THESIS

STOCK MARKET REACTION TO ANIMAL DISEASE OUTBREAKS: AN EVENT STUDY IN KOREAN FOOT-AND-MOUTH DISEASE

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ABSTRACT

STOCK MARKET REACTION TO ANIMAL DISEASE OUTBREAKS: AN EVENT STUDY IN KOREAN FOOT-AND-MOUTH DISEASE

In Korea, there were five foot-and-mouth disease (FMD) outbreaks between 2000 and 2010. This study examines the impact of the FMD outbreaks on the stock market value of agribusiness firms in Korea using an event study methodology. Eighteen companies in six different groups (i.e., pork, poultry, seafood, imported meat, feed and vaccine) are analyzed. For each outbreak, single-day abnormal returns and multiple-day cumulative abnormal returns are calculated to test for the existence and magnitude of stock price reactions. In addition, changes in volatility after the outbreaks are computed to examine whether the riskiness of returns change due to the events.

The results suggest that the FMD outbreaks caused the stock market to react in both a negative and positive manner to related firms. The 2000 outbreaks had the most distinguishing and consenting results to prior expectations. The 2002 results showed relatively stable changes of returns due to appropriate governmental programs. In the 2010 events, some companies' stock market reactions were unexpected and did not meet our prior expectations as a result of other factors such as market supply and demand conditions and another animal disease.

The results also suggest that the stock market reactions were more gradual than instantaneous to the FMD outbreaks. This study observed more meaningful values of multi-day cumulative abnormal returns than single-day abnormal returns and understands

that these long-lasting impacts are due to the continuous negative news reaching the stock market as there were multiple confirmed cases in all outbreaks. When an outbreak severely impacted a particular business sector, the accumulations of abnormal returns became substantial.

Many companies had significant results that met prior expectations, but some groups did not maintain consistency in their reactions to the events. The pork companies realized a negative reaction in the 2000 and the third 2010 events when the outbreak presented a negative outlook for the swine and pork businesses. The poultry and seafood firms reacted positively when there were no other substantial market threats. The imported meat group showed mixed reactions while the vaccine companies had consistent positive reactions that met prior expectations. The feed companies reacted negatively when the outbreaks substantially damaged the livestock production sites. Volatility of the stock prices after the FMD events increased, with more companies showing significant results in a longer-lasting outbreak.

The results imply that managers and shareholders of the affected firms should pay more attention on management of their assets when there is an FMD and other animal disease outbreaks. It also implies that appropriate governmental interventions help mitigate damages on the stock market.

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INTRODUCTION

There are many events that threaten the stability of the livestock and meat industry. The allied firms (i.e., firms that supply input to and process output from the industry such as wholesale and retailing of meat and input suppliers) are also impacted including the stock market value of those firms resulting from those events. These events vary from a worldwide crisis such as the economic recession in 2008 to a nationwide incident such as the foot-and-mouth disease (FMD) outbreak in Taiwan in 1997. These events can be firm-specific such as product recalls due to foodborne illnesses. For example, the bacteria contamination of cantaloupe in Colorado in 2011 significantly impacted the producing firm, Jensen Farms. Recently, issues related to human health and food safety have become noteworthy events as people pay closer attention to their food and environment. Among the noteworthy events include animal disease outbreaks which have generated both short- and long-term economic impacts on related agribusiness sectors.

In the past two decades, many animal diseases have occurred throughout the world and caused significant economic impacts on livestock production and operations of allied businesses. In 1995, the outbreak of bovine spongiform encephalopathy (BSE) in the UK was estimated to cost £3.2 billion GBP ($5.0 billion USD) a year (Atkinson, 1999). Additionally, it had significant impacts on the stock market values of the related firms (Henson and Mazzocchi, 2002). After losing the entire beef export market to Japan and Korea following the U.S. BSE outbreak in December 2003, firms in the beef industry

were significantly impacted in a negative way. Coffey et al. (2005) estimated the losses to the U.S. beef industry in 2004 due to the export market restrictions to range from $3.2 billion to $4.7 billion. Foot-and-mouth disease, one of the most contagious animal diseases, has a great potential for causing severe economic losses. In Taiwan, the 1997 FMD outbreak devastated the swine industry causing billions of dollars in losses, and, needless to say, it affected the allied business. The FMD outbreaks in the UK in 2000 and 2007 also caused significant economic impacts on the livestock and related businesses.

In Korea, there were five FMD outbreaks between 2000 and 2010, and all of those cases triggered considerable economic impacts. In the 2000 event, Korea lost its entire meat export market resulting in a substantial structural change in the swine and pork industry. The following outbreak in 2002 resulted in more animals being culled which ultimately led to reduced meat consumption by consumers and decline in live animal and meat prices. The three outbreaks in 2010 were the worst FMD outbreaks in Korea. More than 30% of the swine population was culled causing billions of dollars in losses to the entire economy.

There has been extensive research that examined primary and secondary economic impacts of animal disease outbreaks. Among governmental agencies and institutes, universities, and private firms, most of the research has confirmed that animal disease outbreaks were definite events that generated shocks to the livestock and meat production and its allied business. Additionally, the research has quantified those impacts to livestock and meat industry and broader economy. However, there has been no research examining how animal disease outbreaks have impacted the stock market values of the allied businesses.

RESEARCH OBJECTIVES

An objective of this study is to determine whether the FMD outbreaks in Korea had any impact on daily returns of related firms' securities. Specifically, the impacts of the daily returns will be estimated by taking the difference between actual returns and expected returns of event dates. This calculation will also provide information on the magnitude of the changes of the daily returns.

Another objective of this study is to determine the patterns, if any, of the market reactions related to both size and length of the outbreaks. There are five sample events for which magnitudes and durations are different. Thus, identifying any significant pattern of the market reactions is meaningful because that information could be used to help predict impacts in a future outbreak.

This study will also examine the changes in volatility of the daily returns. The intent is to observe whether FMD outbreaks have increased the riskiness of returns of the sample companies' securities.

BACKGROUND

This section is included to provide background information about this study. It begins with a description of foot-and-mouth disease (FMD) illustrating what FMD is and how the disease occurred and affected the economy. Because this study is based on the livestock industry and stock market in Korea, explanations on overall features of the livestock production, its allied businesses and its product consumption will be presented. This section will conclude with discussion on the Korean stock market.

Foot-and-Mouth Disease

According to the World Organization for Animal Health (OIE), FMD is a highly contagious viral disease that impacts cloven-hooved animals such as cattle, swine as well as sheep and goats. There are seven immunologically distinct types of FMD viruses. The typical clinical signs include the occurrence of blisters on the muzzle, tongue, lips, mouth, and teats. Other symptoms include fever, depression, hyper-salivation, loss of appetite and weight, and drop in milk production. The disease is rarely fatal in adult animals, but mortality can be high in young animals. However, the disease can weaken and debilitate animals and result in severe production losses (OIE, 2011).

Foot-and-mouth disease is not transmissible to humans and is not a public health risk (OIE, 2012). However, outbreaks of the disease generate significant economic

impacts. Primary losses are a result of culled livestock, reduced consumer demand, and trade bans. For example, the continuous outbreaks in Korea in 2010 resulted in culling 3,318,202 pigs and 150,864 cattle (KREI, 2011). The disease also generated additional losses to the broader economy. The 2010 outbreaks in Korea were estimated to cost 0.1% of the total gross domestic product (GDP) to the nation's economy (KREI, 2011). In addition, FMD outbreaks impose bans of exported meat products from infectious countries in accordance with the OIE's guidelines. The 2000 FMD outbreak in Korea resulted in an export ban on pork to Japan. Korea reacquired an FMD disease-free status in August 2001, 18 months after the break, but pork exports to Japan had not begun before the next outbreak in April 2002 (i.e., 26 months after the 2000 outbreak).

Foot-and-mouth disease occurs throughout much of the world, while Australia, New Zealand, Indonesia, Central and North America, Western Europe, and some countries in Latin America are FMD free. Moreover, FMD is endemic in several parts of Asia, a large part of Africa and the Middle East. Most notable countries that have experienced severe outbreaks in the past include the United Kingdom, Taiwan, China, and Korea (OIE, 2011). The United Kingdom reported two recent epidemics in 2001 and 2007. In 2001, the outbreak resulted in 2,026 cases of the disease in farms throughout the British countryside. Over six million sheep and cattle were destroyed in an attempt to control and eradicate the disease. This episode was recorded as one of the worst FMD outbreaks in the world (Scudamore, 2002). Another disastrous outbreak occurred in Taiwan in 1997. By the end of the outbreak, over 3.8 million swine were destroyed at a cost of $6.9 billion USD. The Taiwanese swine industry, which had supplied 41% of Japan's pork imports in 1996 was devastated (Huang, 2000). Although Japan reopened its

pork market to Taiwan in July 1998, partially allowing for processed products, Taiwan has never recovered its strength of export-centered pork industry until recently (KREI, 2011).

The FMD Outbreaks in Korea: Characteristics and Economic Impacts

After more than 60 years of maintaining FMD disease-free status, FMD was discovered in Korea in 2000. Table 1 summarizes the five Korean FMD outbreaks that occurred between 2000 and 2010. The first infection in 2000 was confirmed on March 27th with the outbreak being eradicated on April 16th, resulting in 15 confirmed cases and 2,216 culled animals. The majority of culled animals were beef cattle. Although this outbreak only lasted 20 days, it caused significant losses to the livestock industry and its allied businesses. Shortly after the outbreak was declared over, the Korea Rural Economic Institute (KREI) estimated the primary and secondary economic impacts of the outbreak. KREI (2000) estimated that the livestock production lost 1,349.3 billion won (1.2 billion USD[1]) with more than 99% of loss due to decline in livestock prices. In the allied business sector, it was estimated the processing, wholesale, and retailing businesses incurred losses of 1,066.3 billion won (0.9 billion USD). In addition to the losses incurred domestically, KREI concluded the swine industry in Korea would lose additional 2,876 billion won (2.5 billion USD) for five years due to the ban on pork exports.

In 2002, another outbreak occurred in Korea with the first confirmation on May 3rd and lasted for 51 days. A total of 160,155 animals were culled with 16 confirmed

[1] Based on the average exchange rate in 2000, 1,131.03 Korean won/USD. The rate is applied for all values in 2000.

cases (KREI, 2002). Different from the 2000 outbreak, 99.1% of the culled animals were swine. KREI (2002) estimated that the swine-producer surplus decreased by 81.7 billion won (65.1 million USD[2]). In addition, KREI conducted a survey to investigate the consumer's reaction to the FMD outbreak. With 500 consumers surveyed in the metropolitan area of Seoul during the outbreak, they found that 99.8% of survey responders were aware of the outbreak with 53.3% believing that FMD was dangerous to human health. Additionally, 49.5% answered that they reduced their meat consumption after the outbreak. This explains why and how an FMD outbreak threatens the livestock industry and its food market.

Three outbreaks occurred in 2010. The first outbreak in 2010 began on January 4th and was eradicated on January 29th. This case ended up with six confirmed cases and 5,956 culled animals. The second outbreak, which was confirmed on April 9th and terminated on May 6th, resulted in 49,784 culled animals with 11 confirmed cases. The final outbreak in 2010 began on November 29th and was over on April 3, 2011. The number of animals culled during this outbreak was approximately 3.5 million head, which accounted for 33.4% and 4.5% of the total swine and cattle population, respectively (NACF, 2011). KREI (2011) estimated that the outbreaks between 2010 and 2011 reduced 32.0%, 8.4%, and 3.9% in pig, dairy, and beef cattle sales, respectively. In addition to the primary loss in the livestock production, KREI (2011) estimated the economic impacts of the outbreak on the entire economy and concluded that the losses accounted for 0.1% of gross domestic product (GDP) in 2010.

[2] Based on the average exchange rate in 2002, 1,254.55 Korean won/USD. The rate is applied for all values in 2002.

The Korean Livestock & Meat Industry

Production Sector

The size of the Korean livestock sector has increased over the past three decades. Table 2 summarizes livestock production in Korea. The number of beef cattle plummeted in the late 1990s and early 2000s due to the trade liberalization of the beef market under the Uruguay Round Agreement. However, it has gradually recovered reaching 2.9 million head in 2010. The number of swine also increased from 6.5 million head in 1995 to 9.9 million head in 2010. The number of chickens increased drastically from 85.8 million in 1995 to 149.2 million head in 2010 (NACF, 2011).

Although the number of livestock has been increasing in the past decade, the number of farms has substantially decreased resulting in increasing farm size. This pattern is similar to what has been seen in the U.S. livestock production. The number of beef cattle, dairy cattle, swine, and chicken per farm increased by 240%, 182%, 854%, and 968% from 1995 to 2010, respectively (NACF, 2011).

The Korean livestock production was 0.3% of the nation's total GDP in 2009, down from 0.6% of GDP in 2005. Sales of total agricultural production in 2010 were 43,720 billion won (37.8 billion USD[3]), with livestock sales valued at 17,872 billion won (15.5 billion USD) (i.e., livestock sales comprised 40.9% of the total agricultural sales). One reason for the increase is that the per capita consumption has continuously increased as shown in Table 3, and price of livestock products has also climbed as production cost increased (NACF, 2011).

[3] Based on the average exchange rate in 2010, 1,155.48 Korean won/USD.

Slaughtering and Wholesale Sector

The Korean slaughtering and wholesale sectors have a complex structure. In the beef sector, slaughtering and wholesale companies are mostly separated. In 2010, there were 87 slaughtering facilities. These facilities slaughter livestock by the request of farmers, farmers' unions, or cooperatives, without transition of ownership of the livestock. Many of the beef slaughtering firms are small in size and operation. There are 14 beef slaughtering companies that also run an auction wholesale market where wholesalers join and bid on livestock carcasses. After slaughtering, general wholesalers, chain retailing stores, individual food businesses, and butcher shops distribute 35%, 33%, 18%, and 14% of the total wholesale quantity, respectively. Overall, there are not any large-scale integrated systems or any leading beef packers in Korea, as in the U.S. (NACF, 2011).

Similar to the U.S., the pork slaughtering and wholesale sectors are more integrated when compared to the beef sector. In 2000, 85% of all pork was slaughtered and distributed by integrated companies. From the early 1990s, farm-processor integration was introduced in this sector, and cooperatives, feed companies, and wholesale companies joined in this movement. Some companies are publically traded and included in this study. However, the market shares of several leading companies, such as Sunjin Holdings and Farmsco, do not exceed 3% of branded pork sales. The poultry sector is the most integrated sector, with 91% of all processed chicken handled by 38 integrators. Among them, the top four companies handle more than 50% of total production with three of them included in this study (NACF, 2011).

Consumer Perspective

Per capita meat consumption in Korea is small when compared to those of western countries. However, it has been steadily increasing since 1995. Table 3 shows per capita meat consumption by product. In 2010, per capita consumption of meat, eggs, and milk was 41.4 kg (90.4 lbs), 11.8 kg (26.0 lbs), and 62.8 kg (138.5 lbs), respectively. Between 1995 and 2010, red meat and milk consumption has increased approximately by 30%, while chicken consumption has more than doubled. Fish consumption also increased from 36.8 kg (81.1 lbs) per capita in 2000 to 49.8 kg (109.8 lbs) per capita in 2009. Korean people have been continuously increasing consumption of protein derived from animal and seafood sources (NACF, 2011).

Allied Businesses of the Korean Livestock Industry

The feed industry in Korea is the most crucial allied business in the livestock industry. Currently, there are 86 feed companies in Korea. In 2010, the feed industry produced 17.5 million metric tons of formulated feed mixture, with gross sales around 7.0 trillion won (6.1 billion USD) (NACF, 2011). Almost 100 percent of commercial swine and poultry operations in Korea use formulated feed mixture that is produced by those feed companies. Approximately 50% of commercial beef and dairy cattle operations in Korea also rely on formulated feeds. This is important because it is possible that a negative event on the livestock production sectors will negatively affect financial performances of feed companies and returns for shareholders. Apart from the feed industry, most of the allied businesses are generally smaller in size, including vaccination companies.

Korean Stock Market

The Korean stock market is run by the Korea Exchange (KRX), which is the sole securities exchange operator in the Republic of Korea. The market has three divisions: Stock Market Division, KOSDAQ Market Division and Derivatives Market Division. As of June 30, 2011, the Korea Exchange had 1,801 publically traded companies with a combined market capitalization of $1.2 trillion (WFE, 2012).

There are several indices in the Korea Exchange: KOSPI, KOSPI 200, KRS 100, and other indices in the Derivatives Market Division. Among them, KOSPI (Korea Composite Stock Price Index) is the index in which all common stocks are traded on the Stock Market Division. It is the representative stock market index of Korea, such as the Dow Jones Industrial Average or S&P 500 in the U.S.

LITERATURE REVIEW

The literature review is divided into four sections. The first section describes the literature that identifies what business sectors are influenced by animal disease outbreaks. The second and third sections examine the literature that has studied event study methodology and has applied event study methodology in the agribusiness sectors, respectively. The fourth section describes the literature that has examined the economic impacts of the FMD outbreaks in Korea. Finally, this chapter concludes with the contribution that this research makes to the applied event study methodology in the agribusiness sectors.

