ESSAYS ON IMPACTS OF AVIAN INFLUENZA OUTBREAKS ON FINANCIAL MARKETS

A Dissertation

by

WEI HUANG

Submitted to the Office of Graduate Studies
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

December 2009

Major Subject: Agricultural Economics

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ABSTRACT

Essays on Impacts of Avian Influenza Outbreaks on Financial Markets. (December 2009)

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A recent outbreak of bird flu or avian influenza (AI), an especially highly pathogenic strain (HPAI) of H5N1, started in Hong Kong in January 2003 and caused 159 human deaths in Asia, Africa and Europe through early 2007. In addition, this outbreak resulted in millions of slaughtered birds and banned international trade of poultry meat in the infected countries. Such events harmed the poultry, tourism, and other related industries in the infected countries and changed the world poultry trade flow. Even in some uninfected countries, related industries were negatively affected. This study investigates the impact of bird flu outbreaks as manifested in financial markets within the US and Japan.

The first essay explores how the avian influenza (AI) outbreaks impacted the security values of poultry-related firms. Using partial equilibrium analysis, this study infers that within a country AI outbreaks drop stock prices of poultry meat producers and raise stock prices of poultry food producers. Simultaneously, we infer that AI outbreaks in other poultry exporting countries raise stock prices of poultry meat producers and drop stock prices of poultry food producers. The empirical findings support our model

results. Recent developments in time series method, directed graphs and search methods of cointegration rank are applied in this study.

The second essay examines whether avian influenza outbreaks cause structural breaks in a model of their prices. It employs the dynamic programming algorithm and the reduced regression method for a cointegrated vector autoregressive (VAR) model to compute the break dates for the data sample. This research then compares the long run relation, short run relation and contemporaneous relation. The model estimations in these three sub-periods find these three sub-samples are significantly different. The breaks were caused by the invasion of Iraq on March 2003 and the 20 Bovine Spongiform Encephalopathy (BSE) induced ban of Canadian live cattle imports to the US on 03 March 2005, not by avian influenza outbreaks in early 2004.

The third essay explores the effects of the avian influenza announcement in Japan on the prices of agricultural commodity futures contracts traded in Japan. Both the VAR model with asymmetric generalized autoregressive conditional heteroskedastic (GARCH) terms and the event study methods were used to examine whether avian influenza outbreaks significantly affected these markets. Our findings point out that the avian influenza outbreak only impacted the egg futures contract.

These three essays found that outbreaks of avian influenza have significant impact on poultry-related stock prices and futures markets. The examined impacts changed the movement of those financial equity prices in the short run, but not in the long run. Research showed, investors and poultry-related producers still encounter huge financial risk and loss.

DEDICATION

To my dearest wife, daughter, and parents

ACKNOWLEDGEMENTS

First and foremost, I would like to acknowledge and thank my wife, Yanhua, for her unwavering support through our marriage. Next, I would like to thank my parents for their generous spiritual and physical support to my study. I am thankful to my committee co-chairs, Dr. McCarl and Dr. Bessler, for their guidance and generous support throughout the course of this research. I am also grateful for my committee members, Dr. Capps and Dr. Jin, for their precious time and patience in the guidance of my research. Finally, I am also grateful for my classmates and friends at Texas A&M for their encouragement, patience and help.

NOMENCLATURE

AFCE	AFC Enterprises
AI	Avian Influenza
BSE	Bovine Spongiform Encephalopathy
CALM	Cal-Maine Foods
DAFCE	Innovation of AFCE Stock Price
DCALM	Innovation of CALM Stock Price
DF	Demand Curve of Poultry Food Served by a Food Producer
DI	Demand Curve of Poultry Meat Provided by a Whole Industry
DIBA	Innovation of IBA Stock Price
DM	Demand Curve of Poultry Meat Served by a Meat Producer
DSAFM	Innovation of SAFM Stock Price
DTSN	Innovation of TSN Stock Price
EDW	Excess Demand of Poultry Meat in the World Poultry Market
ESC	Excess Supply of Poultry Meat in an Exporting Country
ESW	Excess Supply of Poultry Meat in the World Poultry Market
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
IBA	Industrias Bachoco
NSOYBEAN	Non-GMO Soybean
SAFM	Sanderson Farms
SF	Supply Curve of Poultry Food Served by a Food Producer

SI	Supply Curve of Poultry Meat Provided by a Whole Industry
SM	Supply Curve of Poultry Meat Served by a Meat Producer
SP500	Standard & Poor’s 500 Index
TSN	Tyson Foods
US	United States
VAR	Vector Autoregressive

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CHAPTER I

GENERAL INTRODUCTION

A recent outbreak of an especially highly pathogenic avian influenza (AI) strain (H5N1), started in Hong Kong in January 2003, and caused 159 human deaths in Asia, Africa and Europe through early 2007. In addition, this outbreak resulted in millions of slaughtered birds and banned international trade of poultry meat in the infected countries. Such events harmed the poultry, tourism, and other related industries in the infected countries and changed the world poultry trade flow. Even in some uninfected countries related industries were negatively affected. This study investigates the impacts of avian influenza outbreaks on financial markets in US and Japan. The United States (US) is the largest poultry exporting country in the world, followed by Brazil, China and Thailand. Thus recent AI outbreaks could have some detectable effects on the US poultry economy even though the HPAI strain of H5N1 has never been discovered there. Japan is one of the largest countries to import poultry meat in the world. Outbreaks of avian influenza may impact both demand and supply of poultry meat in these two countries, further their related financial markets in these two countries. Most previous studies, regarding AI and the US, simulate hypothetical outbreaks with economic models to explore possible effects of AI outbreaks on industrial, regional or national economy without actual data support (Djunaidi et al., 2007; Brown et al., 2007; Paarlberg et al., 2007).

This dissertation follows the style of *American Journal of Agricultural Economics.*

Objective

The first essay tries to explore the impact of AI events on some poultry-related stock prices. At first, this study employs partial equilibrium analysis to deduce expected impacts of AI outbreaks inside or outside the poultry exporting country on poultry meat or egg producers and poultry food producers; then it investigates how AI outbreaks in Asia and US affected five poultry-related firms publicly traded in the US stock market through the historical decomposition analysis and vector error correction model. Recent developments in cointegration rank search method and directed graphs are applied in this study.

The second essay examines whether avian influenza outbreaks have long run effects on financial markets. The first essay already found avian influenza outbreaks in Asia and the US had caused the stock price of five poultry-related firms publicly listed in the US stock markets to fluctuate greatly in the short term. These findings show that avian influenza outbreaks could impact financial markets through international trade. So a question of whether avian influenza outbreaks affect financial market in long rum term appears naturally. Djunadi and Djunaidi (2007) simulated the effects of avian influenza outbreaks on international trade of poultry around world. They found avian influenza outbreak in European countries or the US reduced international trade of poultry more than would outbreaks in Asia. In 2006, avian influenza was found frequently in Asia, Europe and Africa almost the same time. So this study tries to explore whether break points exist in this data sample and what cause breaks if they exist.

The third essay explores the effects of avian influenza outbreaks in an importing country, contrary to the previous two essays that explore the impact of avian influenza on the economy of the United States, an exporting country. Some previous studies found food safety events have little effect on related agricultural commodity futures. (Lusk and Schroeder, 2002). TSE and Hackard found the effects of mad cow announcement on agricultural commodity futures using the data sample in minute.

Literature Review

Previous studies have explored the impacts of AI outbreak in the United States on the agriculture and trade of the United States and the world. Djunaidi and Djunaidi (2007) employed a spatial equilibrium approach to examine the economic impacts of AI outbreaks. Their simulation results showed that the export price hit its highest point and the volume of world poultry trade reached its lowest point if all producing regions were affected by the outbreaks. Outbreaks in the United States were found to have a greater effect on export price than outbreaks in any other region. Outbreaks in Asia had the smallest effect on export price among these four regions. Brown, Madison, Goodwin and Clark (2007) simulated the effects of an AI outbreak on US agriculture and found that in the first year following an AI event in the US the prices of chicken, turkey and eggs declined significantly. The domestic consumption remained stable while the production and exports decreased where the production reduction was larger than the export reduction. As substitutes for poultry meat, beef and pork prices increased as well with the higher prices of cattle and hog. The prices of corn, soybean and soybean meal declined as feed use decreased for AI outbreaks. As the poultry industries recovered, the prices of these affected categories returned to their normal levels.

Paarlberg, Seitziger and Lee (2007) examined the simulated US economic impacts of regionalization in the event of an outbreak of HPAI. The results indicated an outbreak of HPAI could lead to a decline in price, production, consumption and export of poultry meat and eggs. Both consumers and producers of poultry meat and eggs experienced welfare losses. Regionalization could moderate those effects of AI outbreaks mentioned above. The AI impacts on the poultry industry could almost completely disappear after four quarters following the AI outbreak. For the substitution effects, non-poultry meats decreased their prices as poultry meat did and non-meat food and non-agricultural goods were not affected.

The Economic Commission for Latin America and the Caribbean of the United Nations (ECLAC, 2006) analyzed the recent outbreaks of AI around the world, and concluded six main trade impacts of AI on the world and Latin America and the Caribbean. These impacts included a decline in world poultry trade; an increase in chicken meat stocks in infected producer countries; a drop in prices in infected countries; diversion of trade, with more imports coming from disease-free countries.

Rushton, Viscarra, Bleich and Mcleod (2005) reported impacts of avian influenza outbreaks in the poultry sectors of five East Asian countries: Cambodia, Indonesia, Lao PDR, Thailand and Vietnam. This study found that HPAI affected the whole supply chain such as input industry, production, marketing, processing and consumers. The industries related to poultry lost much production and revenue, while the industries related to other livestock experienced rising consumption and revenue.

Obayelu (2007) studied the impacts of AI outbreaks on household poultry consumption and poultry industry in Nigeria through structured interviews. The study found that AI outbreaks and spread in Nigeria seriously threatened the poultry industry, food security and the livelihoods of both the rural and urban communities. Poultry farmers stopped maintaining their farms; households stopped the consumption of poultry products. Following the outbreak, prices of chicken and egg decreased considerably, as supply overwhelmed demand. Consumption of pork, beef, fish and animal skin rose as substitutes for poultry products.

In a simulation study, Kennedy, Thomson and Vujaovic (2006) found both short-term and medium-term effects of AI outbreaks in Australia. In the short run, GDP might contract by over 5% in the year following an outbreak of a HPAI pandemic. Households were found to reduce consumption, particularly of service-related goods, while business cut both investment and employment. In the medium term, consumption and GDP growth both recovered by the end of the second year; while the unemployment rate did not start falling until the third year after the AI shock.

There is some work on the effects of BSE outbreaks on stock prices for related firms through the event study methodology. Henson and Mazzocchi (2002) explored the impact of the UK Government's announcement on a possible link between BSE and human health on UK firms in the beef and related sectors. They found the Government announcement decreased stock returns of beef processors, dairy products, animal feed and pet food. The announcement increased equity prices of other meat manufacturers. Jin and Kim (2008) studied the effects of the BSE outbreak in the United States on the security values of the agribusiness and food processing firms in the United States. They showed that these US firm values of beef production decreased significantly, while the firm values of non-beef production increased following the BSE outbreak. The BSE outbreak had small or negligible impacts on the firms in other categories, such as farm machinery and equipment, grain marketing, and other foods.

CHAPTER II

HOW DOES AVIAN INFLUENZA IMPACT THE POULTRY-RELATED STOCKS LISTED ON US PUBLIC STOCK MARKETS?

