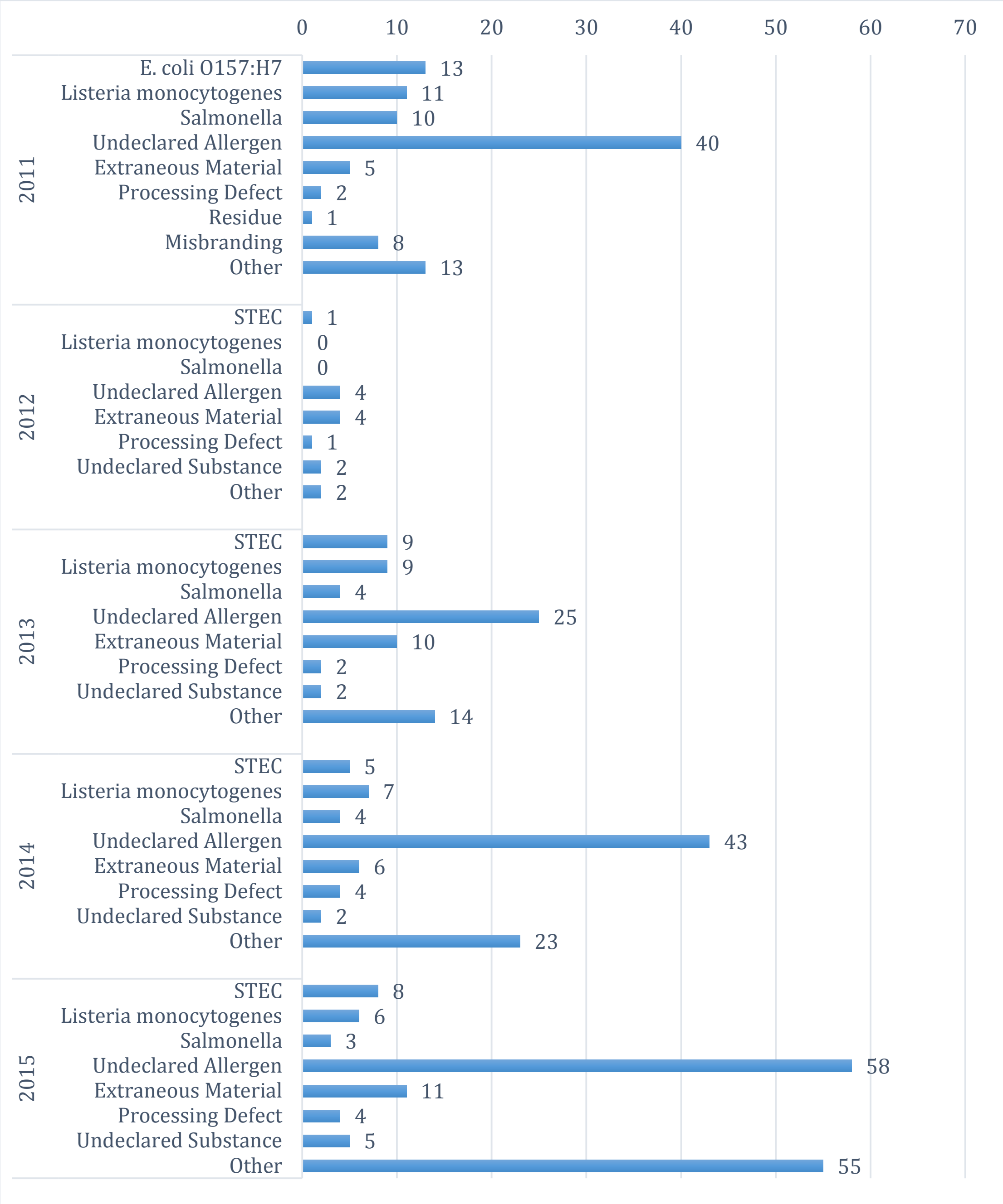
Besides class differences, food recalls are also caused by different reasons and pose differing hazards to people's health. For example, according to the FSIS annual summary, recalls can be caused by STEC[2], Listeria monocytogenes, Salmonella, undeclared allergens, extraneous materials, processing defects, undeclared substances, and other reasons. As shown in Figure 2.4, the presence of an undeclared allergen was always the most common recall reason from 2011 to 2015. In addition to foodborne illnesses, allergens are another significant threat to human health, not only for the 15 million Americans who suffer from food allergies but also for the food manufacturers that produce the foods we eat (Maberry, 2016).

Certainly, the reasons behind each individual recall are more complicated than what is reflected in the annual summary above. For ease of demonstration in this study, however, recall reasons are classified into two main groups. Reason 1 is for products that are misbranded and/or include undeclared allergens, are produced without the benefit of federal inspection and/or do not have a federal mark of inspection or were not presented at the U.S. point of entry for inspection. Reason 2 designates products that may be contaminated with extraneous materials or adulterated with a pathogen such as E. coli, Listeria monocytogenes or Salmonella. In 2015, most recalls were the result of operational mistakes, such as incorrect labeling or the presence of an undeclared ingredient, classed as Reason 1. Although cases with biological causes included in Reason 2, such as the detection of Listeria, Salmonella, and E. coli, appear in weak proportion compared to the overall number of cases, as shown in Table 2.1, they can still cause incidents of foodborne illness. In this paper, I

[2] "STEC" includes recalls due to Shiga toxin-producing E. coli (STEC). STEC organisms include E. coli O157:H7, E. coli O26, E. coli O45, E. coliO103, E. coli O111, E. coli O121, and E. coli O145.

stress the importance of research on how TPC is impacted by foodborne illness recalls, those falling into Reason group 2.

Figure 2.4 Number of Recalls by Reason from 2011 to 2015



Source: FSIS, USDA, 2011-2015

Table 2.1 Reason Groups in Study Period

Reason Group	Frequency	Percent
Reason 1	219	90.87%
Reason 2	22	9.13%

2.2 Background information: Third-Party Certification

With an increase in the number of food recalls resulting from the appearance of many foodborne diseases, such as mad cow disease, foot-and-mouth disease, and microbial contamination of fresh produce, consumer confidence in food safety has declined greatly. There are more than 200 known diseases transmitted through food by a variety of agents that include bacteria, fungi, viruses, and parasites. Consumers' growing concerns regarding the quality and traceability of products and processes call for fundamentally new ways of developing, producing and marketing products, thereby also driving the use of TPC.

Traditionally, the monitoring of food safety and quality standards was the responsibility of government agencies. To solve food safety problems, U.S. federal agencies, such as the Department of Agriculture and the Food and Drug Administration, developed standards and conducted inspections to ensure food safety and other production conditions. Results of this approach, however, have been far from ideal. Simultaneous demands on the food retail industry and the improvement of private retailer standards have shifted the responsibility for this task to third-party certification (Hatanaka et al., 2005).