Specifying Influenced Business Sectors

There is a rich set of literature investigating the impacts of animal disease outbreaks on both the livestock and meat sectors and the broader economy. Pritchett et al. (2005) surveyed previous literature in this area which this thesis refers to define the scope of study. They confirmed that meat processors such as slaughterers, wholesalers, retailing and food service are impacted as a result of animal disease outbreak. In addition, they found that the outbreaks also affected allied agribusinesses such as animal feed and veterinary medicine.

Mangen and Burrell (2001) investigated the change of consumer preference for meat and fish in the Netherlands triggered by bovine spongiform encephalopathy (BSE). They concluded that consumers shifted their preference from red meat to poultry and seafood responding to the BSE crisis of March 1996 in England. This suggests that agribusinesses producing substitute products could experience a positive impact from an animal disease outbreak.

Event Study Methodology

Brown and Warner (1985) reviewed their previous study on event study method with monthly returns and simulated the method with daily return data. They specify how abnormal returns (AR) and cumulative abnormal returns (CAR) are calculated and how the results are tested for significance using parametric tests. They found that the method based on the OLS market model is well-specified under a variety of conditions. However, they argued that daily return data present difficulties due to autocorrelation and heteroskedasticity.

MacKinlay (1997) made a significant contribution to the event study literature. In addition to reviewing and summarizing different methods of conducting event studies, he provided different procedures in conducting an event study. First, he reviewed two statistical models and one economic model for measuring normal return: 1) Constant Mean Return Model, 2) Market Model, and 3) Capital Asset Pricing Model (CAPM). Between the two statistical models discussed, the market model represents a potential improvement over the constant mean return model, as the market model reduces variances of abnormal returns by removing the portion of return that is related to

variation in the market's return. Armitage (1995) also confirmed that the market model is most commonly used to generate expected returns, and no better alternative has been found despite the weak relationship between beta and actual returns. He also demonstrated how abnormal returns (AR) on single days and cumulative abnormal returns (CAR) as aggregations of periodical post-event windows are calculated. In conclusion, most successful applications of this method have been in the area of corporate finance.

Armitage (1995) outlined widely used methods of estimating abnormal returns and testing their significance and reviewed research comparing results produced in various empirical contexts. He concluded that the market model performed the best when generating expected returns. More specifically, he recommended that 250 trading days or one calendar year is appropriate to estimate expected returns using the OLS market model. Additionally, he outlined how to identify event windows. Armitage used several different event windows when examining market reactions (i.e., five-day event window: $T = [-5, +5]$, two-day event window: $T = [-2, +2]$, and one-day event window: $T = [-1, +1]$). Senchack and Starks (1993) noted that event windows generally extend beyond a certain event date to account for information leakage.

Volatility of stock market returns is another critical factor when considering the impacts of a certain market shock because it indicates changes in riskiness of the returns. Salin and Hooker (2001) tested for changes in volatility after food recall events using the standard deviation of the returns. They examined post-event changes in volatility and concluded that two of four sample companies showed increased volatility after food recall events.

Applied Event Study Methodology in Agribusiness Sectors

Event study methodology has been frequently used in the area of mergers and acquisitions of firms to examine how stock prices of related companies reacted to a certain news release about a firm's movement. Researchers have also applied the methods to investigate impacts of innovation news such as acquisition of new patents and development of new technologies. In agribusiness related fields, researchers have investigated firms' market reactions to food safety issues or farm policy legislation.

Salin and Hooker (2001) investigated abnormal daily returns of companies that recalled products due to microbial infections. Applying the methods described in Mackinlay (1997), they selected four different food recall events using three companies from 1996 to 1998 in the U.S. They calculated single-day abnormal returns using -5 to 5 day event windows and cumulative abnormal returns in 5, 10, 20 and 30 post-event days. They concluded the stock market reactions were firm-specific and more significant for a small-size company and larger recall incidents. The volatility of daily returns was examined and determined that the food recall events increased the volatility of the returns.

Detre et al. (2008) investigated how the value of agribusiness firms have changed in response to procedures of legislations of the U.S. farm bills over the past 40 years. Specifically, they selected different key dates during the legislation procedures, such as the dates the conference report is filed, the president's signing into public law, and when a bill is introduced in a chamber. They conclude that agribusinesses react on the date legislation emerges from the joint House and Senate conference committee.

Numerous studies have estimated the economic impacts of highly contagious animal disease outbreaks on an industry (e.g., Pendell et al. (2007), Paarlberg et al.

(2009)). However, there is no known published research that has analyzed the impacts of highly contagious animal disease outbreaks on the value of related firms. The closest published paper, authored by Henson and Mazzocchi (2002), investigated the impacts of BSE to agribusiness firms. The event used was the British government's announcement that confirmed the link between BSE and human health in March 1996. Twenty-four agribusiness firms were selected and grouped into four areas: (1) beef, (2) other meat, (3) dairy, and (4) feed and pet food. Henson and Mazzocchi found that the firms in a number of sectors were negatively affected by the announcement, most notably and obviously, beef processing firms, but also processors of dairy products, animal feed, and pet food. The only firms included in the analysis that were positively impacted were manufacturers of other meats. Although this study is based on a secondary event following an animal health issue, this study is the first attempt to examine impacts of an animal health related event on how the event affected related agribusiness firms' securities.

Literature on Assessing Economic Impacts of FMD Outbreaks in Korea

After terminations of the outbreaks in 2000, 2002, and 2010-2011, the Korea Rural Economic Institute (KREI) published white papers on the FMD outbreaks and their economic impacts with supervision of the Ministry for Food, Agriculture, Forestry and Fishery (MIFAFF). First, KREI confirmed primary damages in the livestock production computing the number of animal culled and production loss due to the culled animals. Second, KREI attempted to estimate secondary impacts on the broader economy, implementing different methods for each case. KREI concluded that all cases caused substantial losses to the livestock industry, its allied business and the entire economy.

Roh et al. (2008) estimated the impacts of the 2000 and 2002 outbreaks on pork and beef prices using a GARCH model and Box and Tiao's intervention analysis model. They found that prices dropped 15% to 20% before the government began an intervention program after the first outbreak. However, the drop in price was much smaller after the 2002 outbreak due to government appropriate and prompt intervention. Park et al. (2006) also investigated economic impact of the 2000 outbreak on meat prices and concluded the outbreak caused a temporary price shock to the Korean meat market. Additionally, they found that the decline in price took 16 months to recover.

The studies described above that have examined the economic impacts of the FMD outbreaks concluded significant economic impacts on the livestock production and meat market sectors. In addition, all found or implied that the outbreaks also caused significant losses to related or allied companies. However, there has not been any research that investigates the FMD outbreaks' impact on the value of firms that were affected by the incidents.

Contribution of This Study

There is an extensive literature estimating the economic impacts of animal disease outbreaks. Most of these studies have used partial equilibrium, Input-Output, computable general equilibrium and/or linear programming models to estimate the economic impacts to producers and consumers.

Although this research is similar to past work (i.e., the applied event study methodology on the agribusiness sectors), it is different because it is the first known

study to investigate the impacts of a highly contagious animal disease outbreak on the value of livestock and allied firms. More specifically, this study will:

- Provide information for managers and shareholders of related companies, which will enable them to develop strategies to protect their assets and prevent investors' negative movement on their investments.
- Yield practical information for investors on how an animal disease outbreak could impact their returns of related firms, and what patterns of returns the outbreaks produce, so investors may able to make better decisions on their investments.
- Support theoretical background to policy makers and research institutes for establishing proper governmental intervention programs to minimize damages and loss of the livestock industry and related business.

MATERIALS AND METHODS

This chapter describes how an event study methodology is conducted in this study. Additionally, discussion of the events, sample companies, and data occur in this section. Measuring abnormal returns and testing for significance are explained both for abnormal returns and cumulative abnormal returns. This is followed by a discussion on volatility.

Procedure of Event Study Methodology

Identifying Events

As described in Mackinlay (1997), identifying an event and event window is the first step to conducting an event study. The event is any objective event of interest, and the event window specifies the period over which the stock prices of the firms involved in this event will be examined. This research's events are five FMD outbreaks in Korea between 2000 and 2010. Table 1 summarizes notable dates and durations of the events.

Before identifying the event window, identification of the correct event date is crucial in event studies (Armitage, 1995). There are three noteworthy dates in the FMD outbreaks in Korea: (1) notification, (2) confirmation, and (3) termination. The notification date is the date when the first case was notified by the Korean government. The confirmation and termination dates are the dates when the first case was confirmed to be FMD virus by the Korean government and when the last case was confirmed,

respectively. Following Salin and Hooker (2001), the official announcement by the Korean government (i.e., confirmation date) is considered to be exact event date used in this research.

Identifying the event window is the next step and is important in an event study. Armitage (1995) and Mackinlay (1997) recommended defining the event window to be larger than a period of interest because this permits examination of the period surrounding the event. It is suggested that the length of the event window would depend on the topic being studied. Armitage (1995) concluded that two-day event windows are common in the finance literature, if the event date can be determined with precision. Additionally, two-day event windows should be supplemented by cumulative abnormal returns for longer periods after the event window. Following two studies in the agribusiness literature, Detre et al. (2008) and Salin and Hooker (2001), five-day pre- and post-event windows are used in this study (i.e., -5 to +5 days of an event date). Five-day pre- and post-event windows are chosen for two reasons: (1) each case had a notification date one or two days prior to the event date, and five-day pre-event windows can cover impacts of the notifications as well as any leakage of information to the stock market and (2) five-day post-event windows are preferable because all outbreaks last more than five days.

Determining Firms for Event Study

After identifying the event and the event window, the companies being evaluated are chosen. This study selected 18 different agribusiness firms that are grouped into six

different categories. Tables 4 and 5 summarize basic information and characteristics of the companies. Four groups in the meat and seafood business are selected as well as two groups in the input business. The six groups include: (1) pork, (2) poultry, (3) seafood, (4) imported meat, (5) feed, and (6) vaccine. In each group, three companies are selected based on availability of public information and the dates that the companies began trading publically.

For the pork group, Sunjin Holdings (SJ), Farmsco (FC), and Farmstory Hannaeng (FH) are chosen. These three companies are fresh pork processors and are the top competitors in the branded pork market in Korea. All three companies have similar business characteristics including: integrated companies that have swine farms, slaughtering houses, processing and packing facilities, and sales departments. Additionally, all three companies own and operate livestock feed plants which supply a formulated feed mixture to its own farms and member farms. In 2010, approximately 50% of revenue for these firms is from pork with the remaining 50% of sales from feed. This study classifies these companies into the pork group, and not the feed group, because consumers perceive them as branded pork companies. Because the companies became publically traded in different years, only Sunjin is included in all five events while the other two companies are included in the 2002 and 2010 events.

The poultry group includes: Harim (HR), Maniker (MK), and Dongwoo (DW). These companies produce fresh and processed poultry products and have the highest market shares for fresh chicken (combined they have more than 50% market share of the fresh chicken market in Korea). Harim has the highest market share of 32%. Both Maniker and Dongwoo process whole poultry and their gross revenues are about 50% of

Harim. Harim is included in all events while Maniker is included in the 2002 and 2010 events and Dongwoo is only included in the 2010 events.

The seafood group is comprised of three seafood-specialized companies: Dongwon Industries (DI), Sajo Industries (SI), and Oyang (OY). Their businesses are fundamentally based on the deep-sea fishing industry. However, they have distinct business characteristics in a final product perspective. Dongwon is strongly specialized in canned tuna products, Sajo emphasizes more on supplying raw tuna to retailers and restaurants, and Oyang specializes in processed fish products. These companies could play important roles if consumers reduce meat consumption. More precisely, if consumers substitute their meat consumption with seafood, Dongwon and Oyang can directly benefit from the substitution. However, Sajo's raw tuna products do not gain immediate benefits because raw tuna is considered to be a luxury good in Korea and cannot easily replace the reduced meat consumption. All three companies are included in all five events.

Companies in the imported meat group have complex characteristics. Dongaone (DA) is a wheat flour and feed company and owns a subsidiary, Donga Food, that imports and sales meat. Hanil Feed (HF) is primarily a feed company, but merged with a meat importing and processing company, Hankook Nangjang, in 2003. Atinum Investment (AI) is an investment company that owns a subsidiary, KR Food and Company, which is involved in meat import and sales. This group is only included in the 2010 events because these companies became publically traded or began in the meat-import business after 2002.

The feed group had three companies that only manufacture animal feed: Woosung Feed (WS), Korea Industry (KI), and KC Feed (KC). In term of gross revenue, Woosung Feed is the largest among the three companies with 324 billion won (281 million USD) of gross revenue in 2010. Its market share consisted of 3.7% of the Korean feed market. In 2010, Korea Industry and KC Feed had market shares of 1.8% and 1.1%, respectively. All three companies are included in all five events.

Three vaccine and veterinary medicine companies are selected for this study. Choong Ang Vaccine Laboratory (CV), Eagle Veterinary Technology (EV), and Cheil Bio (CB) are all classified in the pharmacy industry section of the Korea stock market. They are small in size with gross revenues around 16 billion won (14 million USD). This group is only included for the 2010 events because the companies began to be publically traded on the Korean stock market after 2002. Additionally, emergency vaccination was only applied in the third outbreak in 2010.

Hypotheses of the Stock Market Reaction by Group

The direction of stock price reactions is hypothesized by the groups of companies before calculating abnormal reruns (AR) and cumulative abnormal returns (CAR). First, the pork and feed groups are tested under a hypothesis of negative AR and CAR. KREI (2002) surveyed meat consumers during the 2002 FMD outbreak and found that 49.5% responded that they would reduce their red meat consumption. In addition, KREI (2011) estimated that swine sales declined by 30% as a result of the FMD outbreak. These facts obviously indicate that the pork companies are negatively affected by the FMD outbreaks.

KREI (2000) estimated that the 2000 outbreak cost 13 billion won (11 million USD) to the feed industry. During the 2010-2011 outbreak, approximately 3.5 million livestock were culled (which was 26.7% of total cattle and swine population) in Korea. This indicates that feed companies lost approximately one fourth of their product end users. With the KREI's estimation, the reduction of livestock population makes it possible to hypothesize a negative stock value return to the feed companies.

The groups of poultry, seafood, imported meat, and vaccine are hypothetically assumed to have positive AR and CAR. Mangen and Burrell (1999) estimated consumers' preference shifts in the Netherlands due to the BSE scare. They concluded that changing preferences reduced beef's share by 4.9% and increased those of poultry and fish by 4.1% and 5.2%, respectively. Trend Monitor Co. (2011) surveyed Korean meat consumers on how they changed the pattern of their meat consumption during the third 2010 FMD outbreak and found that 60.1% and 30.9% of people who reduced their red meat consumption switched to seafood and chicken, respectively. These results support the hypothesis of a positive stock market reaction of the seafood and poultry group. Baek (2011) analyzed companies in the stock market that were benefited from the 2010 outbreak and included meat import companies and vaccine companies as earning firms from the event.

Estimating Normal Returns

Evaluating impacts of the events on stock values require a measure of abnormal returns. The abnormal return is an actual ex-post return of the security over the event window

minus the normal return of a firm over the event window. The normal return is defined as the expected return. The abnormal return is estimated as follows:

$$AR_{it} = R_{it} - E(R_{it} \mid X_t) \quad (1)$$

where AR_{it}, R_{it}, and $E(R_{it} \mid X_t)$ are the abnormal return, actual return, and normal return, respectively, for firm *i* and event date *t*.

As discussed previously, Armitage (1995) and Mackinlay (1997) reviewed different models for the normal return estimation and concluded that the market model by an OLS is the most suitable model to estimate the normal returns. As such, this study uses the OLS market model. The OLS market model is:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{\text{it}} \quad (2)$$

$$E(\varepsilon_{\text{it}}) = 0, \quad \text{var}(\varepsilon_{\text{it}}) = \sigma^2 \quad (3)$$

where R_{it} and R_{mt} are the return of the event time *t* on stock of firm *i* and the market portfolio, respectively. α_i and β_i are the estimated coefficients, and ε_{it} is the error term and is assumed to have a zero mean and constant variance.

This research uses Korea Composite Stock Price Index (KOSPI) as the market portfolio (R_{mt}) because it is the most representative stock market index in Korea. The estimation period differs by researcher; Peterson's (1989) estimation period ranges from 100 to 300 days while Armitage (1995) recommends 250 trading days or one calendar year. Therefore, this study uses both the 250-day and 300-day daily returns prior to the test period (-5 to +5 days of an event day) to obtain more precise regression results.

The 2000, 2002, and first 2010 outbreaks have sufficient preceding days to estimate parameters of the market model. However, the second and third outbreaks in

2010 have only 67 trading days and 160 trading days between the first and second outbreaks, respectively. As a result, the normal return estimation for the first 2010 outbreak is used for all three outbreaks in 2010.

Autocorrelation and Heteroskedasticity

The estimated parameters from the market model are used to calculate abnormal returns associated with the events to be examined. However, this routine requires strong statistical assumptions that are pointed out as potential important problems, especially using daily return data (Brown and Warner, 1985). These problems result in lowering efficiency of the model; hence the parameters estimated.