A recent outbreak of an especially highly pathogenic avian influenza strain (HPAI) of H5N1, started in Hong Kong in January 2003, and caused 159 human deaths in Asia, Africa and Europe through early 2007. In addition, this outbreak resulted in millions of slaughtered birds and bans international trade of poultry meat in the infected countries. Such events seriously hurt the poultry, tourism, and other related industries in the infected countries and changed the world poultry trade flow (Rushton et al., 2005; Obayelu, 2007; Nicita 2008). Even in some uninfected countries related industries are negatively affected (ECLAC, 2006). The United States (US) is the largest poultry exporting country in the world, followed by Brazil, China and Thailand. Thus recent AI outbreaks could have some detectable effects on the US poultry economy even though the HPAI strain of H5N1 has never been discovered there.

Most previous studies, regarding AI and the US, simulate hypothetical outbreaks with economic models to explore possible effects of AI outbreaks on industrial, regional or national economy without actual data support (Djunaidi et al., 2007; Brown et al., 2007; Paarlberg et al., 2007). This study is the first one to investigate the firm-level effects of AI theoretically and empirically. This paper explores the AI outbreak effects on stock prices of poultry-related firms in an economic partial equilibrium model. Then the empirical estimations are done on the stock price behaviors of poultry-related firms in US stock markets. The study extends the literature in that little previous literature relates stock price fluctuations to the change of international trade.

The stock market approach has been pursed before in other contexts. For example, previous research found the Bovine Spongiform Encephalopathy (BSE) outbreaks have significant influences on stock prices in meat and other related industries in the United Kingdom (UK) and the United States. (Henson et al, 2002; Jin and Kim, 2008)

This study applies the vector error correction (VEC) model and its associated historical decomposition analysis for five publicly traded firms using data from 1 June 2001 to 16 April 2007. The historical decomposition method is often used in macroeconomic policy analysis. Recently it is employed to discover the effects of BSE events on the beef retail prices in the United Kingdom and Japan (Chopra and Bessler, 2005; Saghaian et al, 2007), and to investigate the transmission of multiple stock market crashes occurring in the October 1987 (Yang and Bessler, 2008). In this context, it appears that this study will be the first effort to apply the historical decomposition to explore the impacts of animal disease outbreaks on the stock prices of firms. Recent developments in directed graphs and cointegration rank tests are also applied to help build and explain the model in this study.

This research could help understand why and how AI outbreaks in different places have different impacts on poultry-related firms. The model and its results can also be used to analyze the impacts of other animal diseases or food safety events on the related firms. Furthermore, this study can help understand how the change of international trade affects the related firms.

The remainder of this paper is organized as follows. The second section develops the partial equilibrium model to analyze how AI outbreaks impact stock prices of poultry-related firms. The empirical methodologies are covered in the third section. The fourth section presents the empirical results of the analysis. Conclusions and suggestions on future research are offered in the last section.

Expectation of AI Outbreak Effects on Stock Prices

This study assumes that the US meat consumers put confidence in the US firm reputation and the food safety inspection system of firm and nation, thus domestic poultry meat/eggs/food consumption remains stable following AI outbreaks inside or outside the United States. The poultry-related firms under study are divided into poultry meat/eggs producers (meat producers) and restaurants, or poultry food producers (food producers). The meat producers are the upstream firms of food producers, while the food producers are the downstream firms of meat producers. The supply curve of food producer is a function of poultry meat price. As poultry meat price increases, poultry food supply decreases; as poultry meat price decreases, poultry food supply increases.

Figure 1 provides the partial equilibrium analysis to show how AI outbreaks in other poultry-exporting countries impact stock prices of poultry-related firms in an uninfected exporting country. Figure 2 provides the partial equilibrium analysis to show how AI outbreaks inside an exporting country impact stock prices of these poultry-related firms in this country. In these figures the supply curves of meat producers, SM, and the supply curves of food producers, SF, are positive-sloped lines; their demand curves, DM and DF, are horizontal lines. The horizontal demand curves indicate firms have no market power and are price takers. The demand curves of poultry meat industry, DI, are negative-sloped lines; their supply curves, SI, are positive-sloped lines. In the world poultry meat market, the world excess demand curves, ESW, are negatively slopped; its excess supply curves, EDW, are positively sloped.

Figures 1(a), 1(b), 1(c), 1(d) and 1(e) respectively analyze the effects of AI outbreaks outside the country on food producer, meat producer, poultry meat industry, excess supply of exporting country and world poultry meat market in sequence. As we know, if some other poultry exporting countries are infected by AI and are banned from exporting poultry meat, then the world excess supply of poultry meat decreases.

In Figure 1(e) of the world poultry market, the supply curve shifts inward from ESW_0 to ESW_1. This change causes the equilibrium price rise from P_{W0} to P_{W1} and the equilibrium quantity decrease from Q_{W0} to Q_{W1}.

In Figure 1(d), even though the excess supply curve of the exporting country, without AI infection, does not change, the price rise of poultry meat in the world market leads to the rise in the poultry meat export price from P_{C0} to P_{C1} in that exporting country, which leads to the quantity of exporting poultry meat rising from Q_{C0} to Q_{C1}.

In Figure 1(c) of poultry meat industry, both the domestic demand and supply are not affected by AI outbreaks in other countries, thus the industry demand curve and supply curve remain unchanged. However, the rise in export price leads to the rise in industry price from P_{I0} to P_{I1}, which leads the decrease in industry equilibrium quantity from Q_{I0} to Q_{I1}.

In Figure 1(b), the supply curve of the meat producer does not change because it is not affected by AI outbreaks; its demand curve shifts downward from DM_0 to DM_1 for the drop of industry meat price. The equilibrium price of the meat producer increases from P_{M0} to P_{M1}; its equilibrium quantity increases from Q_{M0} to Q_{M1}. The producer surplus of meat producer increases in the context as given in Figure 1(b).

In Figure 1(a), the poultry food demand is not affected by AI outbreaks as we assumed previously, and the demand curve of food producer remains unchanged. Its supply curve shifts inward from SF_0 to SF_1 because its production input price, poultry meat price increase as we previously assume the supply curve of food producer is a function of meat price. The equilibrium quantity of the food producer decreases from Q_{F0} to Q_{F1}. The producer surplus of food producer reduces as shown in Figure 1(a). The increase in producer surplus means the increase of firm net income, which further means the rise of firm value, equivalently the stock price rise of firm, and vice verse. Thus, we can make the first expectation that AI outbreaks in other exporting countries do raise the stock prices of meat producers and drop the stock prices of food producers in an exporting country without AI infections.

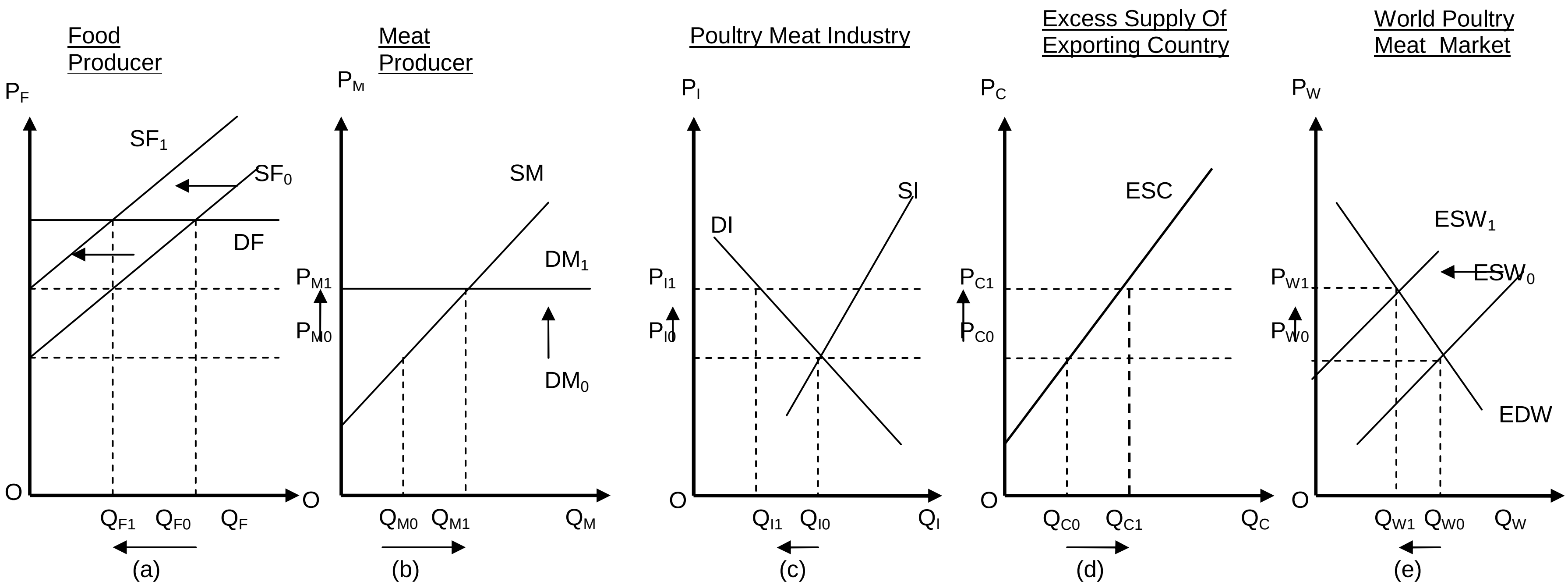


Figure 1. Partial equilibrium analyses for the effects of AI outbreak outside this country on food producers, meat producers, poultry meat industry, excess supply of this exporting country and world poultry meat market

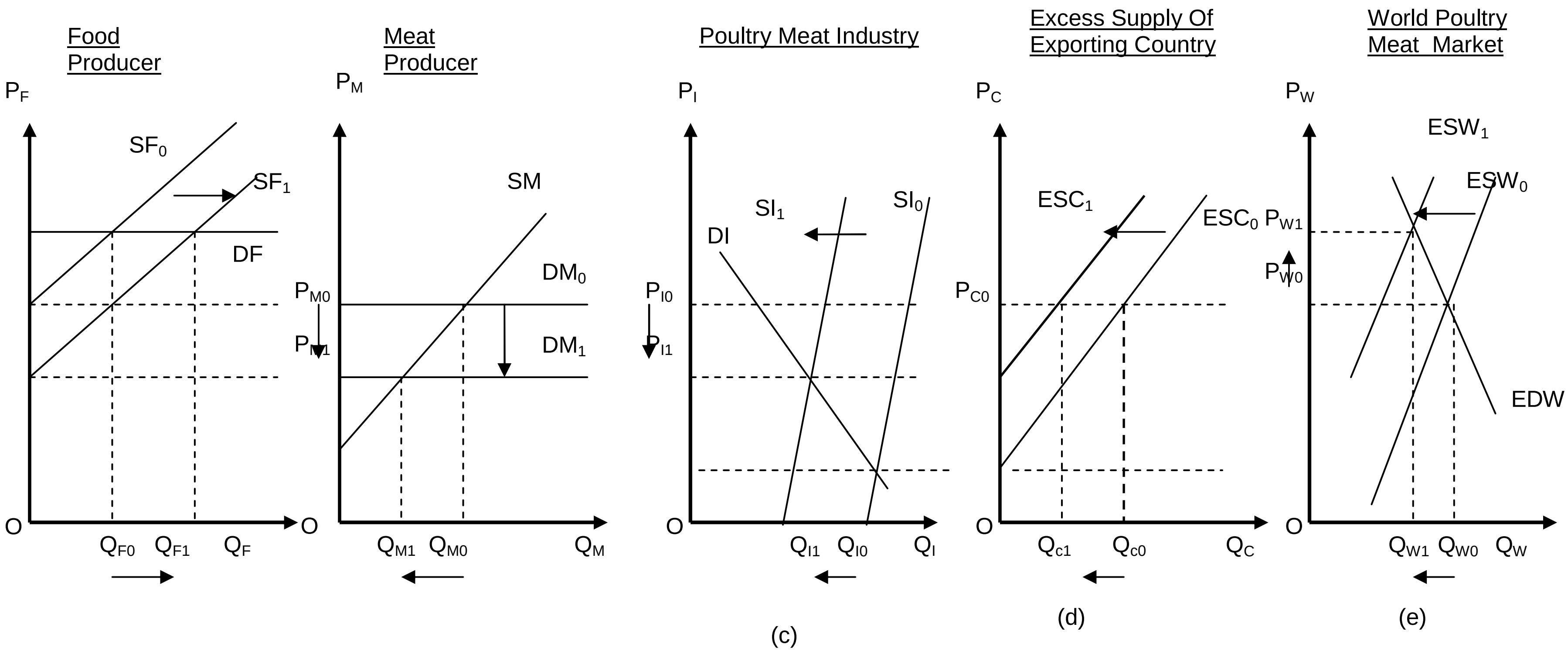


Figure 2. Partial equilibrium analyses of the effects of AI outbreaks inside an exporting country on food producers, meat producers, poultry meat industry, excess supply of exporting country and world poultry meat market