As a result, third-party certifications (TPC) are increasingly viewed as tools for gaining a competitive advantage. The growing number of companies pursuing TPC reflects a broader shift from public to private governance. Certifications provide market signals concerning food quality claims. Successful third-party certifications assure buyers of food quality and reduce the potential for market failure that might otherwise occur when information about food quality is uncertain and asymmetrically distributed.

There has been an increasing number of standards devoted to the promotion of food safety. From the ensemble of food safety certifications, the following six third-party certifications were chosen to be focused on in this paper: the British Retail Consortium's Global Food Safety Standard (BRC); the Safe Quality Food certification (SQF); Primus GFS; Food Safety System Certification 22000 (FSSC 22000); Global Good Agricultural Practice (G.A.P.); and the International Organization of Standardization (ISO) 22000 certification. All are leading and globally-recognized food safety certifications. Companies possessing these certifications are seen as presenting a competitive advantage. The six TPCs are introduced below:

1. The BRC Standard was originally developed by a trade agency in the UK. It is now a leading safety and quality certification program and a basic requirement for leading retailers, used by over 23,000 certificated suppliers in 123 countries and even adopted by suppliers not selling into the UK mark, sites in the United States alone.

2. The SQF certification, established by the SQF Institute (SQFI), presents another third-party entity. Each SQF standard can be achieved at three different levels – Level 2 is approved by the Global Food Safety Initiative (GFSI, an influential non-

profit organization that benchmarks food safety standards) – which link primary production certification to food manufacturing, distribution and agent/broker management certification. It is recognized by retailers and foodservice providers around the world and has 5,301 sites in the United States. Administered by the Food Marketing Institute (FMI), SQF is now the only scheme to integrate a quality component as well as food safety.

3. Primus GFS is a Global Food Safety Initiative and globally-recognized private scheme that establishes food safety requirements for the certification of agricultural produce designated for human consumption in their fresh or minimally-processed state. This standard defines three fundamental areas that must be considered by a company in the agricultural sector when producing or manufacturing their products: a Food Safety Management System, Good Agricultural and/or Manufacturing Practices (one or both), and the HACCP System. There are currently five certification bodies and one provisionally approved certification body in the United States, four of which are located in California.

4. The FSSC 22000 Food Safety System Certification provides a framework for effectively managing an organization's food safety responsibilities. It is also fully recognized by the Global Food Safety Initiative and is based on existing ISO Standards. It demonstrates that a company has a robust Food Safety Management System in place that meets the requirements of consumers. Already, more than ten thousand organizations in over 140 countries have achieved FSSC 22000 certification. There are currently more than one hundred licensed certification bodies and over 1,500 auditors worldwide, with 12,043 companies in the United States holding valid certificates from FSSC22000.

5. Global G.A.P. is the world's leading farm assurance program, translating consumer requirements into Good Agricultural Practices. Through a growing number of producers and retailers from around the world, the European organization has gained global significance and is currently adopted by 160,000 producers under certification in 124 countries. It began in 1997 as EUREPGAP, an initiative by retailers belonging to the Euro-Retailer Produce Working Group, which was started when British retailers working with supermarkets in continental Europe became aware of consumers' growing concerns regarding food safety and traceability, environmental sustainability, worker health and safety, and animal welfare. It now has eight approved certification bodies in the United States.

6. ISO 22000 certification is an international standard that defines the requirements of a food safety management system for food safety and hygiene covering all organizations in the food chain and developed by the International Organization for Standardization. This standard was created from the very successful quality management system standard ISO 9001, which is used worldwide by over 700,000 companies. In response to the need for an international standard for the food industry, ISO developed a Food Safety Management System, which encourages the harmonization of the many existing national and private standards and elaborates on the management systems approach of ISO 9001. Based on a changing focus to food safety management and an incorporation of PRP and HACCP principles, the ISO 22000 currenly counts 92 registered companies in the United States.

CHAPTER 3 LITERATURE REVIEW

3.1 History and Development of TPCs

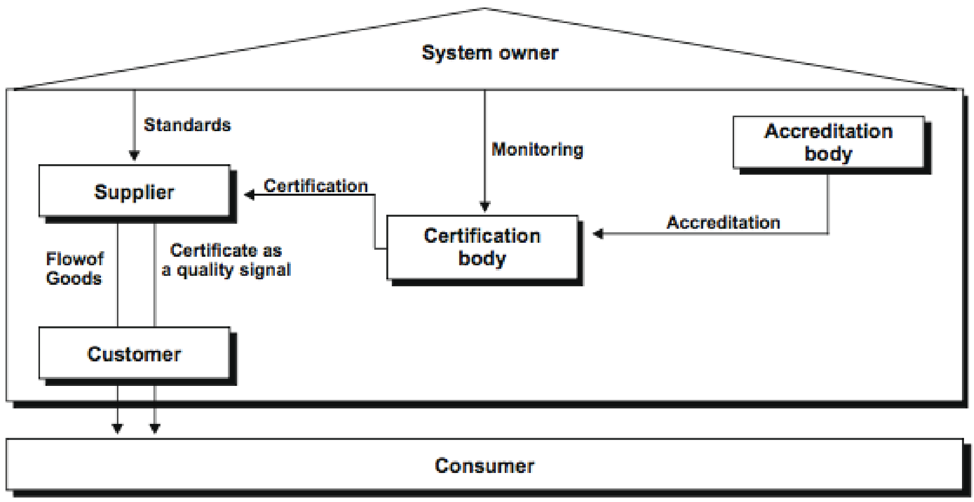
As an important method for of market governance, independent third-party certifications have developed extremely rapidly in recent years and have made a significant contribution towards the improvement of food safety in many fields. Acting on a particular set of standards and compliance methods, third-party certifications are provided by private or public organizations responsible for accessing, evaluating, and certifying safety and quality claims (Deaton, 2004). Historically, government agencies, such as the USDA in the United States, were responsible for establishing food safety standards. However, private safety standards and certification programs are responding to higher consumer requirements, needs for safety controls throughout the vertical chain of distribution. Thus these responsibilities are now increasingly being shifted to third-party certification bodies, which promote the emergence and development of third-party certification as a regulatory mechanism in the global agro-food system (Tanner 2000), especially as global food trade expands dramatically and provides consumers with access to a wider variety of foods all year long.

Worldwide adoption of TPCs results from collaborations between the world's leading food companies, from retailers and manufacturers to food service sector agents and service providers active in the food supply chain. Since food safety is of major importance in international trade, cooperation and coordination in the development and implementation of TPC throughout the supply chain has been marked by a new sense of urgency and focus. The primary goals of TPCs are to provide consistency and cost efficiency, reduce duplication, increase confidence and ensure that the global supply chain is safe for consumers.