One of these assumptions is that the error term, ε_{it}, is uncorrelated. However, this assumption has been questioned and documented that returns on individual stocks are correlated (Lo and Mackinlay, 1998). Therefore, normal return regression results are tested for serial correlation and corrected for first-order serial correlation when detected for serial correlation (Gujurati and Porter, 2008). When normal return regression results for companies are re-estimated correcting for the serial correlation, re-estimated parameters will replace original parameters.

The second assumption of the market model is that the error terms follow a normal distribution with constant variance (Brown and Warner, 1985). Giaccoto and Ali (1982) have shown that the error terms from regressions involving stock returns are rarely normally distributed. As a result, if the assumption of homoscedasticity cannot be satisfied, the standard tests to measure the impact of an event on stock prices must be adjusted for heteroskedasticity. Otherwise, the parameters estimated may be inefficient,

and any inferences could be potentially misleading. This study tests and corrects all models for heteroskedasticity using the White test (Gujurati and Porter, 2008). Re-estimated parameters will be used for further steps substituting original parameters.

Calculation of Abnormal Returns and Cumulative Abnormal Returns

As demonstrated in the previous section, the abnormal return (AR) is calculated by subtraction the expected return from the actual return. The equation for calculating AR is;

$$AR_{it} = R_{it} - (\alpha_i + \beta_i R_{mt}) \quad (4)$$

where AR_{it}, R_{it}, and $(\alpha_i + \beta_i R_{mt})$ are the abnormal return, actual return, and expected return, respectively, for firm *i* and event date *t*. The test period is 11 days from -5 day and +5 day from an event date, designating the event date as day 0.

Cumulative abnormal return (CAR) is an aggregation of multiple-day ARs of the post-event window. Maclinlay (1997) pointed out that CAR is important to monitor periodical inferences for the event of interest. The CAR is calculated using the following equation:

$$CAR_i\ (t_1,\ t_2) = \sum_{t = t_1}^{t_2} AR_{it} \quad (5)$$

where $CAR_i\ (t_1,\ t_2)$ and $\sum_{t = t_1}^{t_2} AR_{it}$ are the cumulative abnormal return and summation of the abnormal returns between t_1 to t_2, respectively. Following Salin and Hooker (2001), this study adopts four post-event CAR windows: 5-day, 10-day, 20-day, and 30-day windows. These periods are also reasonable because the FMD outbreaks last between 14 to 33 trading days for the first four outbreaks.

Test of Significance for Abnormal Returns and Cumulative Abnormal Returns

Brown and Warner (1985) and Armitage (1995) confirmed that a standard *t*-test is appropriate for a significance test for ARs and CARs. The tests seek to prove whether ARs and CARs are significantly different from zero and will be performed with null hypotheses as:

$$H_0 : AR_{it} = 0, \quad H_1 : AR_{it} \neq 0 \tag{6}$$

$$H_0 : CAR_{it} = 0, \; H_1 : CAR_{it} \neq 0 \tag{7}$$

Mackinlay (1997) pointed out that the test of these hypotheses can be conducted under an assumption that the distributions of AR and CAR are normally distributed as

$$AR_{it} \sim N \; (0, \; \sigma_i^2(AR_{it})) \tag{8}$$

$$CAR_i \; (t_1, \; t_2) \sim N \; (0, \; \sigma_i^2(t_1, \; t_2)) \tag{9}$$

The test statistic for AR is the ratio of an abnormal return of event day *t* to its estimated standard deviation of the normal return estimation period while the CAR test statistic is the ratio of a cumulative abnormal return to its estimated standard deviation. The test statistics for AR and CAR are calculated as follows:

$$AR: \; t\text{-statistics} = AR_{it} \; / \; \sigma \; (AR_{it}) \tag{10}$$

$$\text{where} \quad \sigma \; (AR_{it}) = \sqrt{\left(\sum_{t=-256 \text{ or } -306}^{t=-6} (AR_{it} - \overline{AR_{it}} \right)} \; / \; 249 \text{ or } 299$$

$$CAR: \; t\text{-statistics} = CAR_{it} \; / \; \sigma \; (CAR_{it}) \tag{11}$$

$$\text{where} \quad \sigma \; (CAR_{it}) = \sqrt{\left(\sum_{t=0}^{t=N} (CAR_{it} - \overline{CAR_{it}} \right)} \; / \; (N-1)$$

Calculation of Volatility of Daily Returns Before and After the Events

Volatility is the measure for variability of price of a financial unit over time. Volatility is an important factor when discussing stock market returns because it indicates riskiness of returns. Many researchers measure volatility in an attempt of determining what factors have causality in changing volatility. As a measure of volatility, standard deviation is the most representing measure. Specifically, volatility is measured by comparing standard deviations of returns of the same time intervals before and after an event (e.g., 50 days, 100 days, etc). Salin and Hooker (2001) adopted the measure of standard deviation and examined volatility. They compared standard deviations of 50-day, 100-day, and 150-day intervals before and after food recall events and tested for significance of the differences.

This study calculates standard deviations of daily returns of individual firms in intervals of 50 days, 100 days, and 150 days before and after the event dates. In other words, comparisons of standard deviations of the 50-day interval is from -50 day to -1 day and +1 day to +50 day; the 100-day interval is from -100 day to -1 day and +1 day to +100 day; and the 150 day intervals is from -150 to -1 day and +1 day to +150 day. However, there are only 68 trading days between the first and second outbreaks of 2010. Therefore, only 50-day interval is applied in the first and second 2010 outbreaks.

To test significance of the differences of volatility, *F*-tests are employed. Snedecor and Cochran (1980) illustrate an *F*-test to test for equality of two standard deviations. This test can be a two-tailed test or a one-tailed test. The two-tailed version tests against the alternative that the standard deviations are not equal. The one-tailed version only tests in one direction (i.e., the standard deviation from the first population is either greater than or less than the second population standard deviation). This study is

only interested in an increment of volatility due to the disease outbreaks, thus, the one-tailed test is used. The null hypothesis is:

$$H_0 : \sigma_{before} = \sigma_{\text{after}} \quad (12)$$

$$H_1 : \sigma_{before} < \sigma_{after}$$

where σ_{before} and σ_{after} are standard deviations of daily returns before and after the events, respectively. The test statistic is;

$$F = \sigma^2_{i,after} \; / \; \sigma^2_{i,before} \quad (13)$$

where $\sigma^2_{i,after}$ and $\sigma^2_{i,before}$ are variance of daily returns of company *i* after and before the events, respectively. The tests are at the 1%, 5%, and 10% significance levels. Additionally, the test statistic is modified and re-calculated to normalize or account for the change on the market index. In other words, variances of individual companies' daily return are also impacted by change of a market index. This study also calculates an *F*-statistic which is weighted by a ratio of variances of the market index in same test periods. The modified test statistic is calculated as follows:

$$F = (\sigma^2_{i,after} \; / \; \sigma^2_{i,before}) \; / \; (\sigma^2_{index,after} \; / \; \sigma^2_{index,before}) \quad (14)$$

where $\sigma^2_{i,after}$, $\sigma^2_{i,before}$, $\sigma^2_{index,after}$, and $\sigma^2_{index,before}$ are variances of company *i* after and before the events and variances of the market index after and before the events, respectively.

Data

The information on financial and operational characteristics of the sample companies in tables 4 and 5 are obtained from Yahoo Finance Korea and Daum Finance. The statistics on the Korean livestock industry are from the NACF Livestock Industry Statistics Book (NACF, 2011). Daily stock prices and the market index (KOSPI) are collected from Korea Securities Computing Corporation (KOSCOM).

RESULTS AND DISCUSSION

This chapter presents and discusses the results of this study. First, the normal return regression results are presented with a summary of statistics of the daily returns. Second, abnormal returns and cumulative abnormal returns of the five outbreaks are discussed by the group and event. Finally, volatility of the daily returns are presented and discussed.

Summary Statistics of the Daily Returns of the Estimation Periods

As previously discussed, the normal return estimation was performed with both 250-day and 300-day daily returns to obtain more significant estimates. Between estimates, the results with 300-day daily returns were more significant in the 2000 and 2010 events. In the 2002 event, 250-day daily returns generated a better result.[4]

The summary statistics of the daily returns of the estimation periods are shown in Table 6, Table 7, and Table 8. In the 2000 event, only one company in the pork and poultry groups, and three companies in the seafood and feed groups were tested. Six companies experienced both the upper and lower price limit, while Sunjin and Dongwon Industries experienced only the upper price limit.[5] In the seafood group, the largest company, Dongwon Industries, demonstrated smaller variability of daily return (i.e., 4.25%

[4] The estimates of both with 250-day and 300-day daily returns are available from the author upon request.

[5] The price limit of day-trading is positive and negative 15% in the KOSPI and KOSDAQ markets. Before May 2005, the limit for the KOSDAQ market was 12%.

of standard deviation of daily return). Compared to Dongwon Industries, smaller-size companies, Sajo Industries and Oyang's daily returns were more variable. In the feed group, a similar pattern occurred. Woosung, the largest company, had 4.36% of standard deviation while the two smaller companies had higher variability. Sunjin in the pork group was more stable in change of daily return with a maximum of 15.00%, a minimum of -10.78%, and a standard deviation of 4.17%. Although Harim, in the poultry group, had a larger total asset and gross revenue, it experienced a wider range of variability with a standard deviation of 6.06%.

For the 2002 event, this study included three companies in pork, seafood, and feed groups and two companies in the poultry group. All pork companies have shown a daily data of the limit price or very close to the limit price. The poultry companies were similar in terms of the range, average, and variability. The seafood companies showed a positive relationship between size of the company and variability of daily return similar to the data of the 2000 event. In 2002, the feed companies followed the same pattern in regards to size and variability of daily returns. However, there were noticeable differences between the two time periods. The daily returns in 2000 were 22% to 97% more variable than those in 2002. Furthermore, average daily returns were mostly higher in the 2002 compare to 2000. The higher variability and lower daily returns in 2000 was an effect of the aftermath of the 1997 financial crisis in Korea (Koo, 2001).

The summary statistics for 2010 showed similar results as those of 2002. Table 8 displays the summary statistics of the 2010 estimation period. One difference from the previous periods is the inclusion of imported meat and vaccine groups in 2010. In the imported meat group, Dongawon had the lowest average daily return and standard

deviation. The vaccine group was highly variable in daily returns ranging from 4.83% to 6.56% of standard deviation.

Normal Return Regression Results

This study estimated the normal returns using the OLS market model. The results for the normal returns for individual companies by year are shown in Table 9, Table 10, and Table 11. All models were tested for serial correlation and heteroskedasticity. If serial correlation was detected, after-correction statistics are reported. Tables include Durban-Watson *d*- statistics, with after-correction statistics when one was detected for serial correlation. The tables also contains White test χ^2-statistics with a denotation of significance level when one was detected for heteroskedasticity. When the test detected and corrected for serial correlation and heteroskedasticity, corrected parameters and other values such as model *F*-statistics and R^2 replaced the original results.

The estimated beta's in the regression results across all three time periods were statistically significant at 1% significance level. The regression *F*-statistics were also highly significant at 1% significance level, except for Harim in 2000. In 2000, first-order serial correlation was detected and corrected for in three companies (i.e., SJ, HR, and KC) while two companies (i.e., SI and OY) were corrected for heteroskedasticity. The 2002 results suggest the companies did not bear any serial correlation, but three companies (i.e., SJ, DI, and WS) were corrected for heteroskedasticity. In the 2010 results, one company (i.e., HR) was corrected for the first-order serial correlation, and two companies (i.e., SJ and SI) were corrected for heteroskedasticity.

Abnormal Returns and Cumulative Abnormal Returns

This section discusses the calculated abnormal returns (ARs) and cumulative abnormal returns (CARs). Each event will be discussed in separate subsections and comparisons. Table 12 through Table 16 details the results. The tables show values of ARs and CARs by company and event, attaching *t*-statistics of each AR and CAR.

Abnormal returns partly show significant values matching with the prior hypothetical assumptions of direction of the reaction. However, some companies were followed by immediate bounce back in the other direction. Cumulative abnormal returns showed more significant results indicating that lengthy-lasting events, such as an animal disease outbreak, affect the stock market more gradually than instantaneously. However, some groups reacted to the opposite direction from the hypothetical assumption which is interpreted as impacts of other direct factors to groups.

The 2000 Event

The ARs and CARs of the 2000 event indicate that the disease outbreak had impacts on stock prices. Furthermore, the directions of reaction mostly matched with the hypothetical assumption. The ARs and CARs of the 2000 event can be found in Table 12.

The companies analyzed in this research realized significant ARs in different event dates. Sunjin in the pork group showed statistically insignificant negative ARs on day 0 and day 2, but plummeted on day 3 and day 5 with highly significant ARs of -14.00% and -14.09%, respectively. Harim, in the poultry group, experienced statistically significant positive ARs on day 0 (11.49%), day 3 (12.33%), and day 5 (12.01%) with

insignificant negative ARs between the event dates (day 1, day 2, and day 4 had ARs of -8.25%, -8.48%, and -3.57%, respectively).

The feed group did not react immediately to the FMD announcement, but reacted significantly on day 2. Woosung showed significant ARs on day 2, day 3, and day 5 with ARs of -10.07%, -13.27%, and -13.52%, respectively. KC Feed also had -11.89% of AR on day 2, but ARs bounced back on day 3 and day 5. Additionally, Korea Industry appeared to have a significant negative AR of -14.01% on day 2, and additional negative returns on the following event days.

Compared to the pork, poultry, and feed companies, the companies in the seafood group showed indiscernible ARs. Oyang demonstrated a strong positive AR on day 0 (15.01%), but the other two companies showed insignificant ARs. Moreover, Sajo Industries and Oyang had significant negative ARs the following day, but the group showed little reaction for the rest of the test period.

Supporting the AR result, CARs also confirmed an existence of impacts of the disease outbreak. Sunjin, in the pork group, significant CARs were -20.20%, -37.93%, -34.87%, and -31.48% in 5-day, 10-day, 20-day, and 30-day post-event windows, respectively (Table 12). Harim in the poultry group showed positive CARs in 5-day and 10-day windows, but were not significant at the 10% level. Unexpectedly, significant negative CARs occurred in the 20-day and 30-day windows. As expected, the feed companies had negative CARs. Korea Industry experienced the highest loss of their stock value with significant CARs of -21.47%, -24.14%, -26.81%, and -38.03% in 5-day to 30-day post-event periods, respectively.

In summary, the stock market reactions to the pork, poultry, and feed companies were as expected. The FMD outbreak posed a ban on pork exports, resulting in an unexpected market loss which caused investors to reassess the value of the pork company. The poultry company benefited from the disease outbreak, but the impacts did not last longer than 10 days after the event date. The feed companies experienced negative reactions because the outbreak caused a reduction of their revenue as estimated by KREI (2000). The seafood companies did not show any obvious reaction to the disease outbreak. This might suggest that the market did not believe that the seafood group would benefit from the disease outbreak. Additionally, it appears that the reactions began on day 2, March 29th. KREI (2000) explained that the Korean government described the disease as "suspected FMD" when it made an announcement on March 27th. The government sent a blood sample of an infected animal to the United Kingdom to confirm the infection. The test results confirmed the FMD virus on April 2nd. Therefore, it is possible that the delayed reaction was due to the confusion surrounding the procedure of confirming the infection.

The 2002 Event

The stock market reactions to the 2002 FMD outbreak were noticeably different when compared to the 2000 FMD outbreak. Overall, the reactions of the pork and poultry companies met prior expectations while the seafood and feed companies did not match prior expectations. Table 13 lists the ARs and CARs for the 2002 event.

In the pork group, all three companies had statistically insignificant negative ARs for day 0 and day 5. The CARs for Sunjin were negative in 10-day (-6.98%), 20-day

(-19.36%), and 30-day (-16.04%) post-event windows. The other two companies in the pork group (i.e., FC and FH) had unexpected positive CARs in 20-day (5.64%) and 30-day (4.43%) for FC and 30-day (4.61%) for FH. The result is suspected to be unrelated to the FMD outbreak.

Two companies in the poultry group appeared to show the most distinguishing results in the 2002 event. The companies had positive ARs around the event date. Harim had significant ARs of 10.94%, 12.00%, and 6.99% on day -1, day 0, and day 1, respectively. Maniker also had positive ARs on the same event days, but only statistically significant on day 0. Both companies experienced the opposite-direction ARs on day 2. The CARs for the poultry companies did not show any significant values suggesting that the impacts were short lived.

Similar to the result of the 2000 event, the seafood group did not have an obvious reaction to the event. The stock prices of those three companies all rose on day 0, but only Oyang showed a statistically significant value of 10.88%. CARs were not apparent either, except for Dongwon Industries which showed positive CARs in 5-day and 10-day periods.

One difference when compared to the 2000 event is that the feed companies showed an indiscernible result. Woosung did not claim any significant ARs or CARs throughout the test period. KC Feed had a positive AR on day -3 and a negative AR on day 3, but had two positive CARs in 20-day and 30-day intervals. Korea Industry had a strong and negative AR on day -1, but had strong positive ARs in the two previous days. Similar to KC Feed, Korea Industry had strong positive CARs in 20-day and 30-day post-event periods.