Figure 2(a), 2(b), 2(c), 2(d) and 2(e) respectively analyze the effects of AI outbreaks inside the country on food producer, meat producer, poultry meat industry, excess supply of exporting country and world poultry meat market in sequence. The change of the world market in Figure 2(e) is the same as the change in Figure 1(e). The equilibrium price in the world market increases and the equilibrium quantity decreases after an AI outbreak. The AI-infected country is often banned from exporting poultry products. Hence, in Figure 2(d) the exporting quantity reduces to zero and the excess supply curve shifts inward from ESC_0 to ESC_1, since the AI outbreaks inside the country reduces the domestic poultry meat production.

In Figure 2(c) the domestic demand curve is not affected by AI outbreaks and remains unchanged as we assume previously; its supply curve shifts inward from SI_0 to SI_1 due to AI outbreaks reducing the domestic poultry meat production. For the export ban, the exporting quantity reduces to zero. Thus, the industry equilibrium price drop from P_{I0} to P_{I1} and its equilibrium quantity decreases from Q_{I0} to Q_{I1}.

In Figure 2(b) the supply curve of meat producer remains unchanged because its production may not be damaged by AI outbreaks. (Actually our analysis result will not change whether its production is damaged or not damaged by AI outbreaks.) The demand curve of meat producer shifts downward from DM_0 to DM_1 due to the exporting reduction. Hence, the equilibrium price for meat producer drops from P_{M0} to P_{M1} and its equilibrium quantity decreases from Q_{W0} to Q_{W1}. The producer surplus of meat producer decreases in term of Figure 2(b).

In Figure 2(a) the demand curve of the food producer remains unchanged as we assumed previously; its supply curve shifts outward due to the drop of poultry meat price. Hence, the equilibrium price of food producer remains stable and its equilibrium quantity increases from Q_{F0} to Q_{F1}. The producer surplus of food producer increases. According to the relation between producer surplus and stock price described in last paragraph, we can make the second expectation that AI outbreaks inside an exporting country do drop the stock prices of meat producers and raise the stock prices of food producers in this country.

Table 1. Summary on the Expected Impacts of AI Outbreaks on Poultry-related Stock Prices

Location of AI outbreaks	Firm type	Stock price behavior
Outside the country	Poultry meat/eggs producers	Stock price ↑
	Poultry food producers	Stock price ↓
Inside the country	Poultry meat/egg producers	Stock price ↓
	Poultry food producers	Stock price ↑

These two expectations are summarized in Table 1. This study will employ the historical decomposition analysis to explore the behavior of the five poultry-related stock prices during and after AI outbreaks in Asia and the US. The empirical results of the historical analysis can be used to check the theoretical results in this section. The historical analysis requires the knowledge of the multi-variable autogressive relationship among these five stock prices through Vector Error Correction Model (VECM) analysis. The contemporaneous relationship among these five stock prices can be obtained through the directed acyclic graphs (DAGs) analysis.

Empirical Research Methodologies

Historical Decomposition

The historical decomposition method is used to explore data in the neighborhood of a historically important event. It has often been used in macroeconomic policy analysis (Hamilton 1983). Recently, some studies employed this method to discover the effects of BSE events on the beef retail prices in the United Kingdom and Japan (Chopra and Bessler, 2005; Saghaian et al, 2007), and to investigate the transmission of stock market crash around the October 1987 (Yang and Bessler, 2008). This method can decompose the historical values of time series variables under study into a base projection and the cumulative effects of current and past innovations of each variable. Thus, comparing the actual value and projected value of each variable can help to find the actual variations of each variable after the starting point of projection. Further, the actual variation of a variable can be decomposed into its own contribution and the contributions from other variables. Comparing decomposed contributions can help to find major and minor drivers of actual variation.

The historical decomposition method originates from the moving average representation model (MAR). The MAR is expressed as follows:

(2.1) $$P_t = \sum_{i=0}^{\infty} \Theta_i u_{t-i}$$

where P_t denotes a vector that includes the n variables under study: $P_t' = [P_{1t,} P_{2t,} \cdots, P_{nt}]$. The subscript "t" represents time and the integers "1" to "n" denote different variables under study. $\sum$ is the summation operation. Θ is a parameter matrix over "i" lags. u_t

represents a vector of orthogonal innovations (shocks) each of which only impact one variable directly at time t. Equation (1) can be re-written as

(2.2) $$P_{T+k} = \sum_{i=k}^{\infty} \Theta_i u_{T+k-i} + \sum_{i=1}^{k-1} \Theta_i u_{T+k-i}$$

where T is the date of event occurrence. The first term on the right hand side of equation (2) is the forecast of P_{T+k} based on the information available before and at time T, called the base line (projection) or benchmark. The second term equals the difference between actual values and forecasted values of variables. This difference can be partitioned into the contribution from each variable in periods T+1 to T+k. Equation (2) can be re-expressed to illustrate this difference partition, and is shown in the equation (3) below.

(2.3) $$\begin{aligned} P_{q,T+k} &= \sum_{j=1}^{n}\sum_{i=k}^{\infty} \theta_{q,j,i} u_{j,T+k-i} + \sum_{i=1}^{k-1} \theta_{q,1,i} u_{1,T+k-i} + \sum_{i=1}^{k-1} \theta_{q,2,i} u_{2,T+k-i} \\ &+ \cdots + \sum_{i=1}^{k-1} \theta_{q,n,i} u_{n,T+k-i} \end{aligned} \qquad q = 1,2,\ldots,n$$

where $\theta_{q,j}$ is the (q, j) element of the parameter matrix Θ in Equation (2). Equation (3) shows the decomposition of the variable P_q at the time of T+k. The first term on the right hand side of Equation (3) is the forecast of the variable P_q at the time of T+k. The second term denotes the contribution of the variable P_1 to the variable P_q. The third term denotes the variable P_2's contribution to the variable P_q. This partition can illustrate how each innovation series pushes the variable value fluctuations and which variables have major or minor effects during the time period of interest.

The MAR can be transformed into Vector Autoregression model (VAR) with or without error correction term, and vice versa. Thus, practically we should obtain the estimated result of VAR first, and then transform this result into MAR, and finally work the historical decomposition analysis through MAR. Therefore, the VAR with error correction term is described next.

VAR with Error Correction Term

The VAR with error correction term is a cointegrated VAR model, also called as the error correction model (ECM). This study follows some previous literature and uses VAR to denote VAR without error correction term, and uses ECM to denote VAR with error correction term.

When building multiple-variable time series model, there are three commonly-used models: VAR in levels, VAR in first differences and ECM. Testing the cointegration rank in ECM can help to decide which model is appropriate. Here is the decision rule: (a) if the tested rank equals n, the number of dependent variables in the left hand of ECM model, each of these dependent variables, in levels, are stationary (as well as their combination), and the VAR in levels is an appropriate model; (b) if the tested rank equals zero, none of these dependent variables are stationary as well as their combination, and the VAR in first differences is an appropriate model; (c) if the tested rank is equal to the integer of r, greater than zero and less than n, some combinations of these variables are stationary, while some of these variables are nonstationary, the ECM model is an appropriate model.

The ECM model is expressed as follows:

(2.4) $$\Delta P_t = \Pi P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \Phi D_t + \varepsilon_t \qquad t = 1, \ldots, T,$$

(2.5) $$E\{\varepsilon_t \varepsilon_t'\} = \Sigma .$$

Here P_t is a vector of n variables under study, the same definition as in Equation (1); Δ is the difference operator ($\Delta P_t = P_t - P_{t-1}$); Π and Γ are $n \times n$ parameter matrices; D_t is a vector of deterministic variables such as a constant, linear trend, seasonal or intervention dummies, and exogenous variables; Φ is a parameter matrix of D_t; and ε_t is a vector of innovation (error) terms with a (5×5) covariance matrix Σ.

The cointegration rank of ECM model is the rank of parameter matrix, Π. If the matrix, Π, has the reduced rank of r, Π can be written as $\Pi = \alpha\beta'$. Both α and β are ($n \times r$) matrices. These will be used in the exclusion test and weak exogeneity test as discussed below. The rank, r, is also the number of cointegration vectors among these dependent variables in levels. The Trace test is the traditional test of cointegration rank (Johansen and Juselius, 1990; Johansen, 1991). Recently Wang and Bessler (2005) apply statistical loss functions to complement the Trace test in selection of the rank number r. This new method is used in this study.

Existence of the cointegration relationship implies that the variables involved in the relationship build a long-run equilibrium among them. Thus it is necessary to examine which variables are excluded from some or all long-run equilibriums. The long-run exclusion test is designed for this examination. Its hypothesis can be written as

(2.6) $$H_1: R'\beta = 0$$

Here R is a designed matrix of zeros and ones to exclude some variables out of the cointegration space (Denis et al., 2005). This test is to check which rows of β are not significantly different from zero. The likelihood ratio test (Johansen, 1991; Johansen and Juselius, 1990) is employed in this examination.

In addition, the weak exogeneity test can examine how each variable responds to the deviation from the long-run equilibrium. This test hypothesis is expressed as follow:

(2.7) $$H_2:\ B'\alpha = 0$$

where B is a matrix of zeros and ones similar to R in equation (2.6); the element of matrix, α, represents the short-run adjustment speed of each variable to disequilibrium in the long-run relations. This test is to check which rows of α are significantly different from zero. The likelihood ratio test is also conducted to test this hypothesis (Johansen, 1991; Johansen and Juselius, 1990).

The parameters of equation (4) can provide information on long-run, short-run and contemporary structure or pattern of the data generation process. The long-run correlation can be obtained from β; the short-run correlation can be achieved through α and Γ_i (Johansen and Juselius, 1994; Johansen, 1995; Juselius, 1995); Finally, the contemporary structure on innovations can be identified via the directed graphs analysis of the correlation or covariance matrix of $\hat{\varepsilon}_t$.