3.2 Structure and Characteristics of TPCs

Most certification systems employ very similar structures (see Figure 3.1). A certification body is monitored by the system owner and accredited by an accreditation body to ensure its ability to provide supplier certification. A certified supplier offers customers a qualified product or service which complies with the system owners' standards.

Figure 3.1 Basic Structure of Certification System



Source: Jahn et al., 2005

As can be seen in Figure 3.1, certification bodies are independent from other participants in the supply chain as well as from the scheme owner. This structure distinguishes TPCs from other product safety and quality certification mechanisms (Zuckerman 1996; Tanner 2000; Golan *et al.* 2001) and, as certification body managers and scheme owners retain independence from each other, the food industry can be confident that impartiality is maintained during any audit and between certification bodies. Certification bodies can then be viewed as objective arbitrators of product safety and quality (Fagan 2003). In other words, the 'independence' of certification bodies is the basis of TPCs' legality and effectiveness. Besides independence, most TPCs are similar to one another in many ways. Their main purpose is to protect consumer health with integrated food safety management, fulfilled through specifying the basic requirements acceptable for food safety and third-party audits. At the same time, the main differences between food safety standards are that they are owned by different organizations in different regions and that they deal with different stages of production in the value chain (i.e., farming versus manufacturing).

3.3 Certification Process

The certification process for BRC, Primus GFS, Global G.A.P. and SQF are similar, often consisting of five steps in a one-year period, as shown in Figure 3.2 and described below.

Step A – According to the firm's size and nature, the certification body presents the manufacturers with a proposal. When the proposal is accepted, the audit process can proceed.

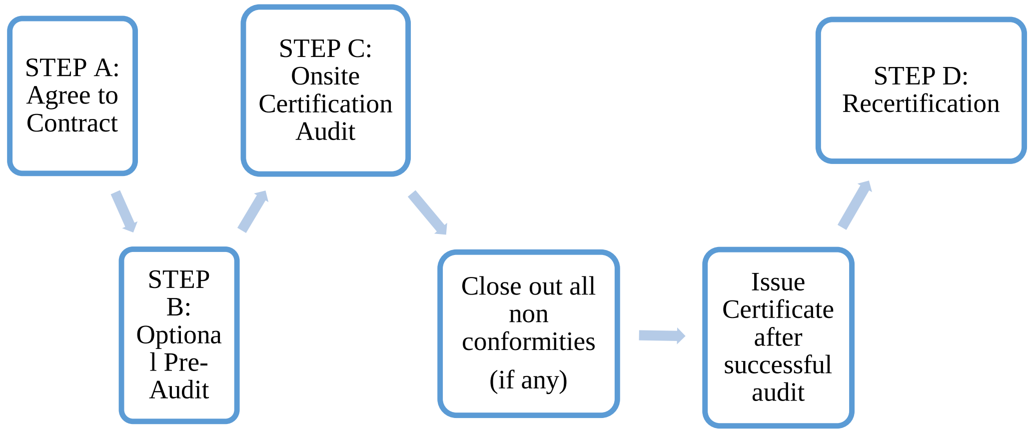
Step B – There is often an optional 'pre-audit' stage before the formal audit, which is useful in identifying any shortcomings in management systems or in the plant's facilities.

Step C - The formal audit is an onsite audit. All site areas are assessed to determine compliance with each clause of the standard. Concerns or observed non-conformities will be issued in this two-week stage as a pre-report and, at the end of the audit, organizations will receive a corrective action report identifying final observed non-conformities. The certifying entity provides the organization with another two weeks to respond to the corrective action report. These non-conformities must be rectified and documented with evidence or through an on-site visit. Once the non-conformities have been corrected and the auditor has accepted the evidence, an independent technical review of the audit is conducted by an authorized certification manager, who approves the issuance of a certificate.

Step D – Most certifications are only valid for one year. Thus, a full recertification audit is scheduled for every twelve-months. The audit is a full re-audit conducted in the same way as the initial audit, where the implementation of the action plan is also reviewed. Earlier non-conformity records are checked.

FSSC 22000 & ISO 22000 certifications are often valid for three years since surveillance visits are scheduled twice a year and five times in two years. During the visits, auditors review the implementation of the action plan, addressing past non-conformities and examining whether certain mandatory and other selected parts of the system are in line with a provided audit plan.

Figure 3.2 The Basic Certification Process



Source: www.SGS.com

3.4 Motives for and Benefits of TPCs

Meeting third-party certifications often entails significant expenses imposed on producers, which can pose a significant economic burden for smallholders. Why do companies and farms keep seeking third-party food safety certification? Very little theoretical research exists which focuses on the motives behind seeking third-party certification, and none has focused on the impact of recalls on certification. From an empirical perspective as well, no research has explored the relationship between third-party certification and food recalls.

Since the market for agro-food products is becoming increasingly competitive, TPC can help suppliers remain in the marketplace, and even expand their market share, by allowing them to demonstrate to their customers that they have met necessary standards. One of the defining purposes of TPC, particularly as it relates to food safety, is an increasing focus on the processes by which food is produced (Henson, Spencer, & Humphrey, 2009), extending into how food is produced, transported or processed. Through the adoption of TPCs, food firms are able to make better management decisions, thereby improving productivity, efficiency, and product and service quality, reducing incidents, rejections and complaints, and improving the organization's public image (Zaramdini, 2007). On the one hand, companies and farms benefit from seeking certification as a means of demonstrating compliance with legal and industry food safety requirements. On the other hand, TPCs promote customer confidence and market access. The Consumer Goods Forum, GFSI, shows that certified companies enjoy higher margins through efficiency savings resulting from the application of TPC-defined regulations and that they are also able to prove the consistency of their respective processes internationally, which in turn promotes international trade.

The number of food recalls in the U.S. has shown a dramatic rise in the last few years, increasing by about 50% from 2011 to 2015. Food recalls directly cost a food company millions of dollars, in addition to indirect brand damage and lost sales. Shiptsova et al. (2002) developed an equation to calculate recall cost, shown below (3.1):

$$Recall\ Cost = 3 \times Retail\ Price\ of\ Product \times Recall\ Amount \tag{3.1}$$

After apologizing, removing the product from store shelves and away from consumers as quickly as possible, and, in the process, spending a large amount of money, many companies are not able to survive. To continue business and earn back their reputation, the recalling company has to improve product quality, reduce incidents and complaints, and improve the organization's public image – which is exactly what TPCs offer. TPCs establish a series of requirements for managing production, handling, processing, and storing operations, thereby ensuring the consumer's safety in each productive stage. These motives encourage recalling companies to apply for TPC.