Some of the results for the 2002 event confirmed the impacts on daily returns of related firms' stock prices, but the magnitude of the impacts were significantly lower than the impacts of the 2000 case. For instance, CARs of Sunjin in the pork groups substantially decreased, and the feed group companies did not show any statistically significant negative reaction. As KREI (2002) describes, the immediate and appropriate government actions minimized disturbance to the livestock industry and its related market. The government established an emergent task-force team to prevent the spread of the disease and to strengthen educating programs for consumers. As a result, the prices of beef cattle and swine did not decline after the outbreak compared to the price before the outbreak, whereas the prices of beef cattle and swine declined by 1.4% and 15.9%, respectively, after the 2000 outbreak. KREI (2002) concluded that the prompt and appropriate response dampened the negative economic impacts. This research could also be interpreted that the government timely response is one of the reasons of stability of the stock market reaction.

The First 2010 Event

The first FMD outbreak in 2010 also caused an abnormal reaction of related firms' stock prices. However, the reaction became lengthier over the post-event time interval. The firms' reactions met expectations for all groups, except for the pork and imported meat groups. Table 14 presents the calculated ARs and CARs.

The pork group had an unexpected positive reaction to this event. The single-day ARs were not significant while the CARs were significant. Sunjin's CARs were 5.89%, 7.75%, 6.27%, and 4.17% in 5-day to 30-day periods, respectively. Farmsco

experienced mixed impacts of 12.23%, -12.83%, and -7.17% of CARs in 10-day, 20-day, and 30-days test-periods, respectively. Farmstory Hannaeng had negative CARs, but the values were small and statistically insignificant. One factor that could explain the pork firms' unexpected reactions is due to the nature of the outbreak. The first FMD outbreak in 2010 was the smallest case of the five outbreaks and only happened in beef and dairy cattle.

In the poultry and seafood groups, single-day ARs were generally not significant. However, the firms in these two groups clearly reacted for a longer period of time. In the poultry group, Harim showed 7.37% of CAR in the 5-day interval, and Maniker accumulated CARs to 5.58%, 16.64%, 24.84%, and 35.33% in 5-day, 10-day, 20-day, and 30-day post-event windows, respectively. Dongwoo also showed 3.65% and 4.63% of CARs in 5-day and 10-day post-event periods, respectively. The seafood companies did not show any significant reactions on the single-day calculations but showed significant results in aggregation of CARs. Dongwon Industries had 5.87%, 12.12%, and 8.31% of CARs in 10-day, 20-day, and 30-day intervals, respectively. Sajo Industries experienced positive reactions in a shorter period of post-event windows with 5-day and 10-day CARs at 10.68% and 5.16%, respectively. Oyang had CARs of 9.15% and 5.99% in the 5-day and 10-day intervals. The results from the poultry and seafood groups conform to our prior expectations about having a positive reaction. With the seafood companies showing a positive reaction for a first time in this study, it is possible to interpret that the stock market began to realize this group of companies as a beneficiary in the FMD outbreak.

Results from the imported meat group showed mixed results. Hanil Feed had a strong positive AR (13.69%) on day 1; however, a strong negative return occurred the

following day. Furthermore, the CARs on the post-event intervals were all negative. Dongawon did not show any significant AR and CAR in this event window. Only Atinum Investment showed positive CARs in 5-day (11.20%) and 10-day (10.01%) post-event windows.

The stock prices of the feed companies had negative response, which met prior expectations. Similar to other groups, the three companies did not show any significant ARs but had significant CARs. Woosung had negative CARs of -3.80% and -9.83% in 20-day and 30-day post-event intervals, respectively. KC Feed had negative CARs throughout all the post-event test periods of -3.53%, -4.87%, -5.20%, and -11.11% in 5-day to 30-day test periods, respectively. Korea Industry only showed a negative CAR of -2.80% in the 10-day test period.

The vaccine companies realized positive reactions to the event with a moderate level of abnormality. However, this result is meaningful because this group was tested only for the three 2010 events and had positive reactions was hypothesized. Eagle Veterinary Technology and Choong Ang Vaccine Laboratory had a significant level of ARs on day 3 with values of 8.53% and 16.07%, respectively. Cheil Bio also showed an AR of 5.27% on day 3, but the value was not statistically significant. In aggregations of ARs, all three companies showed positive values in 5-day and 10-day test windows. However, only the 10-day CAR of Choong Ang Vaccine Laboratory was statistically significant.

The stock market reactions for the first 2010 event were generally insignificant for the ARs, but the CARs had a number of significant values. In addition, there were more significant CARs in shorter test periods, such as 5-day and 10-day, than the longer

test periods. The result is due to the magnitude and duration of the event. The FMD outbreak in January 2010 was the smallest event out of the five events in terms of durations and number of confirmed cases. This outbreak lasted for only 19 trading days with six confirmed cases. Therefore, the shorter duration and smaller number of confirmed cases helps explain the stock market reaction for the first 2010 event.

The Second 2010 Event

In the second FMD event in 2010, the stock market reactions did not meet prior expectations and were different (i.e., opposite reaction) when compared to the other events. The ARs and CARs for the second 2010 outbreak can be found in Table 15.

The pork group companies' responses had relatively positive returns to the outbreak. Considering that the results of the 2002 and the first 2010 outbreaks did not have obvious negative reactions, this result suggests that the FMD outbreak is no longer a threat that outweighs other market factors unless a FMD outbreak is directly related or substantially damages to the swine industry. Almost all significant values of ARs and CARs in this group were positive values, except the negative CARs of Farmstory Hannaeng.

The poultry group showed the most unusual reaction to this event. Harim and Maniker had single-day ARs of 5.44% and 4.74% on day -1, respectively, when the first case was notified. These single-day positive ARs conformed to our hypothesis. However, most of the ARs after day 0 were negative and the CARs for two companies were significantly negative. This indicates that the news of the FMD outbreak momentarily affected the stock prices, but the impact was rapidly offset by other factors. The primary

factor was the market outlook of the chicken market for the second quarter in 2010 which was gloomy as the number of broilers increased from the previous year. Specifically, the broiler price plummeted by 19.8% from 4,066 won/kg in January to 3,260 won/kg in May (NACF, 2010). This market condition had more significant impact on the companies' stock prices and offset the positive influence of the FMD outbreak.

The seafood companies did not show any significant single-day ARs but showed mostly positive CARs in the longer time-periods. These results met our hypothesis that consumers would switch to eating more seafood, thus impact the stock values of those companies.

The stock market reaction to the imported meat companies was unclear for this event. Dangawon had several significant single-day ARs (mostly before day 0), but it is not appropriate to conclude that the result is an impact of the FMD factor because the notification of the infection was one previous day before the confirmation. However, the company realized positive CARs of 5.24% and 13.90% in 20-day and 30-day post-event periods which meets the prior expectation. This result was not consistent when it came to the other two companies. Hanil Feed and Atinum Investment had CARs of -4.39% and -9.46% and -12.17% and -13.94% in 20-day and 30-day post-event intervals, respectively.

Similar to the poultry category, the feed category also had an abnormal reaction in the second 2010 outbreak. Woosung accumulated CARs of 8.68% and 21.87% in 5-day and 10-day post-event periods. KC Feed showed even higher level of CARs with 4.53%, 64.37%, 35.31% and 65.37% in 5-day to 30-day post-event periods, respectively. This positive response for an input supplier is contrary to the hypothesis. The vaccine companies, another input supplier, reacted to the outbreak positively, as expected. All

three vaccine companies showed significant single-day ARs on day 1 and significant CARs in 10-day and 20-day post-event test periods. From the onset, KREI (2011) stated that there was a strong argument of implementing emergency vaccination as this outbreak occurred three months after the previous outbreak. Although the government decided not to vaccinate in this event, the stock prices of vaccine companies strongly benefited from this situation.

The Third 2010 Event

The final FMD outbreak, starting in November 2010, was the worst outbreak among the five sample events in this study. Furthermore, it was one of the worst FMD outbreaks in the world. One essential point of this outbreak is that the outbreak began in a swine operation and primarily impacted the swine industry. The stock market reaction showed statistically significant results mostly in multi-day CARs than single-day ARs. However, in the poultry, seafood, and imported meat groups, the direction of the reaction did not meet prior expectations. One possible factor that could have been impacting the stock prices of these groups is the highly pathogenic avian influenza (HPAI) outbreak during the same period. Table 16 displays the calculated ARs and CARs.

Companies in the pork group generally had a negative stock market reaction. However, the reaction was more significant in multi-day accumulations indicating the reactions occurred at gradual pace. Sunjin had a significant CAR of -5.31% while Farmsco's CAR was -10.51% in 20-day time interval. Farmstory Hannaeng showed -3.49%, -8.83, and -4.73% of CARs in 10-day, 20-day, and 30-day post-event time periods.

The poultry companies had significant CARs, but the direction of CARs was opposite of prior expectations. According to the Animal Plant and Fisheries Quarantine and Inspection Agency in Korea (2012), HPAI occurred between December 10, 2010 and February 2012. This HPAI outbreak had more impact on the daily returns of the poultry companies than the FMD outbreak.

The seafood group had significant negative impacts, but all in multi-day CARs. Dongwon Industries declined -4.47% in 5-day period, and Sajo Industries lost -3.70% and -8.44% in 5-day and 10-day periods, respectively. Oyang's stock prices fell -7.04% and -11.23% in 10-day and 20-day post-event time periods, respectively. The negative abnormal reactions lessened in 30-day post-event window.

The imported meat group had a negative reaction in shorter post-event test periods, but had a significantly positive reaction in the 30-day window. This pattern suggests that the stock market put more of a premium on those companies as the outbreak became more severe, and consumers worried more about domestic meat products.

Two input supplying groups showed relatively significant results that met prior expectations. KC Feed and Korea Industries had declines in CARs of -9.97% and -18.65%, and -7.90% and -12.13% in 20-day and 30-day test periods, respectively. In the vaccine group, all three companies displayed significant single-day ARs on day 0; Eagle Veterinary Technology was 14.26%, Choong Ang Vaccine Laboratory was 14.99%, and Cheil Bio was 14.84%. In the post-event test windows, Choong Ang Vaccine Laboratory showed 20.50% and 12.83% in 5-day and 10-day periods, respectively, while Cheil Bio had a CAR of 17.19% in the 30-day period. Although other CARs were not statistically significant, they all had positive values.

Comparison by Event

In order to compare the stock market reaction by event, the magnitude of the outbreaks should be standardized and quantified. However, available information on the five FMD outbreaks is not enough to standardize and quantify the magnitude of the outbreaks. The information on the outbreaks included qualitative measures such as duration of outbreak, number of confirmed cases, and number of animal culled. With these figures, it is not possible to compare magnitudes of each outbreak, and it needs an appropriate model to quantify the magnitude of each outbreak. Therefore, this study fails to compare the stock market reactions of each outbreak. This is one limitation of this study that can be investigated in further research.

Volatility of Daily Returns

Volatility of daily returns increased after the FMD outbreaks and showed more significant values in the recent events. Incidentally, increased volatility is meaningful only if it corresponds with reactions that satisfied the hypothetical assumptions. If a group's reaction showed to the opposite direction from the hypothetical assumption, it could be due to other factors than the FMD outbreak. Hence, a change of volatility can be a mixed effect of the FMD outbreaks and other factors. Therefore, this result will encounter significant cases that showed significant and matching stock price reactions.

In 2000, Sunjin in the pork group and Sajo Industries in the seafood group showed a significant change of volatility, showing standard deviation of 5.59 in 150-day post-event window compared to 4.45 in 150-day pre-event window for Sunjin and 5.08 in

150-day post-event window compared to 4.48 in 150-day pre-event window for Sajo industries. The magnitude of change was not substantial, but it is meaningful for Sunjin because this company showed significant CARs in all test periods. This is the worst scenario for a firm as this company lost a great amount of its value as well as stability of its stock price. Other companies did not show any statistically significant increment of volatility in this event.

In the 2002 event, more companies faced increasing volatility. Similar to the 2000 event, Sunjin experienced more variable daily returns after the event and the increment approximately by 50% for 100-day and 150-day test periods. Maniker, in the poultry group, also had increased volatility of daily returns in all test periods. Dongwon Industries and Oyang, in the seafood group, also experienced an increase of volatility in both of the 100-day and 150-day periods. Those companies in the poultry and seafood groups realized positive stock market reactions to the FMD outbreak, but the volatility, the riskiness of return, also increased. This suggests that managers and shareholders of these companies need to be more caution to the FMD outbreaks.

In the first two outbreaks in 2010, only a 50-day interval was tested because the longer test periods overlap as there were only 68 trading days between the two outbreaks. In the first outbreak, a relatively small number of companies experienced increased volatility. Two companies in the poultry group, Harim and Maniker, had a significant increased volatility from 1.60 to 3.64 and 1.90 to 2.73 of standard deviations in 50-day pre- and post-event windows, respectively. KC Feed and Korea Industry also had increased volatility from 1.32 to 1.99 and 2.45 to 2.95 of standard deviations, respectively. More companies experienced higher volatility after the event date in the second 2010

outbreak. Two companies in each of the pork, poultry, and seafood groups had increased volatility. The stock market prices for the companies in the vaccine group increased as hypothesized, but their volatility also substantially increased for all post-event time periods. The changes of standard deviations from 50-day pre-event window to 50-day post-event window were 0.87 to 5.65 of Eagle Veterinary Technology, 2.10 to 6.58 of Choong Ang Vaccine Laboratory, and 1.93 to 5.38 of Cheil Bio.

In the last outbreak in 2010, additional companies showed increment of volatility. Considering that this event lasted more than four months, it is possible to conclude that the longer an outbreak continues, the greater change in volatility is caused. In the pork group, Sunjin and Farmstory Hannaeng's standard deviations increased significantly after the event date in all test periods. Likewise for the poultry groups, all three companies experienced significant volatility increments in all test periods. As pointed out before, a HPAI outbreak occurred during this time period resulting in a significant negative impact. Therefore, this suggests that the HPAI outbreak is also a meaningful threat of stock prices and volatility to directly-related companies (i.e., poultry companies). In the imported meat group, Hanil Feed and Atinum Investment showed significant increment of volatility in all test periods. This is interesting because these companies had CAR reactions that changed from negative to positive.

In the feed group, only one company, Woosung, significantly increased its variability of daily returns. Same as the second event in 2010, the vaccine companies experienced significant increases in volatility of daily returns. Particularly, nationwide vaccination was decided and applied in the third 2010 outbreak which generated more

abnormal reactions in longer periods of the event windows.[6] This helps explain the cause of the volatility increase of this group. One more possible cause is a relative smaller size of the companies in the vaccine group. Salin and Hooker (2001) concluded that a small company in size was more influenced in the food recall incident, and this study also finds that smaller companies, in size of total asset and revenue, showed greater increment in their volatility.

The modified F-statistic, which adjusted or normalized the change of the market index returns on individual stocks' daily returns, concluded with the same results as the standard method. *F*-statistic values increased or decreased the values when compared to the standard method, but did not notably change the levels of significance. *F*-statistics of both the standard method and the normalized method are presented in Table 17.

[6] Vaccination in limited infected areas was decided on December 22nd, and nationwide vaccination was decided on January 13th, 2011.

CONCLUSION AND IMPLICATONS

This study concludes that the foot-and-mouth (FMD) outbreaks caused the stock market to react in both a negative and positive manner to related firms. The first event in 2000 had the most distinguishing and consenting results to prior expectations. The 2002 results showed relatively stable changes of returns. Additionally, this study concludes that the appropriate and prompt government responses lessened the stock market disturbance. In the 2010 events, some companies in several groups' stock market reactions were unexpected as a result of other factors such as a market supply and demand conditions and another animal disease. This study succeeded in helping to explain some factors that caused this disagreement, but some were unidentifiable. The last 2010 event was the most severe FMD outbreak and generated many significant abnormal returns, but some of the stock market reactions were mixed.

The stock market reactions were more gradual than instantaneous to the FMD outbreaks. That is to say, this study observed more meaningful values of cumulative abnormal returns than single-day abnormal returns. Furthermore, when an outbreak severely impacted a particular business sector, the accumulations of abnormal returns became substantial. The 2000 outbreak for the pork group is an explicit example. The long-lasting impacts of the FMD outbreak are understandable considering that negative news kept reaching the stock market because there were multiple confirmed cases in all outbreaks.

The different groups did not maintain consistency in their reactions to the events. For example, the pork companies only realized a negative reaction in the 2000 and the third 2010 events. This study concludes that this group reacted negatively when the outbreak presented a negative outlook for the swine and pork businesses. The poultry and seafood firms reacted positively when there were no other substantial market threats. However, the groups' reactions confused the results when other factors, such as an outbreak of highly pathogenic avian influenza, threatened the groups. The imported meat companies also showed mixed reactions. This study suspects that it was originated by the complicated structural characteristics; subsidiary companies are involved in imported meat business while these companies have main businesses in different sectors. The feed companies reacted negatively when the outbreaks substantially damaged the livestock production sites while the vaccine companies demonstrated clear and consistent reactions throughout the events.

The FMD outbreaks increased volatility of daily returns. The change of the volatility was greater when an outbreak lasted for a longer period. For example, the last outbreak in 2010 increased volatility of daily returns for most of the sample companies as the outbreak continued more than four months. Both positive and negative reacting companies showed the increased volatility, indicating that the outbreaks increased riskiness of returns regardless of gaining or losing values of firms.