We need the information on contemporary structure when converting the estimated ECM or VAR into the MAR with orthogonal innovations. The results of graphs analysis with the Bernanke factorization overcome the arbitrary shortcoming of the Choleski factorization, a traditional method of innovation orthogonalization.

(Swanson and Granger, 1997; Bessler and Lee, 2002; Demiralp and Hoover, 2003). Hence, this study summarizes the directed acyclic graphs (DAGs) next.

Directed Acyclic Graphs

The directed acyclic graphs (DAGs) offer data based evidence on the contemporaneous causation among innovations, which the Bernanke factorization requires. This graph analysis is used to show the causal flow among variables in question. We assume there is no cyclic information flow among any of these variables. Arrows indicate the direction of information flow between variables. There are four possibilities between any two variables (for instance, P_i and P_j): (a) there is no causal relation between P_i and P_j (the edge is removed); (b) P_i causes P_j ($P_i \rightarrow P_j$); (c) P_i and P_j are both caused by a common omitted variable ($P_i \leftrightarrow P_j$); (d) causal direction can not be identified between P_i and P_j (P_i — P_j).

Fundamentally, DAGs are illustrations to represent the conditional correlation among a set of variables as implied by the recursive product decomposition:

(2.8)
$$\Pr(v_1, v_2, v_3, \cdots, v_n) = \prod_{i=1}^{n} \Pr(v_i \mid pa_i)$$

where P_r is the probability of variables v_1, v_2, v_3,…, v_n. The symbol “pa_i” refers to the realization of some subset of the variables that precede variable “i” in a causal chain. These are called parents of variable “i”. And the symbol $\prod$ refers to the product operator.

In applications, Fisher’s z, $z(\rho(i,j|k)n) = \frac{1}{2}(n - |k| - 3)^{1/2} \ln\{(|1+\rho(i,j|k)|)(|1-\rho(i,j|k)|)^{-1}\}$, is used to test whether conditional correlations are significantly different from zero. Here n is the number of observation used to estimate correlations, ρ(i,j|k) is the population correlation between series i and j conditioning on series k (removing the influence of series k on each i and j), and |k| is the number of conditional variables in k. If i, j and k are normally distributed and r(i,j|k) is the sample conditional correlation of i and j given k, then the distribution of $z(\rho(i,j|k)n) - z(r(i,j|k)n)$ is standard normal.

DAGs can be built through PC algorithm. This algorithm begins a complete undirected graph, which shows an undirected edge between every variable of the system. Edges between variables are removed sequentially based on zero correlation or partial correlation. Edges are directed by considering triples X—Y—Z, such that X and Y are adjacent as are Y and Z, but X and Z are not adjacent. Direct the (remaining) edges between triples X-Y-Z as X→Y←Z if Y is not in the sepset of X and Z. Furthermore, if X→Y, Y and Z are adjacent, X and Z are not adjacent, and there is no arrowhead at Y, then Y-Z should be positioned as Y→Z. Finally, if there is a directed path from X to Y, and an edge between X and Y, then X-Y should be positioned as X→Y. The PC algorithm and its extensions are programmed in the software TETRAD IV (Scheines et al., 1996). This study employs TETRAD IV to conduct DAG analysis.

Data and AI Event Time Window

This study focuses on poultry-related firms listed in the US public stock market. The data in this study are the daily adjusted stock closing prices from 1 June 2001 to 16 April 2007. There are 1,532 observations on each price series. The original data were obtained from Yahoo Finance (2009) and transformed into natural logarithmic form. Only five firms are chosen due to data availability.

Cal-Maine Foods (CALM), an US egg producer and processor.

Sanderson Farms (SAFM), a US top 5 poultry producer and packer.

Tyson Foods (TSN), the biggest US producer and packer of chicken, beef and pork.

AFC Enterprises (AFCE), a US poultry-related restaurant owner that runs Popeye's Chicken and Biscuits restaurant in North America, Europe and Asia.

Industrias Bachoco (IBA), the biggest Mexican poultry producer and processor.

Among these five firms, only AFC Enterprises is a poultry food producer and others are poultry meat/eggs producers. Thus AFC Enterprises is a downstream firm of poultry meat/egg producers; other firms are upstream firms of poultry food producers.

This paper investigates the impacts of AI outbreaks in Asia and the US in the early 2004. The time window for Asian event is from 8 January 2004 to 10 February 2004, and the time window for the US event is from 11 February 2004 to 14 March 2004. after AI was found, the poultry exporting of those Asian countries and the US were banned to export poultry meat. These events provide a scenario to verify our results from the partial equilibrium model. In this scenario we can assume that between these two periods only international trade factor changes (the exporting is banned) and other factors were held constant. The detailed information on countries and dates of AI outbreaks during this time period is recorded in Appendix A. The AI virus found in Asia is H5N1, which is highly pathogenic and can kill both human beings and animals. The viruses found in US are H5N2 on 11 February 2004 and H7N2 on 23 February 2004. The prior virus is lowly pathogenic and only hurts poultry. The later one is highly pathogenic and can kill poultry, but not human beings. The first case of human death caused by H5N1 virus was announced on 11 January 2004 in Vietnam.

Empirical Results

Results of Simple Statistics and ECM Model

These five stock prices and the Standard and Poor 500 index (S&P500) are plotted over the period 1 June 2001 through 16 April 2007 in Figure 3. The plot of S&P500 gives us a simple image of the behavior of the whole US stock market during the period studied. In the figure the continuous curves denote the stock prices or market index; the discrete dots represent the declarations of AI outbreak in countries. Figure 1 does not show obvious linkages between stock prices and AI outbreaks. Thus this study builds models to explore their linkages.

Table 2 contains the descriptive statistics of daily returns of these five stocks and S&P500 index. Industrias Bachoco has the highest average daily returns and the lowest coefficient variation among this price sample. Cal-Maine Foods has the highest standard deviations and the second highest average daily return. AFC Enterprises has the second highest standard deviation and coefficient variation. S&P500 has the lowest average return and standard deviation, and the highest coefficient variation. These simple statistical results suggest that these five firms are marginally less risky than the S&P500 index. The following will check the time series properties of these five stock prices.

Table 3 presents both Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests on the null hypothesis that the stock price under study is non-stationary. Both of these tests imply the five stock price series are non-stationary in levels as the calculated t-statistic is greater than the 95% critical value of -2.98 in every case. The first difference series of prices appear to be stationary in term of the 95% critical value for all stocks. The residuals from these nonstationary tests show no serious serial correlations under the augmented tests, as their Q-statistics are below the 5% critical value.

Table 4 helps to decide the optimal lag number of VAR model in this study. This table provides Schwartz information criterion (SIC) and Hannan and Quinn's Φ measures (Φ) on alternative lag lengths from the unrestricted VAR fit to these five series in levels. The search of lag length is over the lags of zero through ten periods. Both SIC and Φ reach their lowest values in a level VAR with one lag. Thus one lag is considered to be the optimal lag number for VAR in levels in this study.

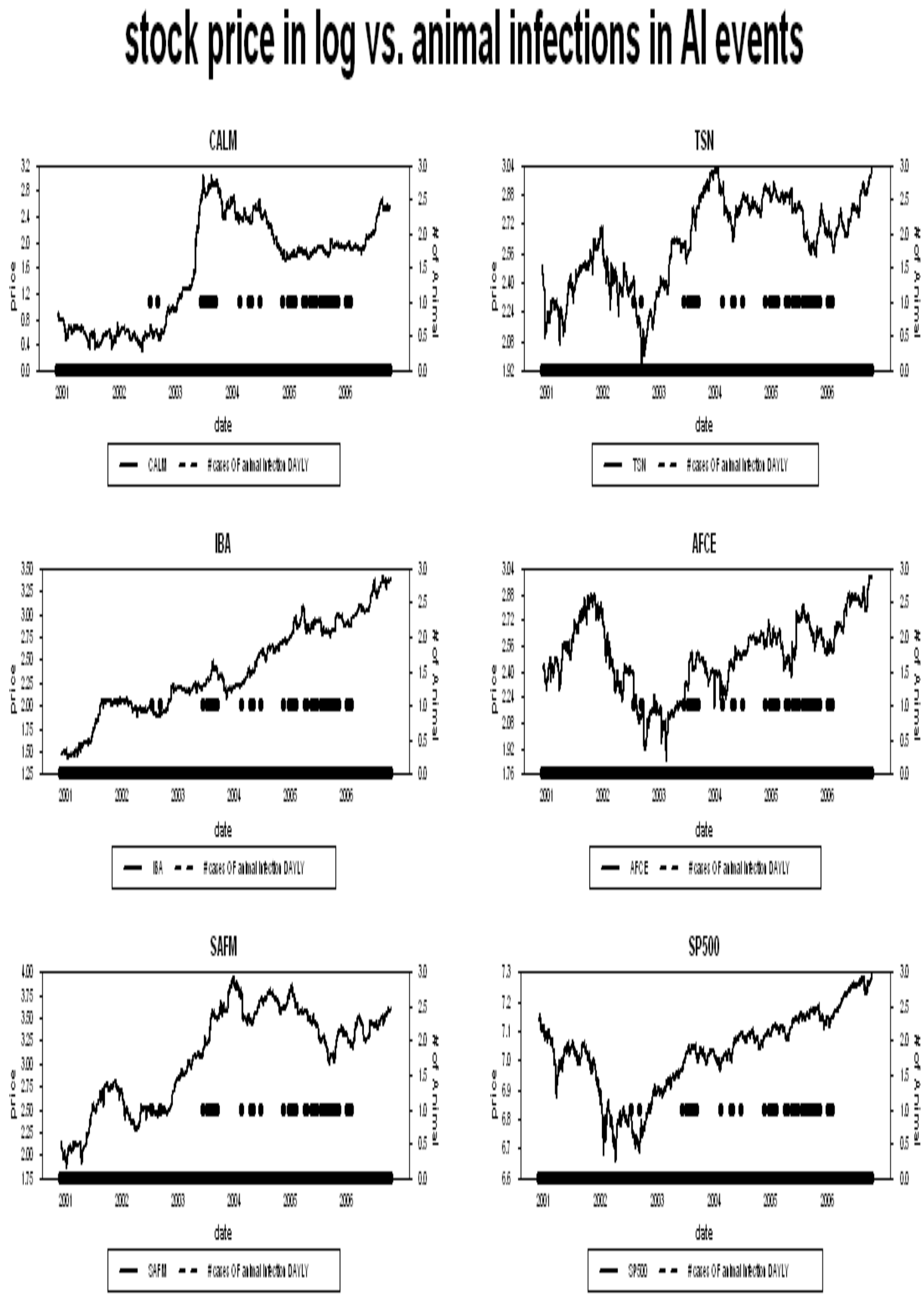


Figure 3. Plots of daily human death and daily stock prices for five poultry related firms publicly traded in US stock markets, 06/01/2001–04/16/2007

Table 2. Summary Statistics on Daily S&P500 Index and Daily Stock Return for Five Poultry Related Firms Publicly Traded in US Stock Markets, 06/01/2001–04/16/2007

Firms	Mean (%)	Mean Rank	SD (%)	SD Rank	CV	CV Rank
S&P500	0.010	6	1.00	6	100	1
AFCE	0.036	4	2.683	2	74.53	2
CALM	0.111	2	3.351	1	30.19	4
IBA	0.124	1	1.634	5	13.18	6
SAFM	0.099	3	2.402	3	24.26	5
TSN	0.036	4	2.119	4	58.86	3

Note: The entries in the column labeled 'Mean' refer to the mathematic average of daily stock return for each firm listed in the far left-hand-most column over the period under study. The column headed by the letter 'SD' gives the standard deviation of daily stock return for the firm interested. The column headed CV give the coefficient of variation, calculated as standard deviation/mean for each firm. The rank on means, standard deviations and coefficients of variation are with respect to the six series listed here and are in the order of highest (1) to lowest (6).