CHAPTER 4 DATA

The data collected for this study dates from early 2015 to February 18, 2016. The complete data set includes recall variables, companies' yearly net sales, and the number of recalls from 2009 to 2013 for a total of 241 observations. The data used in this study can be divided into three main groups.

The first group is composed of recall information collected from the United States Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS), which includes data on both active and completed recalls. The FSIS provides an annual summary of recalls involving meat and meat products each year. Between January 1, 2015 to February 18, 2016, the FSIS reported 150 meat recalls, involving over 21.1 million pounds of product. These figures show an increase from 94 recalls and 18.7 million pounds of product in 2014. Among the 150 cases in 2015, 99 of them were classified as Class I, which involves a serious health hazard. Additionally, over 1.7 million pounds of product were recalled, due to their potentially having been contaminated with extraneous materials or adulterated with a pathogen such as E. coli, Listeria monocytogenes or Salmonella, which, in this study, is classified as recall reason 2.

The second group includes company information containing employee numbers and net sales amounts for all companies. These data were collected from the website LexisNexis Academic. Yearly financial net sales come from WorldBase in U.S. dollars, from March 4, 2014. Access to company-level data allows for more variability, enabling a more efficient estimation for controlling for the different individual company sizes, which is a significant advantage of this analysis. From

Figure 4.1, it is easy to see that companies currently experiencing recalls and companies holding a certification both have higher annual net sales.

The third group looks at whether a subject is certified by either the BRC food safety certification, the Primus GFS, the FSSC22000, the Safe Quality Food (SQF) certification, the Global G.A.P. certification, or the ISO22000 certification. These six certifications are independent third-party certifications and require renewal on an annual basis. Since their websites only cite companies that are currently certified, detailed information on when a company registered their certification for the first time (certification history) was not available to us. Figure 4.2 shows that 44% of observations in this data set have neither food recall nor TPC. For those with certification, the proportion of having a recall and not having a recall during the study period are nearly the same. Only 11% of companies issued recalls are not third-party certified.

In this study, data from 241 companies are collected, including 84 companies with recalls and 160 companies without, from the beginning of 2015 to February 18, 2016. Since these companies are primarily engaged in processing, preserving, assembly cutting, packing, slaughtering and preparing meat and meat products from purchased meats, they fall under the jurisdiction of NAICS[3] codes 311611[4] and 311612[5] lists. There are 4578 companies under these two lists in total. As comparison, 160 companies without food recalls in the study period are randomly

[3] The North American Industry Classification System (NAICS is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy.

[4] Industry 311611 includes establishments that slaughter and processing meats (except poultry).

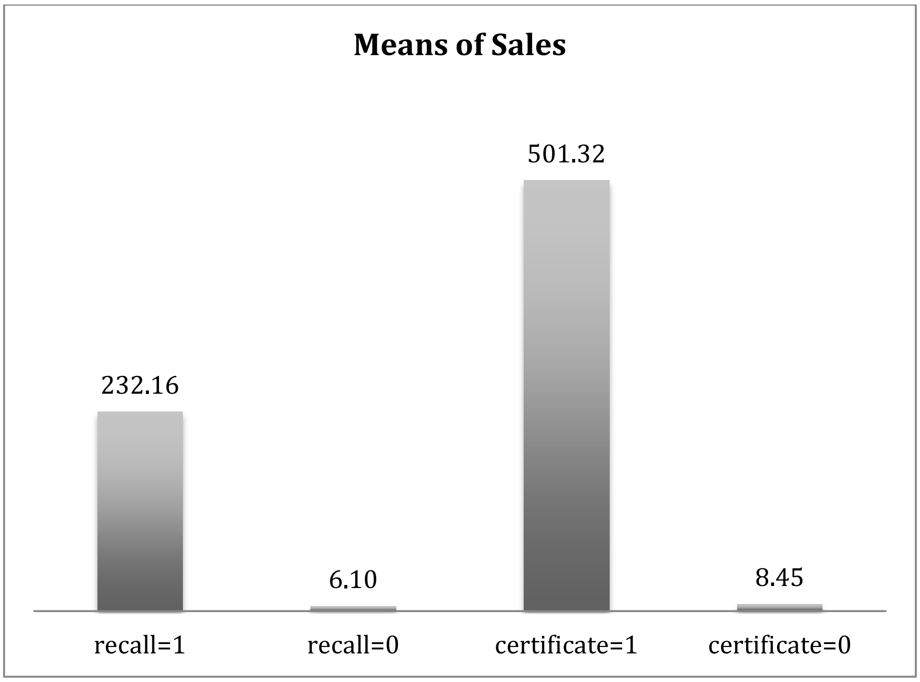
[5] Industry 311612 includes establishments primarily engaged in assembly cutting and packing of carcasses.

selected from NAICS codes 311611 and 311612 lists. Data were collected from all companies, including the company name, whether or not the company had a food recall within the study period, recall history from 2009 to 2014, employee numbers, and net sales. For companies with recall cases within the study period, recall information is also collected, such as recall class, reason and quantity.

The above data are sufficient to answer the research question in this study. We use a probit regression containing a single binary endogenous explanatory variable (one instrument is used) and one exogenous explanatory variable. The dependent variable in this study is whether or not the company is certified, while the independent variables are RECALL, BEFORE, SALES, CLASS1, and REASON2 across all three models. We grouped these explanatory variables together to create dummy variables, and set BEFORE as the instrumental variable. Table 4.1 shows the explanations of dummy variables and Table 4.2 presents the descriptive statistics.

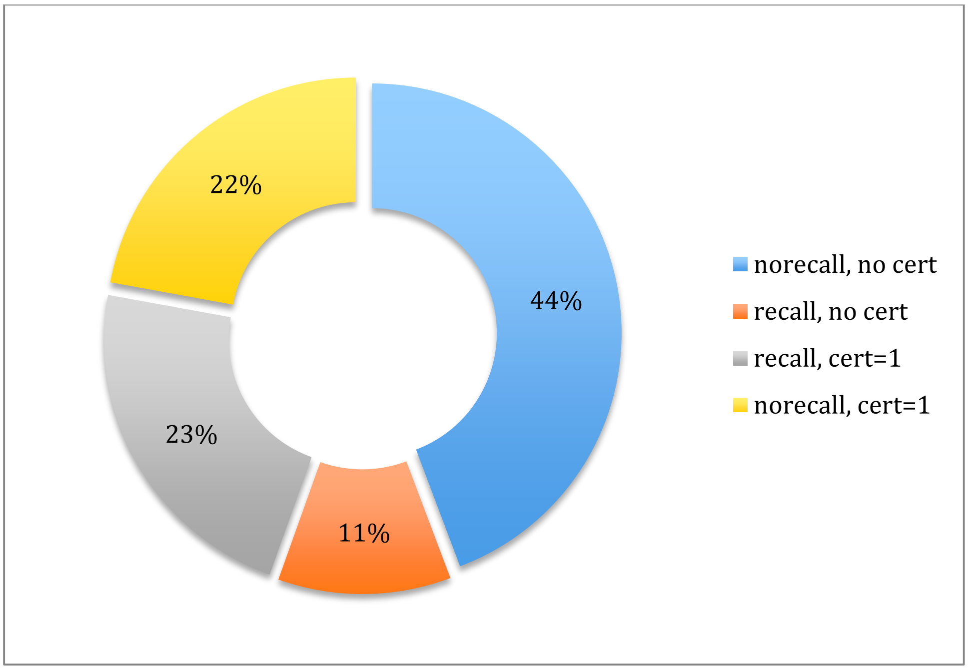
Figure 4.1 Means of Sales by Different Groups