The conclusion of this study implies several significant points. For managers and shareholders, an FMD outbreak and possibly other animal diseases outbreaks require cautious monitoring and proper responses to protect the value of firms. Because of the increased volatility among all most firms, managers and shareholders of related firms

should pay careful attention to the change of their stock prices. Additionally, it is recommended to strengthen actions to improve public relations and sales of their products emphasizing the safety of livestock products consumption.

An appropriate governmental intervention is crucial to mitigate damage of the FMD outbreak. In the 2002 outbreak, the Korean government's actions and guidance were appropriate and prompt and mitigated the loss of the livestock production and market. This study found that the government responses also stabilized the stock market turmoil. Therefore, appropriate governmental programs should be established and applied when there is an animal health issue to help stabilize the livestock and its allied industry.

For stock market participants, they should consider an animal disease outbreak cautiously. Investors, analysts, and other market participants are all interested in returns of stocks, and the abnormal returns caused by an unexpected market shock provide them of the opportunity for investment. However, this study concluded that the riskiness of returns also significantly increased with the presence of abnormal returns. Therefore, the stock market participants need to pay careful attention to an animal disease outbreak when they consider setting or modifying their portfolios and outlooks.

This study has several realized limitations. First, it tested five events and six different groups resulting in several samples with unclear and mixed results. Therefore, it is worthwhile that further research focuses these events more precisely in smaller scopes to create detail conclusions on the impacts of the FMD outbreaks. Second, the OLS market model can be inefficient when it does not satisfy the statistical assumptions. It will be intriguing if further research analyzed these events with other models such as Autoregressive Conditional Heteroskedasticity and Generalized Autoregressive

Conditional Heteroskedasticity models. Finally, time-series comparison (i.e., comparison by the event) has not been performed in this study due to the inability of standardizing the magnitude of the outbreaks. Therefore, further research on impacts of an animal disease outbreak should consider a method or model to quantify damages of animal disease outbreaks.

TABLES

Table 1. Dates and Durations and the Number of Animal Slaughtered in the Korean FMD Outbreaks

Year / Case	2000	2002	2010-1	2010-2	2010-3
Date of					
Notification	Mar 25	May 2	Jan 2	Apr 8	Nov 28
Confirmation	Mar 27	May 3	Jan 4	Apr 9	Nov 29
Termination	Apr 15	Jun 23	Jan 29	May 6	Apr 3, 2011
Duration of Outbreak [a]					
No. of Calendar Days	19	51	25	28	126
No. of Trading Days	14	33	19	18	85
Confirmed Cases	15	16	6	11	153
Animal Culled					
Total	2,216	160,155	5,956	49,784	3,479,866
Beef Cattle	1,832	286	-[b]	-[b]	150,864
Dairy Cattle	163	1,086	-[b]	-[b]	
Pig	74	158,708	-[b]	-[b]	3,318,202
Others	147	75	-[b]	-[b]	10,800

Source: Yahoo Korea Finance (http://kr.finance.yahoo.com/) & Daum Finance (http://stock.daum.net/).
[a] Days from confirmation to termination.
[b] No Information is available.

Table 2. Number of Livestock and Farms in Korea by Species and Sales

	1995	2000	2005	2008	2009	2010
Number of livestock (thousand)						
Beef cattle	2,594	1,590	1,819	2,430	2,635	2,922
Dairy cattle	553	544	479	446	445	430
Swine	6,461	8,214	8,962	9,087	9,585	9,881
Chicken[a]	85,800	102,547	109,628	119,784	138,768	149,200
Number of farms (thousand)						
Beef cattle	519	290	192	181	175	172
Dairy cattle	23	13	9	7	7	6
Swine	46	24	12	8	8	7
Chicken	203	218	136	3	4	4
Number of livestock per farm						
Beef cattle	5	6	9	13	15	17
Dairy cattle	24	41	54	64	66	68
Swine	141	345	729	1,183	1,204	1,345
Chicken	423	471	806	37,433	39,211	41,398
Sales of production (bil won)						
Total agriculture[b]	-[c]	-[c]	35,089 (30.4)	38,470 (33.3)	41,364 (35.8)	43,720 (37.8)
Livestock[b]	-[c]	-[c]	11,767 (10.2)	13,593 (11.8)	16,484 (14.3)	17,872 (15.5)
Livestock/Agriculture (%)	-[c]	-[c]	33.5	35.3	39.9	40.9
Proportion of GDP of Livestock industry (%)	-[c]	0.4	0.6	0.3	0.3	-[c]

Source: NACF Livestock Industry Statistics Book (May 2011).

[a] From 2006, only farms with more than 3,000 heads were included in survey.

[b] Values in parentheses are US billion Dollars.
The USD values are converted with the 2010 average exchange rate of 1,155.48 won/dollar.

[c] No Information is available.

Table 3. Total Consumption and Per Capita Consumption of Livestock Products in Korea

	1995	2000	2005	2008	2009	2010
Per Capita Consumption (kg) [a]						
Meat total	27.4	31.9	32.1	37.4	38.9	41.4
Beef	6.7	8.5	6.7	7.5	8.1	8.9
Pork	14.8	16.5	17.8	19.1	19.1	19.3
Chicken / Duck[b]	6.0	6.9	7.6	10.8	11.7	13.2
Egg	10.1	10.3	12.1	11.2	11.9	11.8
Milk	47.8	59.2	62.7	61.3	62.3	62.8
Fish	-[d]	36.8	49.5	54.9	49.8	-[d]
Total Consumption (thousand Metric Ton)						
Meat total	1,231	1,510	1,512	1,728	1,780	1,794
Domestic	1,048	1,158	1,127	1,253	1,328	1,328
Self-sufficient rate (%) [c]	85.1	76.7	74.5	72.5	74.6	74.0
Beef	301	402	317	365	396	434
Domestic	155	212	152	174	198	189
Self-sufficient rate (%)	51.4	52.8	48.1	47.6	50.0	43.5
Pork	662	780	839	928	916	944
Domestic	625	674	677	713	707	764
Self-sufficient rate (%)	94.5	86.4	80.7	76.9	77.2	81.0
Chicken	268	337	357	436	469	525
Domestic	262	262	298	366	399	426
Self-sufficient rate (%)	97.8	79.9	83.6	83.9	84.9	81.1
Egg	454	479	518	544	581	580
Domestic	454	479	515	542	579	578
Self-sufficient rate (%)	100	100	99.4	99.6	99.7	99.7
Milk	2,144	2,807	3,079	3,035	3,036	3,263
Domestic	1,998	2,253	2,229	2,139	2,077	2,073
Self-sufficient rate (%)	90.9	80.4	73.6	71.8	68.4	63.5

Source: NACF Livestock Industry Statistics Book (May 2011).

[a] 1 kg = 2.21 pounds.

[b] Duck meat is included beginning in 2008.

[c] Self-sufficient rate is defined as a proportion of domestic-origin product to total consumption.

[d] No Information is available.

Table 4. Information on Sample Companies

Group	Company Name (Acronym)	Industry [a]	Establish -ment
Pork	Farmsco (FC)	Food	1999
	Sunjin Holdings (SJ)	Food	1979
	Farmstory Hannaeng (FH)	Food	1991
Poultry	Harim (HR)	Food	1990
	Maniker (MK)	Food	1985
	Dongwoo (DW)	Food	1993
Seafood	Dongwon Industries (DI)	Food	1969
	Sajo Industries (SI)	Food	1971
	Oyang (OY)	Food	1969
Imported	Dongaone (DA)	Food	1972
Meat	Hanil Feed (HF)	Food	1968
	Atinum Investment (AI)	Investment	1988
Feed	Woosung Feed (WS)	Food	1970
	Korea Industry (KI)	Food	1957
	KC Feed (KC)	Food	1970
Vaccine	Choong Ang Vaccine Laboratory (CV)	Pharmacy	1994
	Eagle Veterinary Technology (EV)	Pharmacy	1983
	Cheil Bio (CB)	Pharmacy	1977

[a] Industries indicate the industry classification of the Korea Stock Market in which each company is classified.

Table 5. Total Assets, Gross Revenues, and Operational Characteristics of the Sample Companies. All Values Are Based on Operations in 2010

Group	Company Name (Acronym)	Industry [a]	Establish -ment
Pork	Farmsco (FC)	Food	1999
	Sunjin Holdings (SJ)	Food	1979
	Farmstory Hannaeng (FH)	Food	1991
Poultry	Harim (HR)	Food	1990
	Maniker (MK)	Food	1985
	Dongwoo (DW)	Food	1993
Seafood	Dongwon Industries (DI)	Food	1969
	Sajo Industries (SI)	Food	1971
	Oyang (OY)	Food	1969
Imported	Dongaone (DA)	Food	1972
Meat	Hanil Feed (HF)	Food	1968
	Atinum Investment (AI)	Investment	1988
Feed	Woosung Feed (WS)	Food	1970
	Korea Industry (KI)	Food	1957
	KC Feed (KC)	Food	1970
Vaccine	Choong Ang Vaccine Laboratory (CV)	Pharmacy	1994
	Eagle Veterinary Technology (EV)	Pharmacy	1983
	Cheil Bio (CB)	Pharmacy	1977

Source: Yahoo Korea Finance (http://kr.finance.yahoo.com/) & Daum Finance (http://stock.daum.net/).

a, b Values in parentheses are million US Dollars.
The USD values are converted with the 2010 average exchange rate of 1,155.48 won/dollar.

c Market share

Table 6. Summary Statistics on Daily Returns in the 2000 Estimation Period, 300 Days Before the Test Period

Group	Pork			Poultry		
Company	FC[a]	SJ	FH[a]	HR	MK[a]	DW[a]
Maximum (%)	-	15.00	-	12.00		-
Minimum (%)	-	-10.78	-	-12.00	-	-
Average (%)	-	0.05	-	0.45	-	-
Standard Deviation (%)	-	4.17	-	6.06	-	-
Sample Number[b]	-	300	-	300	-	-

Group	Seafood			Feed		
Company	DI	SI	OY	WS	KI	KC
Maximum (%)	14.95	14.98	15.00	14.83	15.00	12.00
Minimum (%)	-11.83	-15.00	-14.91	-14.58	-15.00	-11.99
Average (%)	-0.03	0.07	0.16	-0.02	0.19	0.67
Standard Deviation (%)	4.25	4.97	5.37	4.36	7.47	6.73
Sample Number[b]	300	300	300	300	300	300

[a] Companies did not exist or was not publically traded during estimation period.

[b] Samples are daily returns from January 5, 1999 to March 17, 2000 (-305 day to -6 day of the event window).

Table 7. Summary Statistics on Daily Returns in the 2002 Estimation Period, 250 Days Before the Test Period

Group	Pork			Poultry		
Company	FC	SJ	FH	HR	MK	DW [a]
Maximum (%)	14.92	14.43	11.96	11.88	11.94	-
Minimum (%)	-14.97	-14.69	-11.65	-11.54	-11.98	-
Average (%)	0.15	0.30	0.03	0.06	0.00	-
Standard Deviation (%)	4.23	2.56	3.22	3.81	3.73	-
Sample Number [b]	250	250	250	250	250	-

Group	Seafood			Feed		
Company	DI	SI	OY	WS	KI	KC
Maximum (%)	12.32	14.90	15.00	14.62	15.00	11.96
Minimum (%)	-14.67	-14.99	-14.93	-14.94	-14.97	-11.82
Average (%)	0.20	0.13	0.08	0.23	0.03	0.00
Standard Deviation (%)	3.49	3.97	4.37	2.57	4.67	3.41
Sample Number [b]	250	250	250	250	250	250

[a] Company was not publically traded during estimation period.

[b] Samples are daily returns from April 4, 2001 to April 24, 2002 (-255 day to -6 day of the event window).

Table 8. Summary Statistics on Daily Returns in the 2010 Estimation Period, 300 Days Before the Test Period

Group	Pork			Poultry			Seafood		
Company	FC	SJ	FH	HR	MK	DW	DI	SI	OY
Maximum (%)	15.00	11.03	14.39	14.97	14.72	15.00	15.00	14.95	15.00
Minimum (%)	-14.98	-15.00	-13.95	-14.73	-12.87	-14.96	-13.46	-10.87	-15.00
Average (%)	0.27	0.23	0.24	0.39	0.20	0.31	0.18	0.25	0.38
Standard Deviation (%)	4.24	2.65	3.42	3.62	3.12	5.23	3.20	3.77	5.04
Sample Number [a]	300	300	300	300	300	300	300	300	300

Group	Imported Meat			Feed			Vaccine		
Company	DA	HF	AI	WS	KI	KC	CV	EV	CB
Maximum (%)	14.72	14.95	14.88	14.95	14.89	13.89	15.00	14.99	15.00
Minimum (%)	-8.16	-14.97	-14.58	-14.98	-14.96	-14.88	-14.98	-15.00	-15.00
Average (%)	0.01	0.26	0.18	0.13	0.21	0.05	0.41	0.21	0.28
Standard Deviation (%)	2.33	5.04	4.54	3.24	3.75	3.44	6.56	4.83	5.36
Sample Number [a]	300	300	300	300	300	300	300	300	300

[a] Samples are daily returns from October 17, 2008 to December 22, 2009 (-305 day to -6 day of the event window).

Table 9. Normal Return Regression Result of the 2000 Event

Group	Pork			Poultry		
Company	FC[c]	SJ	FH[c]	HR	MK[c]	DW[c]
Beta	-	0.4771**	-	0.3387*	-	-
(t-statistics)		(3.60)		(2.48)		
Constant	-	-0.0257	-	0.3381	-	-
Model F-statistics	-	27.56**	-	6.13*	-	-
R^2	-	0.0846	-	0.0202	-	-
D-Watson *d*-statistics[a]	-	1.8482	-	1.7715	-	-
				(1.9576)		
White Test χ^2-statistics[b]	-	1.67	-	0.13	-	-

Group	Seafood			Feed		
Company	DI	SI	OY	WS	KI	KC
Beta	0.6793**	0.6277**	0.5028**	0.7534**	0.5322**	0.3915**
(t-statistics)	(7.69)	(5.03)	(3.98)	(8.45)	(3.18)	(2.72)
Constant	-0.1390	-0.0320	0.0848	-0.1399	0.1092	0.6049
Model F-statistics	59.08**	25.31**	15.87**	71.39**	10.11**	7.48**
R^2	0.1655	0.1031	0.0566	0.1933	0.0328	0.0245
D-Watson *d*-statistics[a]	1.9880	1.9089	1.9279	2.1922	1.9094	1.4325
						(1.9382)
White Test χ^2-statistics[b]	2.69	15.26**	7.27*	3.28	3.09	0.87

* Statistically significant at 5% significance level.
** Statistically significant at 1% significance level.

[a] Significant points of d_L and d_U at 5% significance level of (2, 200) = (1.748, 1.789)
Values in parentheses are Durban-Watson d-statistics after correcting for AR(1). In those columns with autocorrelation, corrected results are presented.

[b] White Test χ^2-statistics with * & ** indicate that the original regression results were detected to contain heteroskedasticity at 5% and 1% significance levels, respectively. In those columns with heteroskedasticity, corrected results are presented using White's method.

[c] Companies did not exist or was not publically traded during estimation period.

Table 10. Normal Return Regression Result of the 2002 Event

Group	Pork			Poultry		
Company	FC	SJ	FH	HR	MK	DW[c]
Beta	0.8767**	0.5599**	0.4917**	0.5454**	0.4648**	-
(t-statistics)	(7.32)	(7.81)	(5.16)	(4.79)	(4.12)	
Constant	-0.0619	0.1635	-0.0678	-0.0703	-0.0870	-
Model F-statistics	53.61**	24.37**	26.61**	22.95**	16.97**	-
R^2	0.1778	0.1976	0.0969	0.0847	0.0640	-
D-Watson d-statistics[a]	2.4808	1.9844	2.3843	2.1947	2.2580	-
White Test χ^2-statistics[b]	0.57	9.65**	2.84	3.95	2.94	-

Group	Seafood			Feed		
Company	DI	SI	OY	WS	KI	KC
Beta	0.6815**	0.6396**	0.7226**	0.4715**	0.5451**	0.7237**
(t-statistics)	(5.11)	(5.45)	(5.64)	(3.58)	(3.85)	(7.54)
Constant	0.0516	-0.0286	-0.1227	0.1283	-0.1058	-0.1686
Model F-statistics	26.12**	29.74**	31.80**	12.79**	14.80**	56.82**
R^2	0.1577	0.1071	0.1136	0.1361	0.0563	0.1864
D-Watson d-statistics[a]	1.8994	2.6234	2.3687	2.5120	1.8525	2.2902
White Test χ^2-statistics[b]	7.57*	2.15	3.59	13.69**	2.03	0.17

* Statistically significant at 5% significance level.
** Statistically significant at 1% significance level.

[a] Significant points of d_L and d_U at 5% significance level of (2, 200) = (1.748, 1.789).

[b] White Test χ^2-statistics with * & ** indicate that the original regression results were detected to contain heteroskedasticity at 5% and 1% significance levels, respectively. In those columns with heteroskedasticity, corrected results are presented using White's Method.

[c] Company was not publically traded during estimation period.