Table 3. Tests for Non-stationarity of Levels and First Differences of Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 06/01/2001–04/16/2007

Firms		Dickey –Fuller Test (DF)		Augmented Dickey Fuller Test (ADF)	
		t-statistics	Q(3)-statistics (p-value)	t-statistics (k)	Q(3)-statistics (p-value)
Levels of each series	AFC	-1.83	13.66 (0.003)	-1.47 (2)	0.02 (0.999)
	CALM	-0.57	7.63 (0.054)	-0.65 (1)	6.91 (0.075)
	IBA	-0.38	5.95 (0.114)	-0.35 (1)	2.93 (0.402)
	SAFM	-1.59	6.65 (0.084)	-2.10 (1)	5.16 (0.161)
	TSN	-1.31	0.96 (0.810)	-1.58 (1)	0.60 (0.896)
First differences of each series	AFC	-41.84	9.07 (0.028)	-30.59 (1)	0.05 (0.997)
	CALM	-39.98	6.77 (0.079)	-21.51 (2)	0.03 (0.998)
	IBA	-37.48	2.83 (0.418)	-25.72 (1)	0.60 (0.896)
	SAFM	-39.16	6.59 (0.086)	-25.88 (1)	0.31 (0.958)
	TSN	-38.44	0.41 (0.938)	-26.87 (1)	0.003 (1.000)

Table 4. Loss Metrics on the Order of Lags (k) in a Log-levels Vector Autoregression on Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 06/01/2001–04/16/2007

Lag = k	**SIC**	**Φ**
0	-13.84	-13.85
1	-37.48*	-37.54*
2	-37.37	-37.49
3	-37.28	-37.45
4	-37.17	-37.40
5	-37.07	-37.36
6	-36.97	-37.31
7	-36.87	-37.26
8	-36.77	-37.23
9	-36.67	-37.18
10	-36.57	-37.13

Note: Metrics considered are Schwarz-loss (SL) and Hannan, and Quinn's M measure on lag length of a levels vector autoregression:

$$SIC = \log (|\Gamma| + (5k) (\log T) / T,$$

$$M = \log (|\Gamma| + (2.01)* (5k) \log (\log T)) / T$$

where Γ is the error covariance matrix estimated with 8k + 1 (the 1 represents a constant) regressors in each equation, T is the total number of observations on each series, the symbol " | | " denotes the determinant operator, and log is the natural logarithm. We select that order of lag that minimizes the loss metric.
The asterisk("* ") indicates minimum.

Table 5. Tests of Cointegration Rank among Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 06/01/2001–04/16/2007

R	P-R	T*	C (5%)*	D*
0	5	76.10	75.74	R
1	4	36.05	53.42	F#
2	3	14.56	34.80	F
3	2	6.36	19.99	F
4	1	1.32	9.13	F

Note:

1) The trace test statistics from an ECM model of these five stocks with the first difference of SP500 index as exogenous variables.

2) The number of cointegrating vectors (r) is tested using the trace test with the constant within and outside the cointegrating vectors. The test statistic (T) is the calculated trace test, associated with the number of cointegrating vectors given in the left-hand-most column. The critical values (C(5%)) are taken from Table B.2 (within) and Table B.3 (outside) in Hansen and Juselius (1995, p.80-81). The tests results presented in columns marked by an asterisk are associated with a constant within the cointegrating vectors. The column labeled "D*" gives our decision to reject (R) or fail to reject (F), at a 5 per cent level of significance, the null hypothesis of the number of cointegrating vectors ($r=0$, $r \leq 1, \ldots, r \leq 5$). Following Johansen (1992), we stop testing at the first "F" (failure to reject) when starting at the top of the table and moving sequentially across from left to right and from top to the bottom. The symbol (#) indicates the stopping point. Here we fail to reject the hypothesis that we have one cointegrating vectors with constants in the cointegrating vectors. Recent work on the selection of the number of cointegrating vectors has focused on the use of information criteria (AIC or Schwarz loss). Such criteria can be successfully applied to solve both the lag length and rank problem; see Kapetanios (2003) and Aznar and Salvador (2002).

Table 5 provides the trace test statistics on the rank of Π from Equation 4. These five stock prices work as dependent variables in Equation 4, the S&P500 index as an exogenous variable. This test examines both the number of cointegration vectors and the placement of constant in the ECM model (Johansen, 1991, 1992). The test procedure is described briefly in the footnote to Table 5. The null hypothesis of cointegration test first fails to be rejected at the zero rank when the test statistic equal 64.68 less than the 95% critical value of 68.68. This test result indicates the rank equals one -- there is one cointegration relation among these five stock price series. The conclusion of one rank needs to be made with great caution because there is an exogenous variable of the first difference of SP500 index in the test model of ECM.

Table 6 helps to further examine the cointegration rank of ECM model. This table compares the Schwartz information criterion (SIC) and Hannan and Quinn's Φ measures (Φ) between a difference VAR model and an ECM model with one rank. Both SIC and Φ from the ECM model are less than those values from the VAR model. This comparison indicates the ECM model with one rank is more appropriate for these five price series other than the difference VAR model is. Thus the optimal rank of ECM model is one. One rank implies that there is a long-run equilibrium among these five stock prices or its subgroup. What's more, one cointegration rank indicates that the matrix of Π can be represented as $\Pi = \alpha\beta'$, where α is a one by five vector of adjustment speed and β is a one by five vector describing the long-run equilibrium of these five price series.

Table 6. Model Choice between Vector Autoregression Model and Vector Error Correction Model for Daily Stock Prices Five Poultry Related Firms Publicly Traded in US Stock Markets, 06/01/2001–04/16/2007

Model	SIC	Φ
VAR	-37.56	-37.63
VEC with one rank	-37.61*	-37.71*

Note: Metrics considered are Schwarz-loss (SL) and Hannan, and Quinn's M measure on lag length of a levels vector autoregression:

$$\text{LogDET} = \log(|\Gamma|)$$

$$\text{SIC} = \log(|\Gamma| + (5\,k)(\log T) / T,$$

$$M = \log(|\Gamma| + (2.01)^{*} (5k) \log(\log T)) / T$$

where Γ is the error covariance matrix estimated with 5k + 1 (the 1 represents a constant) regressors in each equation, T is the total number of observations on each series, the symbol " | | " denotes the determinant operator, and log is the natural logarithm. We select that order of lag that minimizes the loss metric.
The asterisk("* ") indicates minimum.

Table 7. Schwarz Information Criterion and Hannan and Quinn's Φ on One to Four Cointegration Rank and One to Five Lags on ECM Model for Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 06/01/2001–04/16/2007

	One-lag		Two- lags		Three-lags		Four-lags	
	SIC	Φ	SIC	Φ	SIC	Φ	SIC	Φ
Rank=1	-37.71*	-37.75*	-37.69	-37.75	-37.67	-37.74	-37.65	-37.73
Rank=2	-37.61	-37.71	-37.59	-37.70	-37.57	-37.69	-37.55	-37.68
Rank=3	-37.51	-37.66	-37.49	-37.66	-37.47	-37.65	-37.45	-37.64
Rank=4	-37.40	-37.61	-37.38	-37.61	-37.37	-37.60	-37.35	-37.59
Rank=5	-37.26	-37.56	-37.30	-37.58	-37.28	-37.57	-37.26	-37.56

Note: Metrics considered are Schwarz-loss (SL) and Hannan, and Quinn's M measure on lag length and number of rank for an VEC model:

$$SIC = \log (|\Gamma| + (5\ k)\ (\log T) / T,$$

$$M = \log (|\Gamma| + (2.01)^{*}\ (5k) \log (\log T)) / T$$

where Γ is the error covariance matrix estimated with 5k + 1 (the 1 represents a constant) regressors in each equation, T is the total number of observations on each series, the symbol " | | " denotes the determinant operator, and log is the natural logarithm. We select that order of lag that minimizes the loss metric.
The asterisk("* ") indicates minimum.

Table 8. Tests on Exclusion from the Cointegration Space for Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 06/01/2001–04/16/2007

Firm	Beta	Chi-squared test	P-value	Decision
AFCE	1.00	18.52	0.00	R
CALM	-0.004	0.00	1.00	F
IBA	-0.34	9.50	0.00	R
SAFM	1.01	14.50	0.00	R
TSN	-2.01	20.20	0.00	R

Note: Tests are on the null hypothesis that the particular series listed in the far-left-hand column is not in the cointegration space. The heading 'decision' relates to the decisions t to reject (R) or fail to reject (F) the null hypothesis at a 5% level of significance. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom (exclusion from the entire cointegration space would imply one restriction, as , based on results from Table 5, we have one cointegration vector).

Recent work focuses on the use of information criterion to select of number of cointegration vectors (Chao and Phillips, 1999; Wang and Bessler, 2005; Baltagi and Wang, 2006). In Table 7 this study applies the cointegration rank search method discussed in Bessler and Wang (2005). Table 7 represents information criterion statistics on jointly selecting the lag length and cointegration rank. The SIC minimum of -37.71 appears in ECM model of one lag and one rank, as does the Φ minimum of -37.75. This result of rank and lag selection is consistent with the combined results of Table 4 and Table 6. This method avoids the problem the trace test meets in this study.

Table 8 gives the results of the exclusion tests. The null hypothesis of this test is that the firm listed in the table is not in the cointegration space. The exclusion test is distributed chi-squared with one degree of freedom. This study rejects the null hypothesis for Cal-Maine Foods at 5% significance level, while it fails to reject the null hypothesis for other firms at the same level. This test result indicates that the long-run equilibrium consists of Industrias Bachoco, Sanderson Farms, Tyson and AFC Enterprises. These four firms in equilibrium are running business related to poultry meat. Cal-Maine Foods is a business related to eggs, not related to poultry meat. The exclusion of Cal-Maine Foods is reasonable. AFC Enterprises and Sanderson Farms have the positive signs of beta value, contrary to those signs of Tyson Foods and Industrias Bachoco.

The tests of weak exogeneity are presented in Table 9. The null hypothesis of this test is that each stock listed in Table 9 does not respond to deviations from the long run equilibrium. The likelihood ratio test statistics on these restrictions is distributed chi-squared with one degree of freedom (as we are placing a zero associated with firm j in the α vector). At a 5% significance level, the hypotheses for AFC Enterprises, Tyson Foods and Industrias Bachoco are rejected, while for both Sanderson Farms and Cal-Maine Foods we fail to reject this hypothesis. This test result indicates that both Sanderson Farms and Cal-Maine Foods do not respond to the disequilibrium while AFC Enterprises Tyson Foods and Industrias Bachoco do. Further this result suggests Sanderson Farms moves first when a shock hit the stock market while, AFC Enterprises, Tyson Foods and Industrias Bachoco move and respond to the disequilibrium among them. The alpha value corresponding to Tyson Foods is 0.012, about twice as big as the value of Industrias Bachoco. The alpha value of AFC Enterprises is 0.009, one and half times greater than the value of Industrias Bachoco.