(Unit: in million dollars)



Source: FSIS, USDA

Figure 4.2 Percentage of Certification Adoption with Recent Recalls



Source: FSIS, USDA

Table 4. 1 Dummy Variables

Variable	**Explanation**
CERTIFICATION	Whether the firm adopt a TPC in 2016
BEFORE (IV)	Number of firm's recall from 2009 to 2014
RECALL	Whether has recall from January 1, 2015 to February 18, 2016 *takes the value of 1 when recall happened in this period and 0 otherwise
CLASS1	Recall class *takes the value of 1 when has recall in Class I and 0 otherwise
REASON2	Recall reason *takes the value of 1 when has recall reason in group 2 and 0 otherwise

Table 4.2 Descriptive Statistics (N=241)

	Mean	**S.D.**	**Min**	**Max**
Sales	81918191.97	734587642.00	30000.00	9316256000
	Frequency	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
Recall				
0	160	66.39	160	66.39
1	81	33.61	241	100.00
Class1				
0	194	80.50	194	80.50
1	47	19.50	241	100.00
Reason2				
0	219	90.87	219	90.87
1	22	9.13	241	100.00
Certification				
0	205	85.06	205	85.06
1	36	14.94	241	100.00
Before				
0	228	94.61	228	94.61
1	9	3.73	237	98.34
2	3	1.24	240	99.59
7	1	0.41	241	100.00

CHAPTER 5 EMPIRICAL METHODOLOGY

Many factors influence a company's decision to apply for TPC, including meeting consumer requirements, improving product quality, achieving international quality recognition, etc. More producers, co-manufacturers, and re-packers are looking to TPC programs to assist them in meeting government regulatory requirements. In addition, many retailers and food service providers also request that their suppliers become certified by TPC. Companies that currently have recall issues are more likely to rely on TPC to save their public image and improve their perceived product quality. To establish the relationship between food recall and the probability that a company becomes certified, probit analysis is most appropriate when estimating the effects of one or more independent variables on a binary dependent variable.

5.1 Binary Probit Model

The probit analysis model is a type of generalized linear model that extends the linear regression model by linking the range of real numbers to the 0-1 range. When the dependent variable is binary, especially in the case of modeling probabilities extremely close to 0 or 1, a probit regression is used instead of Ordinary least squares (OLS). OLS regression is improper when the dependent variable is discrete (Collett, 1991; Agresti, 1990). It is very important to report robust standard errors because of the intrinsic heteroscedasticity of the linear probability model. A probit model is a rapid method for computing maximum likelihood estimates (Bliss, 1934), and it is the basis for the final models in our paper.

Consider the existence of an unobserved continuous variable, Z, which can be understood as the "propensity towards" the event of interest. In our case, Z represents a firm's tendency to obtain certification. Mathematically, the relationship between Z and the probability of response is:

$$\pi_i = c + (1 - c)F(z_i) \quad (5.1)$$

where

π_i is the probability the i^th case experiences the event of interest;

z_i is the value of the unobserved continuous variable for the i^th case;

F is the link function;

c is the natural response rate.

In a probit model, the value of βX is taken to be the z-value of a normal distribution. The estimated curve is an S-shaped cumulative normal distribution, and the inverse standard normal distribution of the probability is modeled as a linear combination of the predictors. The model also assumes that Z is linearly related to the predictors. The functional form for the probit model can be derived from a latent variable model:

$$y_i^* = \alpha + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$$

$$\mathrm{y}_i = \begin{cases} 1 & if\ y_i^* > \tau \\ 0 & if\ y_i^* \leq \tau \end{cases} \quad (5.2)$$

$$Certification = \alpha + \beta_1 Recall/\ Class1/\ Reason2 + \beta_2 Sales + \varepsilon$$

We can think of y_i^* as the underlying latent propensity that y=1, for the binary variable, certified/not certified, y_i^* is the propensity for certified and τ is the threshold, which is 0 in this study. Since latent variable y_i^* is unobserved, we do not know the distribution of the errors, ε. In order to use ML, we make an assumption that the distribution of the error is normally distributed.

5.2 Endogeneity and Instrumental Variable Problems

For the purpose of our study, we sought to design a model to test the impact of food recalls on third-party certification. We recognize that the predictive power of the recall dummy may be explained by unobserved factors, such as firm quality management, which may affect both the occurrence of a recall and certification adoption. Firms have a higher likelihood of producing poor quality products, which may cause the recall; at the same time, they may also have a higher likelihood of applying for TPC in order to improve management. Thus, if a binary probit model is used, we will have an inconsistent estimation for the estimated coefficient of recall. To overcome potential endogeneity issues and achieve an unbiased and consistent estimator of β based on the exogenous assumption, we propose one instrumental variable (IV) for the recall dummy: companies' recall history. This IV, although found to be closely related to the recall dummy, should not be correlated with unobservable factors contributing to certification.

It is generally acknowledged that if regression models do not take endogeneity into account, significantly biased results may ensue. Since most social science disciplines often rely on non-experimental data, endogenous variables are a very common and important problem (Arendt, and Holm, 2006). Maddala (1983, p. 122) considers a two-equation probit model, in which the disturbances are correlated and the binary dependent variable of the first equation is an endogenous regressor in the second equation. He states that the parameters of the second equation are not identified if there are no exclusion restrictions on the exogenous variables. This two-stage approach has the advantage of incorporating the predicted recall into the probit model as it represents the portion of recall activities related to certification adoption.