Table 11. Normal Return Regression Result of the 2010 Event

Group	Pork			Poultry		
Company	FC	SJ	FH	HR	MK	DW
Beta	0.5032**	0.5657**	1.0129**	0.7421**	0.5579**	1.0767**
(t-statistics)	(4.59)	(6.08)	(14.42)	(8.73)	(7.25)	(8.59)
Constant	0.2106	0.1622	0.1130	0.2929	0.1308	0.1755
Model F-statistics	21.06**	36.93**	207.92**	76.24**	52.50**	73.77**
R^2	0.0660	0.2123	0.4410	0.2037	0.1498	0.1984
D-Watson *d*-statistics[a]	1.8212	1.9326	0.2837	1.7151 (1.9533)	1.9219	2.0523
White Test χ^2-statistics[b]	2.32	7.25*	0.46	5.15	3.70	2.40

Group	Seafood			Imported Meat		
Company	DI	SI	OY	DA	HF	AI
Beta	0.7393**	0.6083**	0.9644**	0.1972**	1.1356**	1.0660**
(t-statistics)	(9.97)	(4.16)	(7.85)	(3.22)	(9.63)	(10.16)
Constant	0.0909	0.1768	0.2560	-0.0195	0.1154	0.0451
Model F-statistics	99.42**	17.29**	61.69**	10.37**	92.70**	103.32**
R^2	0.2502	0.1219	0.1715	0.0336	0.2373	0.2575
D-Watson d-statistics[a]	1.9165	2.0006	1.9328	2.0045	2.0526	2.7042
White Test χ^2-statistics[b]	2.52	12.54**	0.06	0.95	0.90	5.18

* Statistically significant at 5% significance level.
** Statistically significant at 1% significance level.

[a] Significant points of d_L and d_U at 5% significance level of (2, 200) = (1.748, 1.789)
Values in parentheses are Durban-Watson d-statistics after correcting for AR(1). In those columns with autocorrelation, corrected results are presented.

[b] White Test χ^2-statistics with * & ** indicate that the original regression results were detected to contain heteroskedasticity at 5% and 1% significance levels, respectively. In those columns with heteroskedasticity, corrected results are presented using White's method.

Table 11. Normal Return Regression Result of the 2010 Event, Continued

Group	Feed			Vaccine		
Company	WS	KI	KC	CV	EV	CB
Beta	0.4151**	0.7902**	0.3956**	1.1654**	0.9547**	0.8594**
(t-statistics)	(4.97)	(8.83)	(3.87)	(7.18)	(8.16)	(6.38)
Constant	0.0780	0.1134	0.0935	0.2664	0.0845	0.1698
Model F-statistics	27.72**	77.93**	14.95**	51.58**	66.57**	40.76**
R^2	0.0766	0.2073	0.0568	0.1476	0.1826	0.1203
D-Watson *d*-statistics[a]	2.3248	2.2033	1.8566	1.8688	2.0541	2.0070
White Test χ^2-statistics[b]	4.07	4.53	0.11	0.81	0.26	1.02

* Statistically significant at 0.05 significance level.

** Statistically significant at 0.01 significance level.

[a] Significant points of d_L and d_U at 0.05 significance level of (2, 200) = (1.748, 1.789)
Values in parentheses are Durban-Watson d-statistics after correcting for AR(1). In those columns with autocorrelation, corrected results are presented.

[b] White Test χ^2-statistics with * & ** indicate that the original regression results were detected to contain heteroskedasticity at 5% and 1% significance levels, respectively. In those columns with heteroskedasticity, corrected results are presented using White's method.

Table 12. Abnormal Returns and Cumulative Abnormal Returns for the 2000 Event

Group		Pork	Poultry	Seafood			Feed		
Company		SJ	HR	DI	SI	OY	WS	KC	KI
Abnormal Return (%)	-5	-3.03 (-0.76)	-11.05* (-1.84)	3.27 (0.84)	3.07 (0.65)	4.63 (0.89)	1.58 (0.40)	-12.28* (-1.85)	15.13** (2.06)
	-4	0.34 (0.08)	10.98* (1.83)	-5.32 (-1.37)	-0.40 (-0.09)	-3.46 (-0.66)	-3.45 (-0.88)	-12.91* (-1.94)	-7.33 (-1.00)
	-3	-0.91 (-0.23)	10.59* (1.77)	-0.89 (-0.23)	-1.87 (-0.40)	0.98 (0.19)	0.49 (0.13)	0.57 (0.09)	-5.63 (-0.77)
	-2	1.96 (0.49)	0.88 (0.15)	2.66 (0.69)	-0.21 (-0.05)	-0.49 (-0.09)	0.42 (0.11)	12.05* (1.81)	-3.76 (-0.51)
	-1	11.20*** (-2.81)	4.01 (0.67)	0.26 (0.07)	3.73 (0.79)	4.49 (0.86)	2.74 (0.70)	10.32 (1.55)	7.72 (1.05)
	0	-2.84 (-0.71)	11.49* (1.92)	2.12 (0.55)	6.96 (1.48)	15.01*** (2.88)	3.21 (0.82)	11.47* (1.73)	-3.48 (-0.47)
	1	3.39 (0.85)	-8.25 (-1.38)	0.23 (0.06)	-7.79* (-1.65)	-9.61* (-1.84)	0.21 (0.05)	-10.55 (-1.59)	-5.78 (-0.79)
	2	-1.39 (-0.35)	-8.48 (-1.41)	1.88 (0.49)	-1.43 (-0.30)	-5.41 (-1.04)	-10.07** (-2.57)	-11.89* (-1.79)	-14.01* (-1.91)
	3	-14.00*** (-3.51)	12.33** (2.06)	0.26 (0.07)	1.06 (0.23)	-6.73 (-1.29)	-13.27*** (-3.39)	11.96* (1.80)	-6.19 (-0.84)
	4	-5.36 (-1.34)	-3.57 (-0.60)	-3.23 (-0.83)	1.31 (0.28)	0.00 (0.00)	5.21 (1.33)	-6.70 (-1.01)	7.99 (1.09)
	5	-14.09*** (-3.53)	12.01** (2.00)	-0.99 (-0.26)	1.09 (0.23)	-4.25 (-0.81)	-13.52*** (-3.45)	11.99* (1.80)	-5.20 (-0.71)
Cumulative Abnormal Return (%)	5-day	-20.20** (-3.15)	3.52 (0.34)	1.26 (0.59)	0.12 (0.02)	-6.75 (-0.69)	-14.71 (-1.78)	-5.70 (-0.48)	-21.47* (-2.71)
	10-day	-37.93*** (-5.13)	10.49 (1.07)	1.68 (0.58)	-0.63 (-0.15)	-13.81* (-1.98)	-18.69* (-2.09)	-10.18 (-0.96)	-24.14*** (-3.38)
	20-day	-34.87*** (-5.71)	-27.16*** (-3.16)	2.86 (1.01)	7.46 (1.29)	-17.19*** (-3.20)	-1.33 (-0.18)	9.36 (0.90)	-26.81*** (-4.83)
	30-day	-31.48*** (-5.45)	-17.24** (-2.32)	-0.36 (-0.12)	3.59 (0.75)	-26.53*** (-5.93)	-6.80 (-1.09)	15.44* (1.72)	-38.03*** (-7.85)

Values in parentheses are t-statistics.

*** Statistically significant at 1% significance level. (AR >2.59, CAR 5-day >4.60, 10-day >3.24, 20-day >2.86, 30-day >2.75, all in absolute value).

** Statistically significant at 5% significance level. (AR >1.96, CAR 5-day >2.77, 10-day >2.25, 20-day >2.09, 30-day >2.04, all in absolute value).

* Statistically significant at 10% significance level. (AR >1.64, CAR 5-day >2.13, 10-day >1.83, 20-day >1.72, 30-day >1.69, all in absolute value).

Table 13. Abnormal Returns and Cumulative Abnormal Returns for the 2002 Event

Group		Pork			Poultry		Seafood			Feed		
Company		SJ	FC	FH	HR	MK	DI	SI	OY	WS	KC	KI
Abnormal Return (%)	-5	4.23*	0.47	3.32	-5.61	-1.10	-2.17	5.54	-7.72*	0.12	-0.81	-0.88
		(1.85)	(0.12)	(1.08)	(-1.54)	(-0.30)	(-0.68)	(1.48)	(-1.87)	(0.05)	(-0.26)	(-0.19)
	-4	6.94***	6.99*	2.08	1.84	1.99	1.78	0.24	5.16	0.03	-2.09	4.58
		(3.03)	(1.82)	(0.68)	(0.51)	(0.55)	(0.56)	(0.06)	(1.25)	(0.01)	(-0.68)	(1.01)
	-3	-1.72	2.68	-3.63	-5.27	1.32	1.20	-1.20	3.69	1.56	5.32*	17.06***
		(-0.75)	(0.70)	(-1.18)	(-1.45)	(0.37)	(0.38)	(-0.32)	(0.89)	(0.65)	(1.73)	(3.76)
	-2	-0.75	-0.86	-0.16	-1.86	-0.99	0.84	6.76	-1.66	-0.34	-1.83	14.69***
		(-0.33)	(-0.22)	(-0.05)	(-0.51)	(-0.27)	(0.26)	(1.80)	(-0.40)	(-014)	(-0.60)	(3.24)
	-1	2.04	-1.24	0.97	10.94***	3.47	0.51	0.01	-1.22	-1.11	1.63	-14.17***
		(0.89)	(-0.32)	(0.32)	(3.00)	(0.96)	(0.16)	(0.00)	(-0.29)	(-0.46)	(0.53)	(-3.13)
	0	-2.89	-1.18	-4.47	12.00***	11.92***	1.75	4.41	10.88***	0.85	4.14	-7.13
		(-1.26)	(-0.31)	(-1.46)	(3.29)	(3.30)	(0.55)	(1.17)	(2.64)	(0.35)	(1.35)	(-1.57)
	1	-2.91	-1.12	-0.20	6.99*	3.20	1.18	-4.96	-1.81	3.51	4.28	-1.04
		(-1.27)	(-0.29)	(-0.07)	(1.92)	(0.89)	(0.37)	(-1.32)	(-0.44)	(1.46)	(1.39)	(-0.23)
	2	3.39	1.22	1.11	-11.63***	-11.65***	-2.32	0.07	-3.56	-0.10	-0.57	1.57
		(1.48)	(0.32)	(0.36)	(-3.19)	(-3.22)	(-0.73)	(0.02)	(-0.86)	(-0.04)	(-0.18)	(0.35)
	3	-1.07	-2.43	-0.02	-1.63	-0.53	1.60	-0.32	-2.77	-1.17	-5.37*	-3.36
		(-0.46)	(-0.63)	(-0.01)	(-0.45)	(-0.15)	(0.50)	(-0.08)	(-0.67)	(-0.49)	(-1.75)	(-0.74)
	4	3.62	0.68	4.38	-2.51	-1.24	2.35	-0.31	0.31	-2.14	1.50	15.48***
		(1.58)	(0.18)	(1.43)	(-0.69)	(-0.34)	(0.73)	(-0.08)	(0.07)	(-0.89)	(0.49)	(3.41)
	5	1.55	1.68	-0.62	9.58***	5.46	3.14	3.48	1.09	3.04	2.77	-3.31
		(0.68)	(0.44)	(-0.20)	(2.63)	(1.51)	(0.98)	(0.93)	(0.26)	(1.26)	(0.90)	(-0.73)
Cumulative Abnormal Return (%)	5-day	0.15	-2.82	0.80	3.22	1.70	4.55*	-1.11	3.05	0.94	3.98	5.52
		(0.05)	(-1.89)	(0.25)	(0.35)	(0.20)	(2.45)	(-0.34)	(0.51)	(0.44)	(1.00)	(0.64)
	10-day	-6.98**	4.62	0.29	8.29	5.81	6.07**	1.46	4.40	-0.72	5.14	7.14
		(-2.58)	(1.51)	(0.09)	(0.95)	(0.76)	(2.73)	(0.21)	(0.60)	(-0.30)	(1.69)	(0.89)
	20-day	-19.36***	5.64*	1.54	-4.97	4.64	-4.74*	-7.24	5.78	-0.48	7.31**	38.16***
		(-6.21)	(1.88)	(0.62)	(-0.79)	(0.84)	(-1.79)	(-1.46)	(1.12)	(-0.24)	(2.60)	(3.70)
	30-day	-16.04***	4.43*	4.61**	-1.15	4.61	3.03	-7.60*	1.87	0.35	7.99**	39.00***
		(5.31)	(1.70)	(2.08)	(-0.21)	(1.02)	(1.26)	(-1.86)	(0.42)	(0.17)	(2.51)	(4.23)

Values in parentheses are t-statistics.

*** Statistically significant at 1% significance level. (AR >2.59, CAR 5-day >4.60, 10-day >3.24, 20-day >2.86, 30-day >2.75, all in absolute value).

** Statistically significant at 5% significance level. (AR >1.96, CAR 5-day >2.77, 10-day >2.25, 20-day >2.09, 30-day >2.04, all in absolute value).

* Statistically significant at 10% significance level. (AR >1.65, CAR 5-day >2.13, 10-day >1.83, 20-day >1.72, 30-day >1.69, all in absolute value).

Table 14. Abnormal Returns and Cumulative Abnormal Returns for the First 2010 Event (January)

Group		Pork			Poultry			Seafood		
Company		SJ	FC	FH	HR	MK	DW	DI	SI	OY
Abnormal Return (%)	-5	-0.36	-1.44	1.25	-0.06	-0.93	-1.34	-1.70	0.79	-5.53
		(-0.15)	(-0.35)	(0.48)	(-0.02)	(-0.32)	(-0.29)	(-0.61)	(0.22)	(-1.21)
	-4	1.62	-3.61	-0.27	-2.21	-0.23	-0.22	-1.02	-0.11	-0.18
		(0.69)	(-0.88)	(-0.10)	(-0.68)	(-0.08)	(-0.05)	(-0.37)	(-0.03)	(-0.04)
	-3	-0.73	1.01	-1.42	-2.25	-1.45	-1.42	2.95	0.04	0.41
		(-0.31)	(0.25)	(-0.54)	(-0.70)	(-0.50)	(-0.30)	(1.07)	(0.01)	(0.09)
	-2	0.12	-6.95	-8.88***	0.79	-0.31	3.41	-0.40	-0.69	3.04
		(0.05)	(-1.70)	(-3.39)	(0.24)	(-0.11)	(0.73)	(-0.14)	(-0.20)	(0.66)
	-1	-0.97	-0.06	-0.74	-0.75	0.14	-1.73	4.34	-0.22	-0.85
		(-0.41)	(-0.01)	(-0.28)	(-0.23)	(0.05)	(-0.37)	(1.57)	(-0.06)	(-0.19)
	0	-1.23	4.02	-1.54	2.46	-0.57	0.00	-0.25	1.99	1.04
		(-0.52)	(0.98)	(-0.59)	(0.76)	(-0.20)	(0.00)	(-0.09)	(0.56)	(0.23)
	1	2.04	3.05	0.84	0.43	1.28	0.17	1.42	3.57	4.92
		(0.86)	(0.75)	(0.32)	(0.13)	(0.44)	(0.04)	(0.51)	(1.01)	(1.07)
	2	0.87	-2.58	0.25	0.99	0.60	2.84	1.35	-0.24	-1.09
		(0.37)	(-0.63)	(0.09)	(0.31)	(0.21)	(0.61)	(0.49)	(-0.07)	(-0.24)
	3	5.20**	-0.66	1.19	4.76	5.38**	1.57	-2.82	2.46	4.84
		(2.21)	(-0.16)	(0.45)	(1.48)	(1.87)	(0.34)	(-1.02)	(0.70)	(1.06)
	4	-0.99	-3.88	-1.44	-1.27	-1.09	-0.93	1.51	2.90	-0.56
		(-0.42)	(-0.95)	(-0.55)	(-0.39)	(-0.38)	(-0.20)	(0.55)	(0.82)	(-0.12)
	5	1.46	5.77	-0.66	-3.13	-2.97	-2.30	0.37	-1.17	-0.19
		(0.62)	(1.41)	(-0.25)	(-0.97)	(-1.03)	(-0.49)	(0.14)	(-0.33)	(-0.04)
Cumulative Abnormal Return (%)	5-day	5.89*	-0.05	-0.70	7.37**	5.58*	3.65*	1.20	10.68***	9.15**
		(2.25)	(-0.01)	(-0.55)	(3.25)	(2.18)	(2.47)	(0.65)	(7.37)	(3.16)
	10-day	7.75***	12.23**	-1.66	3.55	16.64***	4.63*	5.87**	5.16*	5.99**
		(3.49)	(2.59)	(-1.56)	(1.48)	(3.39)	(2.13)	(2.75)	(2.13)	(2.54)
	20-day	6.27***	-12.83***	-1.14	-7.07***	24.84***	3.80	12.12***	-5.54**	-4.61*
		(3.57)	(-3.12)	(-1.33)	(-3.00)	(5.10)	(1.10)	(7.71)	(-2.48)	(-1.89)
	30-day	4.17**	-7.17*	-1.04	-4.11*	35.33***	0.02	8.31***	-6.94***	-8.64***
		(2.17)	(-1.92)	(-1.06)	(-1.93)	(8.45)	(0.01)	(4.48)	(-3.59)	(-3.84)

Values in parentheses are t-statistics.