The statistic results from Table 8 and Table 9 show Cal-Maine Foods is not part of the long run equilibrium. This implies that Cal-Maine Foods is not related to the long run equilibrium among the other four firms or this study omits some firms which can form new long-run equilibriums with Cal-Maine Foods and those four firms. The ECM model also offers an alternative to tests on the null of nonstationarity in Table 3. Table 10 presents this alternative test, whose null hypothesis is that the series is stationary. Conditional on one cointegration vector suggested by Tables 6 and 7, this hypothesis actually is a test of zero restrictions on four beta coefficients on the cointegration vector. Under the null hypothesis the test statistic is distributed chi-squared with four degrees of freedom. The null of stationarity is rejected for each series under a 5% significance level. Thus all the price series are nonstationary in levels. This result is consistent with the results from Table 3.

Table 9. Tests on Weak Exogeneity from the Cointegration Space for Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 06/01/2001 – 04/16/2007

Firm	Alpha	Chi-squared test	P-value	Decision
AFCE	-0.009	5.05	0.02	R
CALM	-0.008	2.16	0.14	F
IBA	0.006	6.60	0.01	R
SAFM	-0.004	0.59	0.44	F
TSN	0.012	12.83	0.00	R

Note: Tests are on the null hypothesis that the particular series listed in the far left hand column is weakly exogenous, i.e., that series does not respond to perturbations in the cointegration space. The heading ‘Decision’ relates to the decision to reject (R) or fail to reject (F) the null hypothesis at a 5% level of significance. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom. The null hypothesis, that firm does not respond, implies one zero restriction (on the alpha matrix of the error correction representation, see text

Table 10. Tests on Stationarity from the Cointegration Space for Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 06/01/2001–04/16/2007

Firm	Chi-squared test	P-value	Decision
AFCE	32.01	0.000	R
CALM	37.26	0.000	R
IBA	35.09	0.000	R
SAFM	32.99	0.000	R
TSN	33.19	0.000	R

Note: Tests are on the null hypothesis that the particular series listed in the far-left-hand column forms a stationary vector. That is, tests are on the null hypothesis that the single cointegration vector arises because one of the individual series is itself stationary (the series listed in the left-hand-most column is stationary in its level). Under the null hypothesis, the test statistic is distributed chi-squared with four degree of freedom. The heading ‘Decision’ relates to the “decision’ to reject (R) or fail to reject (F), at a 5% level of significance, the null hypothesis of stationarity of the series listed in the far-left-hand column of the table. Tests of the null hypothesis of nonstationarity agree with the tests reported here. Applying an approximate 5% critical value of -2.86 (reject the null for t-ratios < -2.8), this study fails to reject the null hypothesis of nonstationarity for each series. The reference is to read Table 3.

The estimated ECM model is represented as follows:

(2.9)

$$\begin{bmatrix} \Delta P_{CALM} \\ \Delta P_{IBA} \\ \Delta P_{SAFM} \\ \Delta P_{TSN} \\ \Delta P_{AFCE} \end{bmatrix}_t = \begin{bmatrix} -0.008 \\ 0.006 \\ -0.004 \\ 0.012 \\ -0.009 \end{bmatrix} \begin{bmatrix} -0.004 & -0.34 & 1.01 & -2.01 & 1.00 \end{bmatrix} \begin{bmatrix} P_{CALM} \\ P_{IBA} \\ P_{SAFM} \\ P_{TSN} \\ P_{AFCE} \end{bmatrix}_{t-1}$$

$$+ \begin{bmatrix} 0.25 & -0.002 \\ 0.15 & 0.004 \\ 0.58 & -0.001 \\ 0.63 & 0.006 \\ 0.68 & -0.004 \end{bmatrix} \begin{bmatrix} \Delta P_{SP500} & 1 \end{bmatrix}_{t-1} + \varepsilon_t \qquad t = 1, \cdots, T.$$

Results of Directed Acyclic Graphs

As discussed earlier, the innovation generated from the ECM model of Equation (4) is used to study the contemporaneous causal relations of innovations through the directed acyclic graphs (DAGs). Equation (10) gives the contemporaneous correlation between innovations in each of these five stock prices in the order: Cal-Maine Foods, Industrias Bachoco, Sanderson Farms, Tyson Foods and AFC Enterprises.

$$\begin{matrix} & CALM & IBA & SAFM & TSN & AFCE \end{matrix}$$

(2.10)

$$Corr(\hat{\varepsilon}_t) = \begin{bmatrix} 1.000 & & & & \\ 0.055 & 1.000 & & & \\ 0.065 & 0.042 & 1.000 & & \\ 0.034 & 0.027 & 0.168 & 1.000 & \\ -0.046 & 0.049 & 0.021 & 0.034 & 1.000 \end{bmatrix}$$

The strongest correlation of 0.168 is between Sanderson Farms and Tyson Foods. It does make sense because they are competitors for each other in the poultry meat industry. The correlation between Cal-Maine Foods and AFC Enterprises is negative. Other correlations fall in the range from 0.02 to 0.07 with positive signs.

In term of the correlation matrix in Equation (10), DAGs explores contemporaneous causation flow among these five stock prices through PC algorithm. The result of DAGs is shown in Figure 4. This figure shows that the directions are not determined between Sanderson Farms and Cal-Maine Foods and between AFC Enterprises and Industrias Bachoco at 10% significance level. DAGs' results at 3% and 5% significance level (in Appendix B and C) help to find that innovation in Cal-Maine Foods causes innovation in Sanderson Farms, and innovation in AFC enterprises causes innovation in Industrias Bachoco. Thus in this causal structure, there are two information sources -- Tyson Foods and AFC Enterprises, and only one information sink -- Sanderson Farms. Sanderson Farms receives market shocks from other four firms, and has no influence on others. Two information transmission paths are discovered:

AFC Enterprises → Industrias Bachoco → Cal-Maine Foods → Sanderson Farms ← Tyson Foods.

Historical Decomposition's Results

This study further carries out the historical decomposition analysis in terms of the contemporaneous information transmission path and the estimated model in Equation (9). These results of decomposition analysis are presented in Table 11 and Figures 5 to 9.

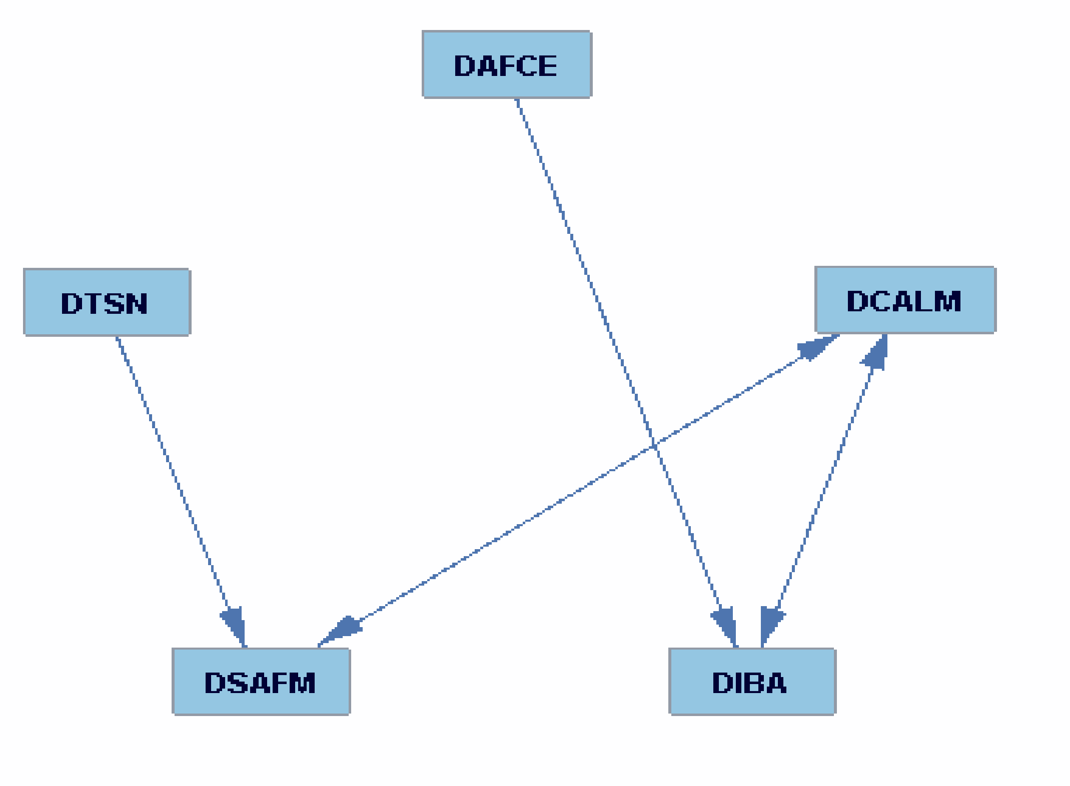


Figure 4. Pattern found with PC algorithm with its P-value = 0.10 on innovations from a VEC model on daily stock prices for five poultry related firms publicly traded in US stock markets, 06/01/2001-04/16/2007

Table 11. The Period Effect of AI Outbreaks in Asia from 8 January 2004 to 10 February 2004 and in USA from 11 February 2004 to 15 March 2004.

	Jan.8-Feb.10 (Asia)	Jan.8 – Feb.10 (Asia)	Feb.11 – Mar.15 (USA)	Feb.11 – Mar.15 (USA)
Firm	Price growth rate	Average daily return rate	Price growth rate	Average daily return rate
CALM	17.01%	1.18%	-13.06%*	-0.52%*
IBA	14.26%	0.59%	-7.48%	-0.33%
SAFM	37.32%	1.43%	-9.62%	-0.42%
TSN	23.07%	0.94%	0.12%	0.02%
AFCE	12.90%	0.61%	10.47%	0.44%

Note:

(a) Price growth rate = (stock price at starting date)/(stock price at end date)-1.

(b) Daily return rate = (stock price at t – stock price at t-1)/stock price at t-1.

(c) * denotes the period from 17 February 2004 to 15 March 2004.

The historical decompositions display the evolution of AI outbreak shocks through the system using graphs. Each figure has five sub-graphs. Each sub-graph shows three series of price: actual price projected (forecasted) price, and contribution from each individual firm over the period of decomposition analysis. These three series are derived from Equation (3). The actual price for each stock is in black solid line, the projected price in blue line, and the contribution from an individual firm in green line. This actual price is plotted the same across each of the five sub-graphs of any figure. So is this projected price. The contributions from each individual firm are plotted in the sub-graphs respectively. This study also adds a vertical line in these figures, indicating the first date of AI outbreaks.