5.3 Probit Model with a Binary Endogenous Explanatory Variable and the Endogeneity Hypothesis

We observe the following binary choice, y_1, made by a food company such as a meat producer, co-manufacturer, or re-packer: the company enrolls in a TPC or does not. We denote these two choices by y_1 = 0,1, respectively. We also observe the binary result, y_2, standing for the recall, where y_2 = 1 if the company has a food recall in the study period, and y_2 = 0 otherwise. In this study, I use a binary probit model that contains a single binary endogenous explanatory variable in addition to one instrument and two exogenous explanatory variables. The model is:

$$y_{1i}^{*} = \alpha_1 y_{2i} + \beta_1 z_{2i} + u_i$$

$$y_{2i}^{*} = \pi_1 z_{1i} + \pi_2 z_{2i} + \varepsilon_i$$

$$\mathrm{y}_{1i} = \begin{cases} 1 & if\ y_{1i}^{*} > 0 \\ 0 & if\ y_{1i}^{*} \leq 0 \end{cases} \qquad (5.3)$$

$$\mathrm{y}_{2i} = \begin{cases} 1 & if\ y_{2i}^{*} > 0 \\ 0 & if\ y_{2i}^{*} \leq 0 \end{cases}$$

where

$\mathrm{y_i}^{*}$ is still an unobserved latent variable;

z_{1i} is an instrument;

z_{2i} is a vector of determinants of the decision to enroll;

π_1 is a conformal vector of unknown parameters;

ε_i is a stochastic error term that I characterize below.

Model 2.1: Certification= $\alpha_1 Recall + \beta_1 Sales + u_i$

$$Recall = \pi_1 Before + \pi_2 Sales + \varepsilon_i$$

Model 2.2: Certification= $\alpha_1 Class1 + \beta_1 Sales + u_i$

$$Class1 = \pi_1 Before + \pi_2 Sales + \varepsilon_i$$

Model 2.3: Certification = $\alpha_1 Reason2 + \beta_1 Sales + u_i$

$$Reason2 = \pi_1 Before + \pi_2 Sales + \varepsilon_i$$

In equation 5.3, (u_i, ε_i) is independent and distributed as bivariate normal with mean zero; each has unit variance, and ρ = Cov(u_i, ε_i). ρ (shown as Rho in result tables) is the correlation parameter, which can be understood as the correlation between the unobservable explanatory variables of the two equations. If ρ ≠ 0, then u_i and y_{2i}^* are correlated, and probit estimation of equation (5.3) is inconsistent for $\alpha_1$and $\beta_1$and is therefore endogenous. On the contrary, if ρ=0, u_i and y_{2i}^* are uncorrelated, this leads us to definite the hypothesis system as follows:

$$H_0: \rho = 0$$
$$H_1: \rho \neq 0 \quad (5.4)$$

The effect of y_{1i} is often of primary interest, especially when y_{1i} indicates participation in some sort of program, which in this paper is the adoption of certification. The first equation is a selection that uses the probit model and creates the predicted probability of adoption certification of each subject in the sample. The second statement is also a probit model to the predicted probability of recall/class1/reason2. The purpose of this model is to estimate the probability that an observation with food recall will adopt a third-party certification. The probit model analyzes whether the sample company chose to certify. It transforms the sigmoid dose-response curve to a straight line that can then be analyzed by regression, either through least squares or maximum likelihood. For this study, we use the “qlim” routine in SAS (SAS 9_4, 2016).

We test the null hypothesis that all coefficients except that of the intercept are statistically equal to zero. And we test three models in the same way, trying to identify which recall element has the most significant impact on certification adoption. In all three models, the dependent variable is whether the sample company certified or not. The independent variables in the first probit model are RECALL, BEFORE, and SALES. RECALL is the binary endogenous explanatory variable and we use CLASS1and REASON2 instead of RECALL in second and third models, respectively.

5.4 Maximum Likelihood Estimation and Log Likelihood Function

The maximum likelihood method is used to estimate the parameters due to the nonlinearity of the Probit model in β. When using the maximum likelihood estimation method to estimate the parameter of the distribution model, the likelihood value can be used to assess the fit of the distribution to the data set. The likelihood function is the basis of the maximum likelihood estimation parameter estimation method. Assume we have an independent random sample (y_i, x_i), where i=1, 2, 3…, n from the Bernoulli distribution with probability $P(x_i, \beta)$. The probability density function of a Bernoulli random variable, x, is given by $f(x)=p^x(1-p)^{1-x}$, where x=0, 1 and p is the probability of success. Collecting all n observations and assuming independence, which gives the likelihood function, is:

$$
\begin{aligned}
L(\beta|y,x) &= \prod_{i=1}^{n} \Pr(y_i|x_i,\beta),\\
&= \prod_{i=1}^{n} \Pr(y_i = 0|x_i,\beta)^{1-y_i} \Pr(y_i = 1|x_i,\beta)^{y_i}, \qquad (5.5)\\
&= \prod_{i=1}^{n} [1 - \mathrm{P}(x_i,\beta)]^{1-y_i} [\mathrm{P}(x_i,\beta)]^{y_i}.
\end{aligned}
$$

The natural logarithm of the likelihood function is log-likelihood, which is more convenient to work with. The log of $L= L(\beta|y,x)$ yields:

$$In(L) = \sum_{i=1}^{n}\{y_i \ln P\ (x_i,\beta) + (1-y_i) \ln [1 - \mathrm{P}(x_i,\beta)]\}. \qquad (5.6)$$

It is then easy to show that the log-likelihoods for the probit model are as follows:

$$In(L) = \sum_{i=1}^{n}\{y_i \ln F\ (x_i^T \beta) + (1-y_i) \ln F\ (x_i^T \beta)]\} \qquad (5.7)$$

The maximum likelihood parameter is found by taking the derivative of the log-likelihood equation (5.8), setting it to zero and then solving for the unknown parameters; extending to the probit model, we find:

$$L(\beta) = \sum_{i=1}^{n}[\frac{y_i p_i}{P_i} + (1-y_i)\frac{-p_i}{1-P_i}]\, x_i.$$

$$L(\beta) = \sum_{i=1}^{n}\frac{y_{i-\phi(x_i^T\beta)}}{\phi(x_i^T\beta)\times[1-\phi(x_i^T\beta)]}\varphi(x_i^T\beta)x_i. \qquad (5.8)$$

5.5 Marginal Effects

In the interpretation of a probit model, presenting marginal effects often brings more information than just looking at coefficients. Since the variance of the underlying latent variable (y*) is not identified and can differ across models, comparing coefficients across models can be very misleading. The marginal effect of a predictor is defined as the partial derivative of the event probability with respect to the predictor and it measures the expected change in the response variable as a function of the change in that predictor while other explanatory variables are held constant.