*** Statistically significant at 1% significance level. (AR >2.59, CAR 5-day >4.60, 10-day >3.24, 20-day >2.86, 30-day >2.75, all in absolute value).

** Statistically significant at 5% significance level. (AR >1.96, CAR 5-day >2.77, 10-day >2.25, 20-day >2.09, 30-day >2.04, all in absolute value).

* Statistically significant at 10% significance level. (AR >1.64, CAR 5-day >2.13, 10-day >1.83, 20-day >1.72, 30-day >1.69, all in absolute value).

Table 14. Abnormal Returns and Cumulative Abnormal Returns for the First 2010 Event (January), Continued

Group		Imported Meat			Feed			Vaccine		
Company		HF	DA	AI	WS	KC	KI	EV	CV	CB
Abnormal Return (%)	-5	-1.28	-1.34	-7.19*	0.05	0.11	-1.34	-2.51	-1.43	-4.01
		(-0.29)	(-0.59)	(-1.84)	(0.02)	(0.03)	(-0.40)	(-0.57)	(-0.24)	(-0.80)
	-4	-2.32	-0.23	-3.00	-3.62	-0.59	-1.75	0.13	-0.21	-1.50
		(-0.53)	(-0.10)	(-0.77)	(-1.16)	(-0.17)	(-0.52)	(0.03)	(-0.04)	(-0.30)
	-3	-0.72	-0.35	-2.71	0.12	-0.51	-3.32	-0.04	-7.26	-2.79
		(-0.16)	(-0.15)	(-0.69)	(0.04)	(-0.15)	(-0.99)	(-0.01)	(-1.20)	(-0.55)
	-2	-4.68	2.47	3.31	-5.39*	-1.15	2.33	0.66	1.45	2.51
		(-1.06)	(1.08)	(0.84)	(-1.73)	(-0.33)	(0.70)	(0.15)	(0.24)	(0.50)
	-1	7.42	2.94	-3.98	2.05	-0.34	-1.09	-0.67	-2.58	2.01
		(1.68)	(1.29)	(-1.02)	(0.66)	(-0.10)	(-0.33)	(-0.15)	(-0.43)	(0.40)
	0	0.88	-0.29	1.65	0.18	-1.44	0.73	-2.24	-1.19	-0.61
		(0.20)	(-0.13)	(0.42)	(0.06)	(-0.42)	(0.22)	(-0.51)	(-0.20)	(-0.12)
	1	13.69***	0.08	5.26	0.06	0.04	0.63	0.94	1.33	2.50
		(3.11)	(0.04)	(1.34)	(0.02)	(0.01)	(0.19)	(0.21)	(0.22)	(0.50)
	2	-9.00**	-0.15	-1.76	2.75	-2.88	1.61	0.73	1.53	1.42
		(-2.04)	(-0.07)	(-0.45)	(0.88)	(-0.84)	(0.48)	(0.17)	(0.25)	(0.28)
	3	4.20	2.45	2.12	-0.67	1.13	-0.04	8.53*	16.07***	5.27
		(0.95)	(1.07)	(0.54)	(-0.21)	(0.33)	(-0.01)	(1.95)	(2.65)	(1.05)
	4	-10.29*	-1.19	3.93	1.34	-0.37	-1.30	-3.98	-5.51	-4.71
		(-2.34)	(-0.52)	(1.00)	(0.43)	(-0.11)	(-0.39)	(-0.91)	(-0.91)	(-0.94)
	5	0.73	-1.35	-2.98	-0.89	-0.07	-1.65	-2.24	-4.81	-2.16
		(0.17)	(-0.59)	(-0.76)	(-0.28)	(-0.02)	(-0.49)	(-0.51)	(-0.79)	(-0.43)
Cumulative Abnormal Return (%)	5-day	-0.52	0.91	11.20**	3.65*	-3.53*	1.63	3.97	12.24	3.87
		(-0.05)	(0.67)	(4.21)	(2.73)	(-2.32)	(1.50)	(0.83)	(1.51)	(1.04)
	10-day	-2.97	-0.62	10.01***	1.47	-4.87***	-2.80**	2.16	16.11**	4.33
		(-0.45)	(-0.60)	(3.68)	(0.99)	(-4.54)	(-2.34)	(0.62)	(2.62)	(1.60)
	20-day	-15.17***	-0.03	2.35	-3.80**	-5.20***	3.20*	0.44	7.04	-3.19
		(-3.06)	(-0.05)	(0.94)	(-2.66)	(-5.12)	(1.84)	(0.15)	(1.15)	(-1.14)
	30-day	-14.18***	1.83**	1.69	-9.83***	-11.11***	-2.23	-3.01	1.94	-7.46***
		(-3.41)	(2.72)	(0.77)	(-6.40)	(-5.44)	(-1.15)	(-1.23)	(0.39)	(-2.84)

Values in parentheses are t-statistics.

*** Statistically significant at 1% significance level. (AR >2.59, CAR 5-day >4.60, 10-day >3.24, 20-day >2.86, 30-day >2.75, all in absolute value).

** Statistically significant at 5% significance level. (AR >1.96, CAR 5-day >2.77, 10-day >2.25, 20-day >2.09, 30-day >2.04, all in absolute value).

* Statistically significant at 10% significance level. (AR >1.64, CAR 5-day >2.13, 10-day >1.83, 20-day >1.72, 30-day >1.69, all in absolute value).

Table 15. Abnormal Returns and Cumulative Abnormal Returns for the Second 2010 Event (April)

Group		Pork			Poultry			Seafood		
Company		SJ	FC	FH	HR	MK	DW	DI	SI	OY
Abnormal Return (%)	-5	0.65	0.64	-0.37	-1.10	0.13	0.19	-1.10	-2.50	-0.50
		(0.28)	(0.16)	(-0.14)	(-0.34)	(0.05)	(0.04)	(-0.40)	(-0.71)	(-0.11)
	-4	-1.02	5.57	-2.69	1.82	-2.99	-0.77	-0.57	-1.03	-0.80
		(-0.43)	(1.36)	(-1.02)	(0.56)	(-1.04)	(-0.17)	(-0.21)	(-0.29)	(-0.17)
	-3	0.48	-2.54	1.10	-1.56	0.66	-0.37	-0.14	-2.85	-0.32
		(0.20)	(-0.62)	(0.42)	(-0.48)	(0.23)	(-0.08)	(-0.05)	(-0.81)	(-0.07)
	-2	-0.86	7.76*	1.74	4.15	4.36	4.62	-1.37	3.76	-1.21
		(-0.36)	(1.89)	(0.67)	(1.29)	(1.52)	(0.99)	(-0.49)	(1.07)	(-0.26)
	-1	-0.94	-2.81	0.70	5.44*	4.74*	1.07	-1.67	0.57	-2.06
		(-0.40)	(-0.69)	(0.27)	(1.68)	(1.65)	(0.23)	(-0.60)	(0.16)	(-0.45)
	0	0.00	-3.95	0.43	0.11	-0.95	0.40	1.59	0.55	4.05
		(0.00)	(-0.96)	(0.16)	(0.03)	(-0.33)	(0.09)	(0.58)	(0.15)	(0.88)
	1	-3.13	8.32**	3.77	0.04	-1.18	-0.24	-1.60	2.10	4.19
		(-1.33)	(2.03)	(1.44)	(0.01)	(-0.41)	(-0.05)	(-0.58)	(0.60)	(0.91)
	2	4.80**	-3.01	-1.31	-2.95	-1.29	-1.40	-0.54	-4.26	-5.12
		(2.04)	(-0.74)	(-0.50)	(-0.91)	(-0.45)	(-0.30)	(-0.19)	(-1.21)	(-1.12)
	3	-3.55	1.27	-1.58	2.07	-0.16	0.82	-0.29	-1.26	0.20
		(-1.51)	(0.31)	(-0.60)	(0.64)	(-0.06)	(0.18)	(-0.10)	(-0.36)	(0.04)
	4	-0.16	0.62	-1.21	-1.49	-2.33	0.00	-0.46	-1.49	-1.64
		(-0.07)	(0.15)	(-0.46)	(-0.46)	(-0.81)	(0.00)	(-0.16)	(-0.42)	(-0.36)
	5	0.70	15.02***	1.04	-2.26	-1.79	2.17	0.31	0.15	-0.65
		(0.30)	(3.67)	(0.40)	(-0.70)	(-0.62)	(0.46)	(0.11)	(0.04)	(-0.14)
Cumulative Abnormal Return (%)	5-day	-2.04	3.26	0.09	-2.23	-5.91***	-0.41	-1.29	-4.37	1.68
		(-0.61)	(0.67)	(0.04)	(-1.18)	(-7.60)	(-0.49)	(-1.12)	(-1.83)	(0.43)
	10-day	1.65	33.09***	-0.19	-5.44**	-7.57***	5.31**	-0.26	-1.05	8.39**
		(0.44)	(3.37)	(-0.09)	(-2.98)	(-5.74)	(3.02)	(-0.25)	(-0.48)	(2.38)
	20-day	2.42	21.47**	-3.93**	-6.28**	-9.70***	0.72	4.97***	13.98***	3.71
		(0.92)	(2.72)	(-2.39)	(-2.83)	(-5.34)	(0.37)	(4.09)	(3.72)	(1.26)
	30-day	4.56*	5.83	-9.82***	-9.32***	-23.78***	0.67	8.09***	21.60***	9.73***
		(2.04)	(0.87)	(-6.91)	(-4.09)	(-12.05)	(0.35)	(5.02)	(5.53)	(3.51)

Values in parentheses are t-statistics.

*** Statistically significant at 1% significance level. (AR >2.59, CAR 5-day >4.60, 10-day >3.24, 20-day >2.86, 30-day >2.75, all in absolute value).

** Statistically significant at 5% significance level. (AR >1.96, CAR 5-day >2.77, 10-day >2.25, 20-day >2.09, 30-day >2.04, all in absolute value).

* Statistically significant at 10% significance level. (AR >1.64, CAR 5-day >2.13, 10-day >1.83, 20-day >1.72, 30-day >1.69, all in absolute value).

Table 15. Abnormal Returns and Cumulative Abnormal Returns for the Second 2010 Event (April), Continued

Group		Imported Meat			Feed			Vaccine		
Company		HF	DA	AI	WS	KC	KI	EV	CV	CB
Abnormal Return (%)	-5	-0.40	1.91	-7.10*	0.62	-0.19	0.64	-0.82	-1.02	0.74
		(-0.09)	(0.83)	(-1.81)	(0.20)	(-0.06)	(0.19)	(-0.19)	(-0.17)	(0.15)
	-4	-1.52	3.80*	1.19	2.01	9.87***	14.70***	-0.66	-4.07	-1.08
		(-0.34)	(1.66)	(0.30)	(0.65)	(2.87)	(4.40)	(-0.15)	(-0.67)	(-0.22)
	-3	-0.19	0.01	2.50	-3.23	-7.77**	4.19	-1.39	-0.82	-0.22
		(-0.04)	(0.00)	(0.64)	(-1.04)	(-2.26)	(1.26)	(-0.32)	(-0.14)	(-0.04)
	-2	0.29	14.95***	4.38	-1.43	-3.73	-6.23*	1.15	2.60	0.93
		(0.07)	(6.95)	(1.12)	(-0.46)	(-1.09)	(-1.87)	(0.26)	(0.43)	(0.18)
	-1	-1.03	-4.17*	-2.32	3.02	-3.21	-3.09	-0.98	-0.28	-0.53
		(-0.23)	(-1.83)	(-0.59)	(0.97)	(-0.94)	(-0.92)	(-0.22)	(-0.05)	(-0.10)
	0	4.02	-1.12	6.12	-1.44	4.27	6.11*	7.18	15.31**	2.24
		(0.91)	(-0.49)	(1.56)	(-0.46)	(1.24)	(1.83)	(1.64)	(2.53)	(0.45)
	1	1.67	-1.64	-6.23	-0.54	-0.30	-4.36	15.69***	15.33**	15.52***
		(0.38)	(-0.72)	(-1.59)	(-0.17)	(-0.09)	(-1.31)	(3.59)	(2.53)	(3.09)
	2	-3.51	-0.13	-4.49	3.16	-0.37	-2.83	-14.97***	-9.15	-12.27**
		(-0.80)	(-0.06)	(-1.15)	(1.01)	(-0.11)	(-0.85)	(-3.43)	(-1.51)	(-2.44)
	3	-0.88	0.88	-0.92	2.99	1.21	3.41	0.21	-1.56	0.20
		(-0.20)	(0.38)	(-0.24)	(0.96)	(0.35)	(1.02)	(0.05)	(-0.26)	(0.04)
	4	-2.41	9.24***	0.09	4.51	-0.29	0.46	-1.03	-5.11	-1.13
		(-0.55)	(4.04)	(0.02)	(1.45)	(-0.08)	(0.14)	(-0.24)	(-0.84)	(-0.22)
	5	-3.03	-1.81	-0.12	-2.50	15.12***	-2.19	-0.75	1.17	-1.04
		(-0.69)	(-0.79)	(-0.03)	(-0.80)	(4.40)	(-0.66)	(-0.17)	(0.19)	(-0.21)
Cumulative Abnormal Return (%)	5-day	-1.12	7.24	-5.44	8.68**	4.53*	2.79	7.08	14.82	4.57
		(-0.36)	(1.62)	(-1.44)	(3.37)	(2.27)	(0.65)	(0.63)	(1.28)	(0.46)
	10-day	1.77	5.15	-0.21	21.87***	65.37***	4.27	32.98***	48.94***	23.26**
		(0.62)	(1.46)	(-0.06)	(4.29)	(8.81)	(0.85)	(3.37)	(4.68)	(2.59)
	20-day	-4.39*	5.24*	-12.17***	0.62	35.31***	-0.63	18.48*	36.86***	9.56
		(-1.91)	(1.89)	(-4.21)	(0.13)	(3.59)	(-0.14)	(2.06)	(3.84)	(1.17)
	30-day	-9.46***	13.90***	-13.94***	-2.51	65.37***	-7.02*	3.65	10.92	-7.23
		(-4.73)	(5.49)	(-5.12)	(-0.59)	(6.46)	(-1.83)	(0.49)	(1.29)	(-1.06)

Values in parentheses are t-statistics.

*** Statistically significant at 1% significance level. (AR >2.59, CAR 5-day >4.60, 10-day >3.24, 20-day >2.86, 30-day >2.75, all in absolute value).

** Statistically significant at 5% significance level. (AR >1.96, CAR 5-day >2.77, 10-day >2.25, 20-day >2.09, 30-day >2.04, all in absolute value).

* Statistically significant at 10% significance level. (AR >1.64, CAR 5-day >2.13, 10-day >1.83, 20-day >1.72, 30-day >1.69, all in absolute value).

Table 16. Abnormal Returns and Cumulative Abnormal Returns for the Third 2010 Event (November)

Group		Pork			Poultry			Seafood		
Company		SJ	FC	FH	HR	MK	DW	DI	SI	OY
Abnormal Return (%)	-5	-1.39	-3.74	-0.02	-0.73	-1.20	-1.28	0.16	-1.92	0.50
		(-0.59)	(-0.91)	(-0.01)	(-0.23)	(-0.42)	(-0.27)	(0.06)	(-0.54)	(0.11)
	-4	0.29	0.58	0.55	-2.04	0.31	1.26	0.87	-1.12	-0.41
		(0.12)	(0.14)	(0.21)	(-0.63)	(0.11)	(0.27)	(0.31)	(-0.32)	(-0.09)
	-3	-0.46	-1.51	-1.45	-2.47	-2.21	-1.74	-2.97	4.51	-1.34
		(-0.19)	(-0.37)	(-0.55)	(-0.76)	(-0.77)	(-0.37)	(-1.07)	(1.28)	(-0.29)
	-2	1.13	-0.26	-0.20	-1.64	-0.18	3.14	-0.54	0.58	-1.59
		(0.48)	(-0.06)	(-0.08)	(-0.51)	(-0.06)	(0.67)	(-0.20)	(0.16)	(-0.35)
	-1	0.03	-2.74	1.52	-0.05	-2.00	-2.26	-1.81	-2.45	-1.49
		(0.01)	(-0.67)	(0.58)	(-0.02)	(-0.70)	(-0.48)	(-0.65)	(-0.69)	(-0.33)
	0	-3.21*	0.37	0.91	1.80	8.64***	3.95	0.15	1.56	2.98
		(-1.36)	(0.09)	(0.35)	(0.56)	(3.00)	(0.84)	(0.06)	(0.44)	(0.65)
	1	0.75	-0.86	-0.19	-4.60	-4.21	-0.69	-1.24	0.81	-1.66
		(0.32)	(-0.21)	(-0.07)	(-1.42)	(-1.46)	(-0.15)	(-0.45)	(0.23)	(-0.36)
	2	4.16	1.62	-1.43	-3.81	-0.36	-1.57	1.36	-1.77	-1.19
		(1.77)	(0.39)	(-0.54)	(-1.18)	(-0.12)	(-0.34)	(0.49)	(-0.50)	(-0.26)
	3	0.15	0.05	-0.53	0.84	0.25	-0.66	-0.11	1.60	-1.62
		(0.06)	(0.01)	(-0.20)	(0.26)	(0.09)	(-0.14)	(-0.04)	(0.45)	(-0.35)
	4	-0.37	-2.79	-0.48	-0.11	1.13	0.34	-1.13	-1.30	-0.28
		(-0.16)	(-0.68)	(-0.18)	(-0.03)	(0.39)	(0.07)	(-0.41)	(-0.37)	(-0.06)
	5	-1.16	3.16	-1.00	-2.72	0.45	-2.44	-1.91	-0.52	-0.71
		(-0.49)	(0.77)	(-0.38)	(-0.84)	(0.16)	(-0.52)	(-0.69)	(-0.15)	(-0.16)
Cumulative Abnormal Return (%)	5-day	1.48	-1.62	-1.72	-5.88	5.45	1.37	-0.97	0.90	-1.77
		(0.56)	(-0.99)	(-2.05)	(-2.06)	(1.16)	(0.63)	(-0.91)	(0.56)	(-0.91)
	10-day	-1.26	-2.64	-3.49***	-6.96**	0.14	-2.64	-4.47***	-3.70**	-7.04***
		(-0.66)	(-1.16)	(-4.87)	(-2.84)	(0.04)	(-1.43)	(-3.62)	(-2.04)	(-4.64)
	20-day	-5.31***	-10.51***	-8.83***	-13.95***	-3.14	-8.73***	-0.35	-8.44***	-11.23***
		(-3.23)	(-5.54)	(-10.94)	(-6.76)	(-1.15)	(-5.67)	(-0.29)	(-4.86)	(-6.51)
	30-day	-3.52**	-2.37	-4.73**	-20.89***	0.56	-10.32***	1.79	8.90***	-0.76
		(-2.37)	(-1.21)	(-2.25)	(-11.20)	(0.23)	(-5.22)	(1.30)	(3.78)	(-0.35)

Values in parentheses are t-statistics.