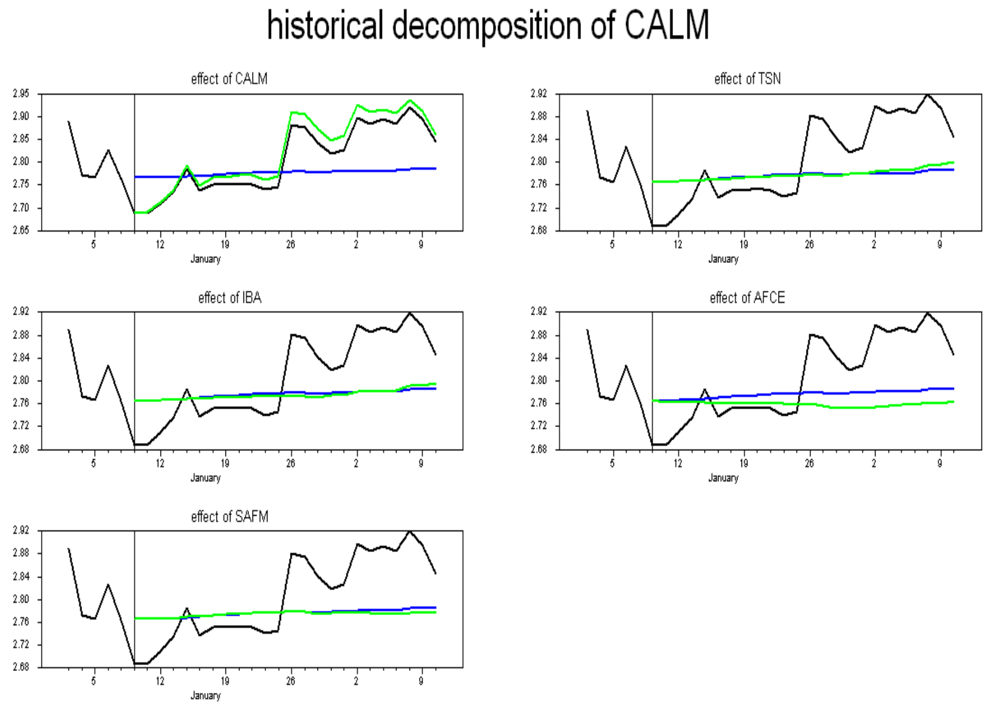
Table 11 and Figures 5 to 9 describe the impacts of AI outbreaks in Asia on these five stock prices. Figure 5 represents the decomposition for the stock price of Cal-Maine Foods in the logarithm form. In this figure the stock price of Cal-Maine Foods has a rising trend following the first Asian AI outbreak. During the period of Asian events, its stock price growth rate and average daily return equal 17.01% and 1.18% respectively shown in Table 11. Thus, generally the AI outbreaks in Asia raised the stock price of Cal-Maine Foods. This finding is consistent with the theoretical impacts of AI outbreaks summarized in Table 1. This figure also shows AFC Enterprises had more negative effect on Cal-Maine Foods than other firms did.

Figure 6 provides the decompositions for Industrias Bachoco. In this figure its actual price has a growing-up trend following the first AI outbreak in Asia. Its actual price has a growth rate of 14.26% and an average daily return of 0.59% shown in Table

11. Thus, generally the AI outbreaks in Asia raised the stock price of Industrias Bachoco. This finding is consistent with the theoretical impact of AI outbreaks in Table 1. Figure 6 also shows that AFC Enterprises had more positive influence on Industrias Bachoco than others did.

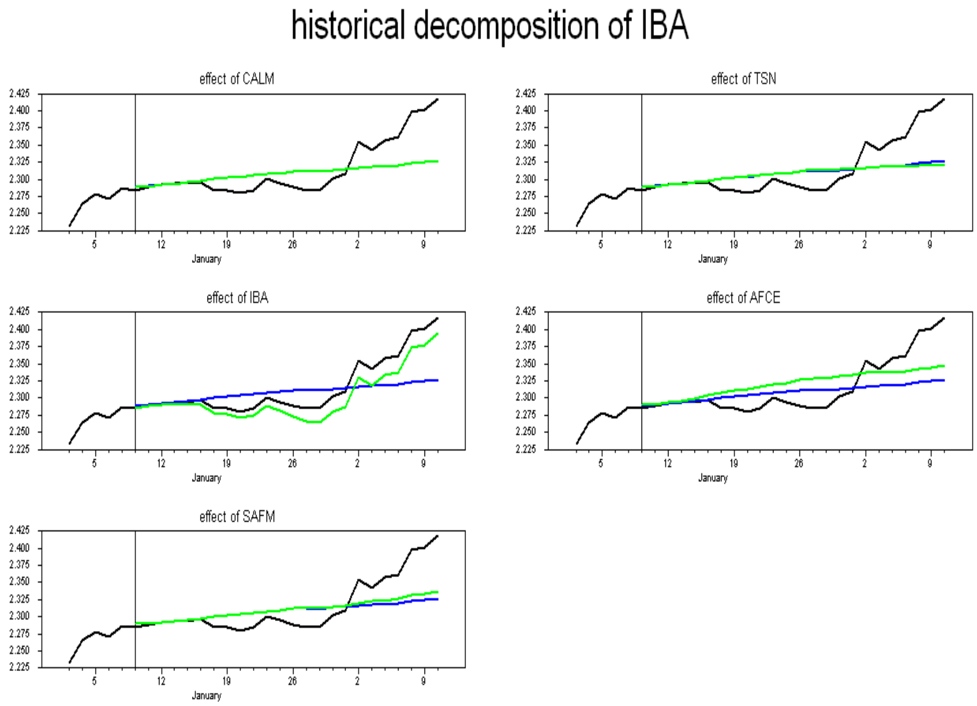
Figure 7 gives the decompositions for Sanderson Farms. Sanderson Farms has a rising trend of price following the first AI outbreak in Asia. Its growth rate and average daily return equal 37.32% and 1.43% during the Asian outbreak period, shown in Table 11. Thus, generally the AI outbreaks in Asia raised the stock price of Sanderson Farms. This finding is consistent with the theoretical results in Table 1. Moreover, Tyson Foods have more big positive effect on Sanderson Farms in term of Figure 7.

Figure 8 shows the decompositions for Tyson Foods. Tyson Foods has the similar story to Sanderson Farms. Its price growth rate and average daily return equal 23.07% and 0.94% during the Asian outbreak period, shown in Table 11. Thus, generally the AI outbreaks in Asia raised the stock price of Tyson Foods. This finding is consistent with the theoretical impact of AI outbreaks in Table 1. Moreover, AFC Enterprises had more positive influence on Tyson Foods than other firms did in Figure 8.



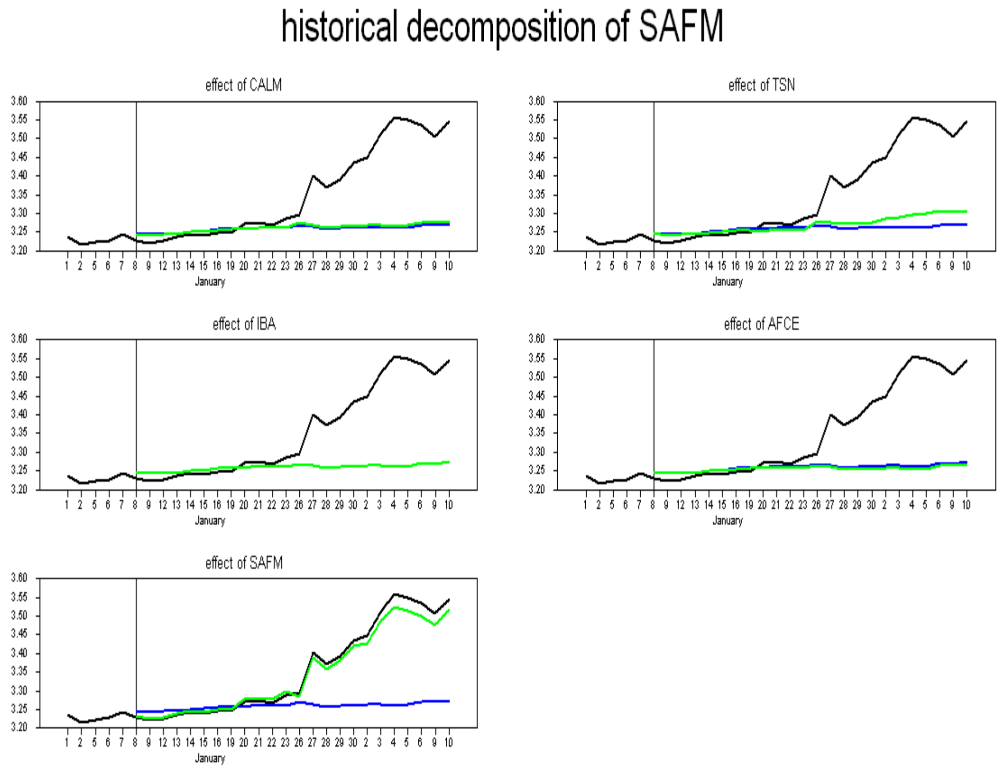
Note: each panel gives the projection of the stock price of Cal-Maine Foods ( ), the contribution of shocks in the series given in the panel label to the stock price of Cal-Maine Foods ( ), and the actual price of Cal-Maine Foods ( ). The vertical shades denote the dates of AI outbreaks

Figure 5. Plots of historical decompositions of Cal-Maine Foods from 8 January 2004 to 10 February 2004



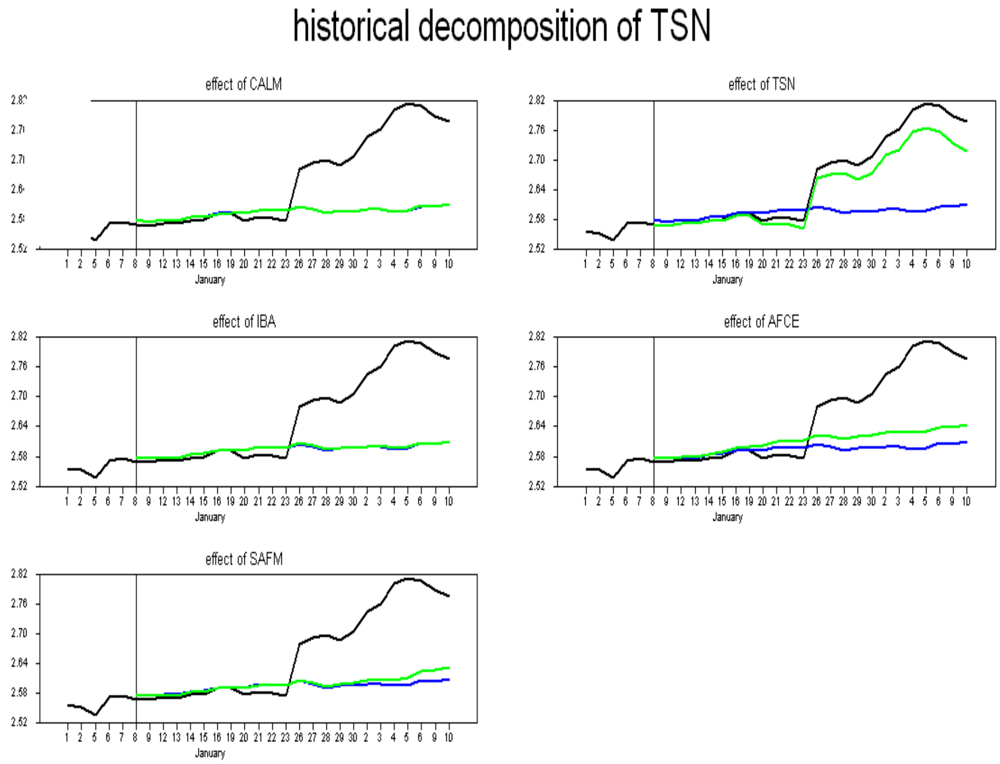
Note: each panel gives the projection of the stock price of Industrias Bachoco ( ), the contribution of shocks in the series given in the panel label to the stock price of Industrias Bachoco ( ), and the actual price of Industrias Bachoco ( ). The vertical shades denote the dates of AI outbreaks