The marginal effect is the slope of the line drawn along the tangent to the fitted probability curve $\phi(y = 1|X = x)$ at the selected point holding all other variables constant. The binary probit main-effects model is $\phi^{-1}(p) = \sum_i x_i \beta_i$, where ϕ^{-1} is the inverse of the cumulative normal distribution function. The marginal effect of x_i in the probit model is equal to $\varphi(x'_i\beta)\beta_i$, where $\varphi(x'_i\beta)$is the density function of the standard normal distribution evaluated at $x'_i\beta$, $x'_i\beta$ is the product of the row vector of chosen covariate values, x'_i, and the column vector of parameter estimates, β, and β_i is the parameter estimate for x'_i .

CHAPTER 6: RESULTS AND DISCUSSION

In this section, in order to investigate the role of food recall and net sales factors that influence the adoption of third-party certification, we report the maximum likelihood estimates from probit models without IV (Tables 6.1) to compare them with probit models with IV (Table 6.2.1, 6.2.2 and 6.2.3). The log likelihood of each model is also provided in that model's table. Marginal effects and predicted probabilities are shown in Table 6.3.

6.1 Binary Probit Model without Using an Instrument

In this section, we estimate the probability of a firm having a TPC by using a probit model without an instrumental variable.

Across these three models, a firm's annual net sales are significant to its decision of whether or not to obtain certification. However, the impacts of recall variables differ. Our results show that if the firm had a food recall, then there was a significant impact on the company's decision about certification adoption; if the recall was Class I, it is not significant at all; and if the recall happened for Reason 2, it has a significant influence on a company's decision at a 5% significance level.

Table 6.1 Binary Probit Model (N=241)

Dependent Variable: *Certification*						
	Model 1		**Model 2**		**Model 3**	
Variable	***Recall*** (β_1)	***Sales*** (β_2)	***Class1*** (β_1)	***Sales*** (β_2)	***Reason2*** (β_1)	***Sales*** (β_2)
Coef	0.612 ***	0.006 ***	0.183	0.007 ***	0.766 **	0.006 ***
S.E.	0.219	0.002	0.254	0.002	0.318	0.002
Log likelihood	-85.65		-89.30		-86.76	
McFadden LRI (R2)	0.16		0.12		0.15	

Note: Asterisks ***, ** and * denote significance at 1%, 5% and 10% level, respectively.

6.2 Probit Model with a Binary Endogenous Explanatory Variable

The results presented in Table 6.2.1, 6.2.2 and 6.2.3 are drawn from three probit models with the same IV, and have different binary endogenous explanatory variables, which are RECALL, CLASS1 and REASON2, respectively. Table 6.2.1 includes sales and whether the firm had a recall or not within the study period to predict the influence of each variable on the firm's TPC adoption decision. Model 2 includes recall sales and Class I, while Model 3 uses sales and recall reason group 2 instead.

First of all, recall variables RECALL, CLASS1, and REASON2 are statistically significant. All have a marked impact on firms' third-party certification adoption. Results from three models indicate that firms recently having recall cases and being recalled in Class I and/or Reason 2 are more likely to apply for certification. In Model 1, firms' net yearly sales are somewhat insignificant to certification adoption, while in Model 2 and 3 they are significant at the 5% significance level, which suggests that net sales have a positive effect on certification adoption. Companies with large net sales tend to certify more than do low-net-sale companies.

Regarding the recall equation, a company's recall history from 2009 to 2014, variable BEFORE, has notable influence on whether the company has recalled in the study period at the 5% significance level in Model 1, indicating that companies with a recall history are more likely to continue having recalls in the current period. Company recall history is also significant at the 5% significance level to recall Class I in Model 2 and at the 1% significance level to recall Reason 2 in Model 3. This means that current year and past Class I recalls are correlated, as is the case with Reason 2 recalls.

Yearly net sales have a different impact on endogenous explanatory variables in these three models. Sales have a significant influence on whether or not the company has recalled in the study period at the 1% significance level, and also have an influence on whether the recall happened for Reason 2 at the 10% significance level. It is not, however, significant to recall class, which means the annual net sales have varied impact on a firm's recall variables.

Output includes the following table of parameter estimates. The endogenous dummy coefficient (certification. recall/ certification. class1 and certification. reason2) and the correlation coefficient (Rho) in each model have a central role in the inference. The parameter estimates for these endogenous explanatory variables indicate a strong effect of the recall variables on certification adoption (p <. 0001). Rho parameter estimates, at the end of each results table, is the correlation of the error terms from the two equations. The default value of Rho, 0, means the responses are uncorrelated, hereby making y_{1i}^{*} a standard probit model. Rho parameters in these three models are obtained as -0.781, -0.810, and -0.779 respectively, and all are significant at the 1% significance level, indicating that certification adoption is correlated with recall variables and that Equation 5.3 cannot be replaced by a standard probit model. This justifies the use of the instrument method.

Table 6.2.1 Probit Estimates of Recall on Certification Adoption

Dependent Variable: ***Certification***		
Variable	**Coef**	**S.E.**
Certification_recall (α_1)	1.851***	0.469
Certification_sales (β_1)	0.002	0.002
Recall_before (π_1)	0.601**	0.252
Recall_sales (π_2)	0.010***	0.003
Rho	-0.781***	0.249
Number of observations: 241		
Endogenous Variable: *Recall*		
Log likelihood value: -203.25		

Note: Asterisks ***, ** and * denote significance at 1%, 5% and 10% level, respectively.

Table 6.2.2 Probit Estimates of Recall Class I on Certification Adoption

Dependent Variable: ***Certification***		
Variable	**Coef**	**S.E.**
Certification_class1 (α_1)	1.700 ***	0.550
Certification_sales (β_1)	0.005 **	0.002
Class1_before (π_1)	0.550 **	0.237
Class1_sales (π_2)	0.0001	0.0001
Rho	-0.810 ***	0.216
Number of observations: 241		
Endogenous Variable: *Class1*		
Log likelihood value: -224.01		

Note: Asterisks ***, ** and * denote significance at 1%, 5% and 10% level, respectively.

Table 6.2.3 Probit Estimates of Recall Reason 2 on Certification Adoption

Dependent Variable: ***Certification***		
Variable	**Coef**	**S.E.**
Certification_reason2 (α_1)	2.317***	0.648
Certification_sales (β_1)	0.005**	0.002
Reason2_before (π_1)	0.369***	0.124
Reason2_sales (π_2)	0.0002*	0.0001
Rho	-0.779***	0.281
Number of observations: 241		
Endogenous Variable: *Reseason2*		
Log likelihood value: -156.09		

Note: Asterisks ***, ** and * denote significance at 1%, 5% and 10% level, respectively.