*** Statistically significant at 1% significance level. (AR >2.59, CAR 5-day >4.60, 10-day >3.24, 20-day >2.86, 30-day >2.75, all in absolute value).

** Statistically significant at 5% significance level. (AR >1.96, CAR 5-day >2.77, 10-day >2.25, 20-day >2.09, 30-day >2.04, all in absolute value).

* Statistically significant at 10% significance level. (AR >1.64, CAR 5-day >2.13, 10-day >1.83, 20-day >1.72, 30-day >1.69, all in absolute value).

Table 16. Abnormal Returns and Cumulative Abnormal Returns for the Third 2010 Event (November), Continued

Group		Imported Meat			Feed			Vaccine		
Company		HF	DA	AI	WS	KC	KI	EV	CV	CB
Abnormal Return (%)	-5	0.17 (0.04)	-0.35 (-0.15)	0.33 (0.08)	0.13 (0.04)	0.78 (0.23)	-0.52 (-0.16)	-0.74 (-0.17)	-0.13 (-0.02)	0.26 (0.05)
	-4	-1.15 (-0.26)	4.55** (1.99)	-0.12 (-0.03)	-0.03 (-0.01)	0.92 (0.27)	-0.58 (-0.17)	-0.06 (-0.01)	-1.74 (-0.29)	0.51 (0.10)
	-3	-2.21 (-0.50)	0.21 (0.09)	-0.81 (-0.21)	-0.01 (0.00)	-2.58 (-0.75)	-2.47 (-0.74)	-3.64 (-0.83)	-3.60 (-0.59)	-1.47 (-0.29)
	-2	0.29 (0.07)	2.90 (1.27)	-0.14 (-0.04)	0.73 (0.23)	-0.84 (-0.25)	-1.31 (-0.39)	0.86 (0.20)	1.09 (0.18)	-2.27 (-0.45)
	-1	1.41 (0.32)	-4.09* (-1.79)	-0.68 (-0.17)	-3.99 (-1.28)	-1.24 (-0.36)	-0.91 (-0.27)	-1.09 (-0.25)	-2.29 (-0.38)	-2.57 (-0.51)
	0	3.57 (0.81)	-2.04 (-0.89)	0.31 (0.08)	4.15 (1.33)	1.26 (0.37)	0.58 (0.17)	14.26*** (3.26)	14.99** (2.47)	14.84*** (2.95)
	1	2.25 (0.51)	0.09 (0.04)	1.36 (0.35)	-1.12 (-0.36)	-1.25 (-0.36)	0.38 (0.11)	-6.24 (-1.43)	4.03 (0.67)	-4.59 (-0.91)
	2	-0.64 (-0.15)	3.43 (1.50)	-1.43 (-0.36)	-1.18 (-0.38)	4.02 (1.17)	1.74 (0.52)	-3.01 (-0.69)	-1.47 (-0.24)	-2.96 (-0.59)
	3	-0.41 (-0.09)	-0.19 (-0.09)	-0.26 (-0.07)	0.90 (0.29)	-2.15 (-0.63)	-1.25 (-0.37)	-1.61 (-0.37)	0.93 (0.15)	-0.25 (-0.05)
	4	-5.62 (-1.28)	-2.30 (-1.01)	-0.61 (-0.16)	-0.51 (-0.16)	0.47 (0.14)	-1.24 (-0.37)	0.07 (0.02)	2.02 (0.33)	5.70 (1.13)
	5	-0.88 (-0.20)	3.67 (1.61)	-0.41 (-0.10)	-0.28 (-0.09)	-0.96 (-0.28)	-1.66 (-0.50)	0.83 (0.19)	-6.19 (-1.02)	1.84 (0.37)
Cumulative Abnormal Return (%)	5-day	-0.85 (-0.24)	-1.01 (-0.44)	-0.63 (-0.61)	2.24 (1.00)	2.35 (0.98)	0.21 (0.16)	3.46 (0.44)	20.50** (3.20)	12.74 (1.61)
	10-day	-4.57 (-1.79)	7.42*** (3.48)	-2.99*** (-3.92)	0.95 (0.61)	0.13 (0.07)	-0.93 (-0.89)	4.31 (0.81)	12.83* (2.05)	6.73 (1.12)
	20-day	-7.04*** (-3.17)	-0.37 (-0.16)	-4.17*** (-3.70)	-0.72 (-0.63)	-9.97*** (-6.32)	-7.90*** (-8.36)	1.65 (0.29)	9.76 (1.50)	4.77 (0.78)
	30-day	36.52*** (7.24)	19.36*** (6.95)	34.17*** (7.73)	14.45*** (4.85)	-18.65*** (-11.04)	-12.13*** (-11.83)	7.67 (1.57)	5.35 (0.92)	17.19*** (2.85)

Values in parentheses are t-statistics.

*** Statistically significant at 1% significance level. (AR >2.59, CAR 5-day >4.60, 10-day >3.24, 20-day >2.86, 30-day >2.75, all in absolute value).

** Statistically significant at 5% significance level. (AR >1.96, CAR 5-day >2.77, 10-day >2.25, 20-day >2.09, 30-day >2.04, all in absolute value).

* Statistically significant at 10% significance level. (AR >1.64, CAR 5-day >2.13, 10-day >1.83, 20-day >1.72, 30-day >1.69, all in absolute value).

Table 17. Volatility Change of Stock Prices Before and After the FMD Outbreaks Using Standard Deviation

Group			Pork						Poultry					
Company			SJ		FC		FH		HR		MK		DW	
2000	-150	4.45		-		-		6.24		-		-		
	-100	4.99		-		-		7.18		-		-		
	-50	5.40		-		-		7.18		-		-		
	50	5.79	(1.15,0.59)	-		-		7.54	(1.10,0.56)	-		-		
	100	5.01	(1.01,0.67)	-		-		6.43	(0.80,0.53)	-		-		
	150	5.59***	(1.58,0.95)	-		-		5.92	(0.90,0.54)	-		-		
2002	-150	2.68		4.39		3.06		3.89		3.28		-		
	-100	3.12		5.00		3.07		3.82		2.59		-		
	-50	3.33		5.42		3.65		4.85		3.05		-		
	50	3.15	(0.90,0.53)	2.88	(0.28,0.17)	2.52	(0.48,0.28)	4.70	(0.94,0.56)	4.09**	(1.80,1.07)	-		
	100	4.68***	(2.25,2.22)	3.08	(0.38,0.37)	2.72	(0.79,0.78)	3.76	(0.97,0.96)	3.35***	(1.68,1.65)	-		
	150	4.01***	(2.24,2.02)	3.59	(0.67,0.61)	2.35	(0.59,0.53)	3.45	(0.79,0.71)	7.98***	(5.92,5.35)	-		
2010-1	-50	1.41		5.03		2.20		2.54		1.60		1.90		
	50	1.71*	(1.48,1.54)	3.42	(0.46,0.48)	1.08	(0.24,0.25)	1.96	(0.60,0.62)	3.64***	(5.15,5.35)	2.73***	(2.07,2.15)	
2010-2	-50	1.45		3.06		1.25		2.05		3.33		2.33		
	50	1.71	(1.39,1.07)	5.45***	(3.18,2.45)	2.09***	(2.78,2.15)	3.36***	(2.69,2.08)	4.69***	(1.99,1.53)	2.71	(1.35,1.04)	
2010-3	-150	2.50		3.40		1.42		2.66		3.16		2.00		
	-100	2.99		3.48		1.01		2.28		1.95		1.56		
	-50	3.50		2.93		0.68		2.38		2.00		1.66		
	50	4.98***	(2.02,2.36)	2.39	(0.66,0.77)	4.09***	(36.28,42.33)	3.12**	(1.72,2.00)	3.14***	(2.47,2.88)	2.09*	(1.58,1.84)	
	100	4.61***	(2.37,1.87)	3.19	(0.84,0.66)	5.21***	(26.59,21.00)	3.63***	(2.53,2.00)	3.66***	(3.52,2.78)	2.87***	(3.38,2.67)	
	150	4.29***	(2.95,2.55)	3.10	(0.83,0.72)	4.82***	(11.55,9.99)	3.25***	(1.49,1.29)	3.67**	(1.35,1.17)	2.78***	(1.94,1.68)	

Values in parentheses are *F*-statistics ($F = \sigma^2_{i,after} / \sigma^2_{i,before}$, $F = (\sigma^2_{i,after} / \sigma^2_{i,before}) / (\sigma^2_{index,after} / \sigma^2_{index,before})$.

*** Statistically significant at 1% significance level (50-day >1.95, 100-day >1.59, 150-day >1.45).
** Statistically significant at 5% significance level (50-day >1.59, 100-day >1.38, 150-day >1.29).
* Statistically significant at 10% significance level (50-day >1.43, 100-day >1.28, 150-day >1.22).

Table 17. Volatility Change of Stock Prices Before and After the FMD Outbreaks Using Standard Deviation, Continued

Group		Seafood						Imported Meat					
Company		DI		SI		OY		HF		DA		AI	
2000	-150	4.47		4.48		5.14		-		-		-	
	-100	4.74		4.92		5.82		-		-		-	
	-50	5.01		5.40		6.31		-		-		-	
	50	4.87	(0.95,0.48)	5.78	(1.15,0.59)	5.92	(0.88,0.45)	-		-		-	
	100	4.67	(0.97,0.64)	4.75	(0.93,0.62)	5.31	(0.83,0.55)	-		-		-	
	150	4.51	(1.01,0.61)	5.08*	(1.28,0.77)	5.48	(1.14,0.69)	-		-		-	
2002	-150	2.53		3.32		3.37		-		-		-	
	-100	2.33		3.16		3.07		-		-		-	
	-50	2.41		3.57		3.12		-		-		-	
	50	2.22	(0.85,0.50)	3.58	(1.00,0.60)	3.84*	(1.51,0.90)	-		-		-	
	100	2.81**	(1.46,1.44)	3.00	(0.90,0.89)	3.34	(1.18,1.17)	-		-		-	
	150	3.29***	(1.69,1.53)	3.30	(0.99,0.89)	3.70	(1.21,1.09)	-		-		-	
2010-1	-50	1.85		2.34		2.89		3.36		1.75		3.85	
	50	1.74	(0.89,0.92)	1.85	(0.63,0.65)	2.06	(0.51,0.53)	3.48	(1.07,1.11)	0.80	(0.21,0.22)	2.47	(0.41,0.43)
2010-2	-50	1.42		1.68		1.66		1.95		2.39		3.98	
	50	1.43	(1.01,0.78)	3.40***	(4.11,3.17)	2.31**	(1.92,1.48)	2.39*	(1.50,1.16)	2.37	(0.99,0.76)	3.84	(0.93,0.72)
2010-3	-150	1.50		2.70		1.77		2.17		3.01		3.14	
	-100	1.54		2.25		1.66		2.06		3.39		2.65	
	-50	1.67		2.59		1.74		2.10		4.57		1.64	
	50	1.56	(0.87,1.02)	3.22*	(1.54,1.80)	3.16***	(3.32,3.87)	6.39***	(9.28,10.83)	2.29	(0.25,0.29)	6.06***	(13.56,15.82)
	100	1.67	(1.17,0.92)	2.90***	(1.67,1.32)	3.42***	(4.26,3.36)	6.15***	(8.90,7.03)	2.58	(0.58,0.46)	5.27***	(3.96,3.13)
	150	1.75**	(1.36,1.18)	2.70	(1.00,0.87)	3.10***	(3.07,2.66)	5.42***	(6.23,5.39)	2.70	(0.80,0.70)	4.57***	(2.13,1.84)

Values in parentheses are *F*-statistics ($F = \sigma^2_{i,after} / \sigma^2_{i,before}$, $F = (\sigma^2_{i,after} / \sigma^2_{i,before}) / (\sigma^2_{index,after} / \sigma^2_{index,before})$.

*** Statistically significant at 1% significance level (50-day >1.95, 100-day >1.59, 150-day >1.45).
** Statistically significant at 5% significance level (50-day >1.59, 100-day >1.38, 150-day >1.29).
* Statistically significant at 10% significance level (50-day >1.43, 100-day >1.28, 150-day >1.22).

Table 17. Volatility Change of Stock Prices Before and After the FMD Outbreaks Using Standard Deviation, Continued

Group		Feed						Vaccine					
Company		WS		KC		KI		EV		CV		CB	
2000	-150	4.54		6.82		8.00		-		-		-	
	-100	4.96		7.26		8.37		-		-		-	
	-50	5.45		8.13		7.76		-		-		-	
	50	6.35	(1.36,0.69)	9.26	(1.30,0.66)	6.71	(0.75,0.38)	-		-		-	
	100	5.13	(1.07,0.71)	8.00	(1.21,0.80)	6.86	(0.67,0.45)	-		-		-	
	150	4.74	(1.09,0.66)	7.27	(1.13,0.68)	7.61	(0.90,0.55)	-		-		-	
2002	-150	2.64		3.03		3.84		-		-		-	
	-100	2.36		2.38		3.58		-		-		-	
	-50	2.81		2.91		4.39		-		-		-	
	50	1.52	(0.29,0.17)	2.80	(0.92,0.55)	8.67***	(3.89,2.31)	-		-		-	
	100	1.72	(0.53,0.52)	2.38	(1.00,0.99)	6.94***	(3.77,3.72)	-		-		-	
	150	2.08	(0.62,0.56)	2.30	(0.58,0.52)	6.37***	(2.76,2.49)	-		-		-	
2010-1	-50	2.51		1.32		2.45		3.47		6.49		3.87	
	50	2.57	(1.05,1.09)	1.99***	(2.28,2.37)	2.95*	(1.45,1.50)	1.81	(0.27,0.28)	3.99	(0.38,0.39)	2.48	(0.41,0.43)
2010-2	-50	3.06		4.24		4.08		0.87		2.10		1.93	
	50	3.69*	(1.45,1.12)	8.75***	(4.26,3.29)	3.25	(0.63,0.49)	5.65***	(41.99,32.38)	6.58***	(9.81,7.56)	5.38***	(7.76,5.98)
2010-3	-150	1.90		5.72		2.00		2.52		3.61		2.44	
	-100	1.17		4.23		1.63		1.68		2.94		1.49	
	-50	1.06		3.04		1.90		1.12		2.28		1.36	
	50	2.79***	(6.87,8.02)	1.78	(0.34,0.40)	1.56	(0.68,0.79)	3.40***	(9.13,10.65)	4.28***	(3.54,4.13)	4.32***	(10.04,11.72)
	100	2.56***	(4.77,3.77)	2.88	(0.46,0.37)	1.45	(0.79,0.62)	2.63***	(2.46,1.94)	3.41	(1.35,1.06)	3.36***	(5.07,4.00)
	150	2.78***	(2.15,1.86)	3.16	(0.30,0.26)	1.69	(0.71,0.61)	3.57***	(2.01,1.74)	3.02	(0.70,0.60)	3.05***	(1.56,1.35)

Values in parentheses are *F*-statistics ($F = \sigma^2_{i,after} / \sigma^2_{i,before}$, $F = (\sigma^2_{i,after} / \sigma^2_{i,before}) / (\sigma^2_{index,after} / \sigma^2_{index,before})$.

*** Statistically significant at 1% significance level (50-day >1.95, 100-day >1.59, 150-day >1.45).
** Statistically significant at 5% significance level (50-day >1.59, 100-day >1.38, 150-day >1.29).
* Statistically significant at 10% significance level (50-day >1.43, 100-day >1.28, 150-day >1.22).

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