6.3 Marginal Effects

From Table 6.3 below, we observe that once a recall occurs, a firm's probability to seek certification will increase by 36.37%. If the recall was a Class I recall, the firm's probability of becoming certified will go up by 34.32%. The situation that most increases a company’s likelihood of applying for certification, at 40.30%, is when the firm has a food recall for Reason 2.

If a company has a recall history from 2009 to 2014, no matter the number of recalls, its probability of having a recall during the study period increases by 19.86%. The probability of this company having a recent Class I or Reason 2 recall increases by 14.69% and 5.7% respectively. These results indicate that once a food company has a recall record, the probability of this company having food recalls again increases.

In the above three models, if the average yearly net sales of a firm increases by one unit (one million dollars, in this study), the probability of the firm becoming certified increases by less than 0.1%. We observe that a limited improvement in annual net sales entails an unremarkable impact on certification adoption. Moreover, an increase in average yearly net sales does not increase a company’s likelihood of having a food recall.

Table 6.3 Marginal Effects of Recall Elements on Certification Adoption

Variable	Estimated Marginal Effects	Predicted probabilities
Model 1 (Endogenous Variable: *Recall*)		
Certification_recall(α_1)	0.3637	*Certification*: 0.2462
Certification_sales(β_1)	0.0004	*Recall:* 0.3364
Recall_before(π_1)	0.1986	
Recall_sales(π_2)	0.0032	
Model 2 (Endogenous Variable: *Class1*)		
Certification_class1(α_1)	0.3432	*Certification*: 0.2179
Certification_sales(β_1)	0.0010	*Class1:* 0.1963
Class1_before(π_1)	0.1469	
Class1_sales(π_2)	0.00003	
Model 3 (Endogenous Variable: *Reason2*)		
Certification_reason2(α_1)	0.4030	*Certification*: 0.1782
Certification_sales(β_1)	0.0009	*Class1:* 0.0925
Reason2_before(π_1)	0.057	
Reason2_sales(π_2)	0.00003	

CHAPTER 7 CONCLUSIONS

7.1 Concluding Discussion

In this paper, we propose a binary probit model to analyze the relationship between current recalls and certification adoption, while also controlling for the endogeneity of the recall variable. This econometric framework enables us to control the self-selection bias and other forms of unobserved endogeneity problems. Using firm level of annual net sales and recall information, we obtain marginal effects allowing us to explore how a firm’s probability of becoming certified changes with different recall variables. We found that if a company in the U.S. meat product industry had a food recall between January 1, 2015 and February 18, 2016, there was a significant positive effect on the company’s decision regarding third-party certification adoption. Similar results hold for companies that issued Class I and Reason 2 recalls. Both of these variables may cause health hazard situations, which can then cause health problems, death or large-scale food safety problems. Once a recall occurs, a firm’s probability of becoming certified increases by 36.37%. As for Class I and Reason 2 recalls happening, the firm's probability of becoming certified increases by 34.32% and 40%, respectively.

Furthermore, a company with larger yearly net sales has a stronger preference for applying TPC than low-net-sale companies. However, the improvement of firms’ net sales does not generate an equivalent increase in certification adoption, as was initially expected. If a firm’s average yearly net sales increase by one million dollars, the probability of the firm becoming certified only increases about 0.1%. Moreover, companies with a previous food recall record are more likely to have recent recall issues.

These results highly suggest that firms with recent recall cases, especially recalls caused by the threat of foodborne illnesses, tend to be more likely to apply for certification. Successful third-party certifications monitor and enforce standards and prevent firms from producing poor quality and/or unsafe products, which may lead to foodborne pathogens. Certification would likely help firms regain lost market shares and rebuild consumer confidence in product safety. Moreover, firms with TPC have a competitive advantage and better access to global agro-food systems. Thus, certification might be one of the best options for recovery after food recall incidents.

7.2 Limitations and Suggestions for Further Research

This empirical study is limited in that the data do not provide details on registration time or adoption with specific certification bodies and auditors. This study is also constrained by limited company information. These limitations could be addressed in further research through the use of case studies and increased sample sizes to supplement the statistical company data. A better perspective could then be gained on how food recalls affect TPC adoption, as well as how this might affect food recalls by controlling for other motives that influencing companies' decisions. And with companies' TPC adoption records, in further study we can also discus how TPC adoption influences recall occurrence. These topics are both important and can shed light on the strategic relevance and economic value of TPC to companies with recalls and the impact of TPC on subsequent recalls.

APPENDIX

Appendix: SAS Codes

Descriptive Statistics

```
data qlim2; set qlim;
if num=0 then recall=0; else recall=1;
if class=1 then class1=1; else class1=0;
if reason=2 then reason2=1; else reason2=0;
sales2=sales/1000000;
run;
/*mean*/
proc means data =qlim2;
var employees sales weight;
run;
/*frequency*/
proc freq data = qlim2;
table num recall before class1 reason2 certificate;
run;
```

Binary Probit Model

```
/*Model 6.1.1*/
proc qlim data=qlim2;
model certificate=recall Sales2/ discrete;
run;
/*Model 6.1.2*/
proc qlim data=qlim2;
model certificate=class1 Sales2/ discrete;
run;
/*Model 6.1.3*/
proc qlim data=qlim2;
model certificate=reason2 Sales2/ discrete;
run;
```

Binary Probit Model with IV and Marginal Effect

```
/*Model 6.2.1*/
proc qlim data=qlim2;
model certificate=recall Sales2/ discrete;
```

```
model recall=before sales2/ discrete;
output out=outqlim1 marginal proball;
run;
proc means data=outqlim1 n mean;
var Meff_P2_certificate_recall Meff_P2_certificate_sales2 Meff_P2_recall_before
Meff_P2_recall_sales2 Prob2_certificate Prob2_recall;
title 'Average of the Individual Marginal Effects 1';
run;
/*Model 6.2.2*/
proc qlim data=qlim2;
model certificate=class1 Sales/ discrete;
model class1=before sales/ discrete;
output out=outqlim2 marginal proball;
run;
proc means data=outqlim2 n mean;
var Meff_P2_certificate_class1 Meff_P2_certificate_sales2
Meff_P2_class1_before Meff_P2_class1_sales2
Prob2_certificate Prob2_class1;
title 'Average of the Individual Marginal Effects 2';
run;
/*Model 6.2.3*/
proc qlim data=qlim2;
model certificate=reason2 Sales/ discrete;
model reason2=before sales/ discrete;
output out=outqlim3 marginal proball;
run;
proc means data=outqlim3 n mean;
var Meff_P2_certificate_reason2 Meff_P2_certificate_sales2
Meff_P2_reason2_before Meff_P2_reason2_sales2
Prob2_certificate Prob2_reason2;
title 'Average of the Individual Marginal Effects 3';
run;
```

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