Figure 6. Plots of historical decompositions of Industrias Bachoco from 8 January 2004 to 10 February 2004



Note: each panel gives the projection of the stock price of Sanderson Farms ( ), the contribution of shocks in the series given in the panel label to the stock price of Sanderson Farms ( ), and the actual price of Sanderson Farms ( ). The vertical shades denote the dates of AI outbreaks

Figure 7. Plots of historical decompositions of Sanderson Farms from 8 January 2004 to 10 February 2004



Note: each panel gives the projection of the stock price of Tyson Foods ( ), the contribution of shocks in the series given in the panel label to the stock price of Tyson Foods ( ), and the actual price of Tyson Foods ( ). The vertical shades denote the dates of AI outbreaks

Figure 8. Plots of historical decompositions of Tyson Foods from 8 January 2004 to 10 February 2004

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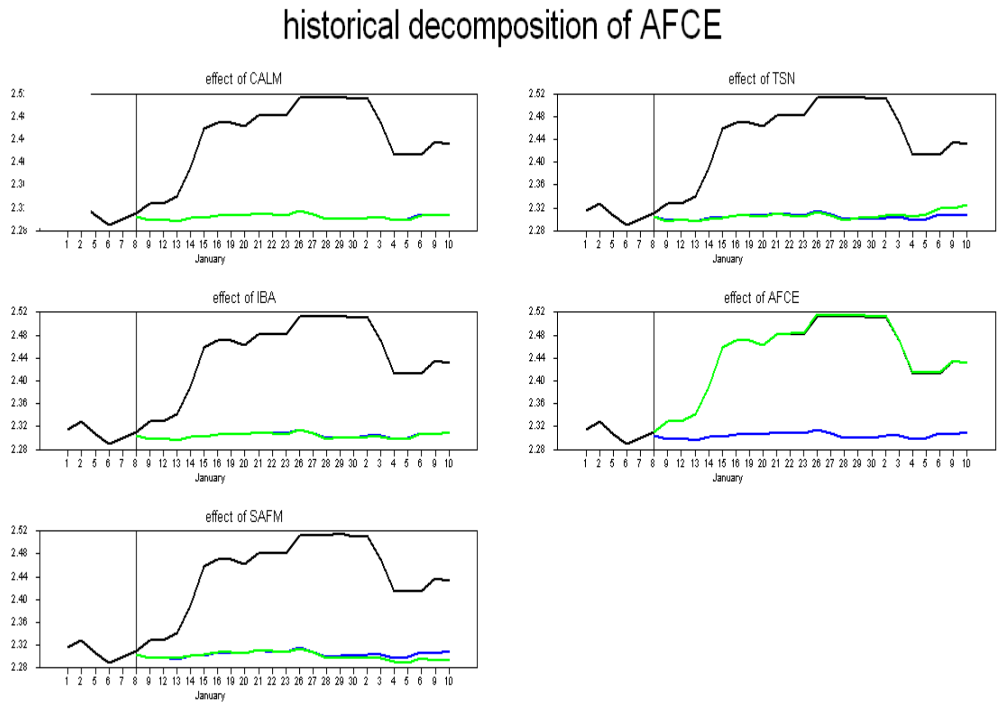


Note: each panel gives the projection of the stock price of AFC Enterprises ( ), the contribution of shocks in the series given in the panel label to the stock price of AFC Enterprises ( ), and the actual price of Enterprises ( ). The vertical shades denote the dates of AI outbreaks

Figure 9. Plots of historical decompositions of AFC Enterprises from 8 January 2004 to 10 February 2004

Figure 9 shows the decompositions for AFC Enterprises. AFC Enterprises has positive trend of price following the AI outbreaks in the graphs. Its price growth rate and average daily return equal 12.90% and 0.61% during the AI outbreak period in table 11. This finding seems not to be consistent with the theoretical result in Table 1. Considering AFC Enterprises has some of its own restaurants in those infected Asian countries, Thus, AFC Enterprises can be regarded as a firm in a country infected by AI virus to some degree. The price growth is consistent with the theoretical impact of AI outbreaks.

Table 11 and Figures 10 to 14 describe the impacts of AI outbreaks in the US on these five stock prices. Figure 10 shows the decomposition for the stock price of Cal-Maine Foods during AI outbreaks in the US. Cal-Maine Foods had a decreasing trend of stock price from 17 February 2004 to 15 March 2004 after the first US announcement of AI on 11 February 2004. Its growth rate and average daily return equal -13.06% and -0.52% respectively from 17 February 2004 to 15 March 2004, shown in Table 11. Thus, generally the AI event in the United States dropped the stock price of Cal-Maine during this period. This finding is consistent with the theoretical result in Table 1. Other firms almost have no effect on Cal-Maine Foods.

Figure 11 presents the decomposition for the stock price of Industrias Bachoco. The figure shows Industrias Bachoco had a decreasing trend following the first announcement of AI infection in the United States. The growth rate and average daily return of its stock equal -7.48% and -0.33% shown in Table 11. Thus, generally the AI events in the United States dropped the stock price of Industrias Bachoco. This finding is not consistent with the theoretical impact in Table 1. This inconsistence could be due to the close relation between US and Mexico, which could lead to a high probability of spreading the AI virus from US to Mexico and hitting Mexican poultry industry.

Figure 12 shows the decomposition for Sanderson Farms during the AI events in the United States. Its stock price has a decreasing trend following the first announcement of AI infection in the figure. Its growth rate of stock price and average daily return equal -9.62% and -0.42% shown in Table 11. Thus, generally the AI events in the United States dropped the stock price of Sanderson Farms. This finding is consistent with the theoretical impact in Table 1. Moreover, Sanderson Farms is negatively impacted by other firms, especially by Tyson Foods in term of Figure 12.

Figure 13 shows the decomposition for Tyson Foods during the AI events in the United States. In the figure the price curve of Tyson Foods looks like a valley. The price went down following the first announcement of AI infection, reached its lowest point on 24 February 2004, and then rose up to fluctuate around its projection. Its growth rate of stock price and average daily return are 0.12% and 0.02%, very close to zero, shown in Table 11. Thus, generally the AI events in the United States dropped the stock price of Tyson Foods from February 11 to February 24, and raised it after February 25. The first part of price decreasing is consistent with the theoretical impact in Table 1. The second part of price recovery could be due to the reason that Tyson Foods is not only one of the biggest poultry meat producers but also one of the biggest beef and pork producers. It can benefit from AI outbreaks. Moreover, other firms almost did not impact Tyson Firms.

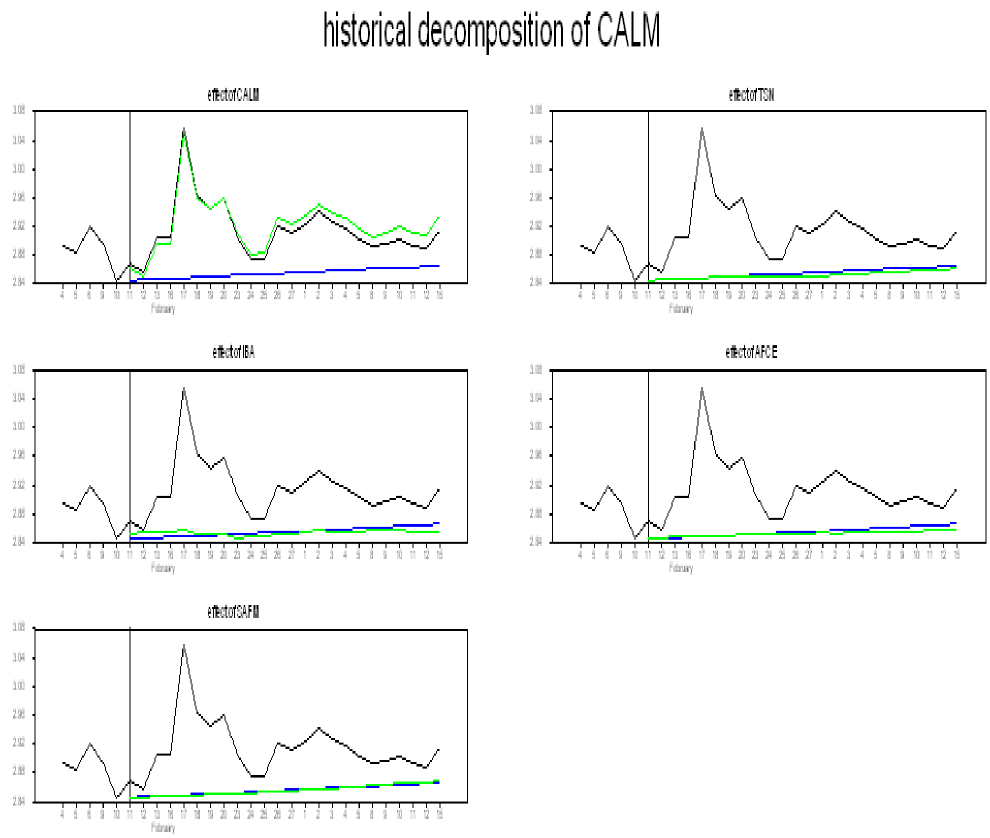


Figure 10. Plots of historical decompositions of Cal-Maine Foods from 11 February 2004 to 15 March 2004

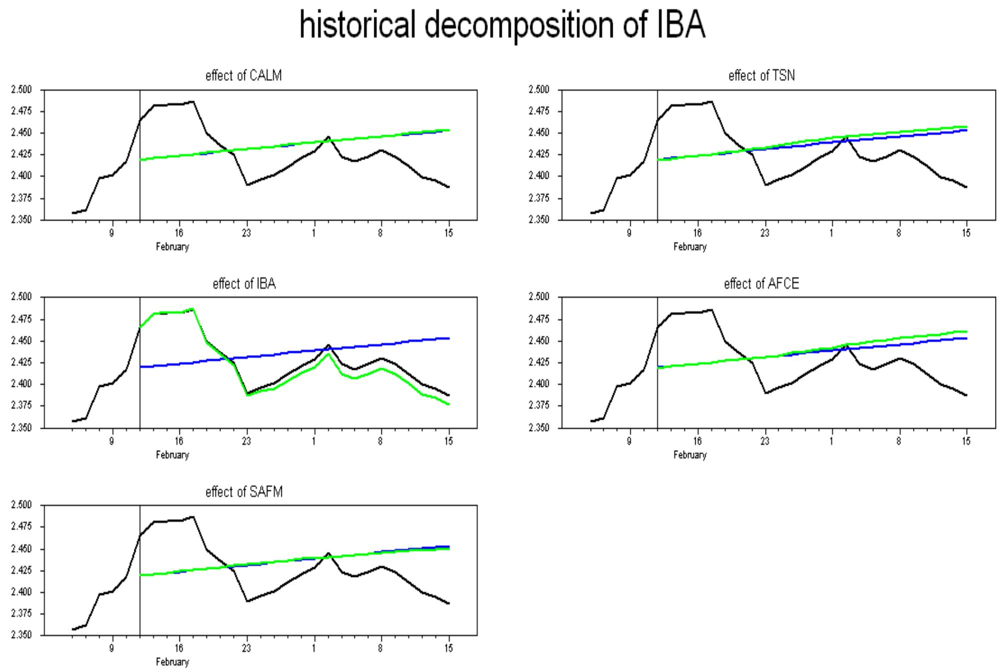


Figure 11. Plots of historical decompositions of Industrias Bachoco from 11 February 2004 to 15 March 2004

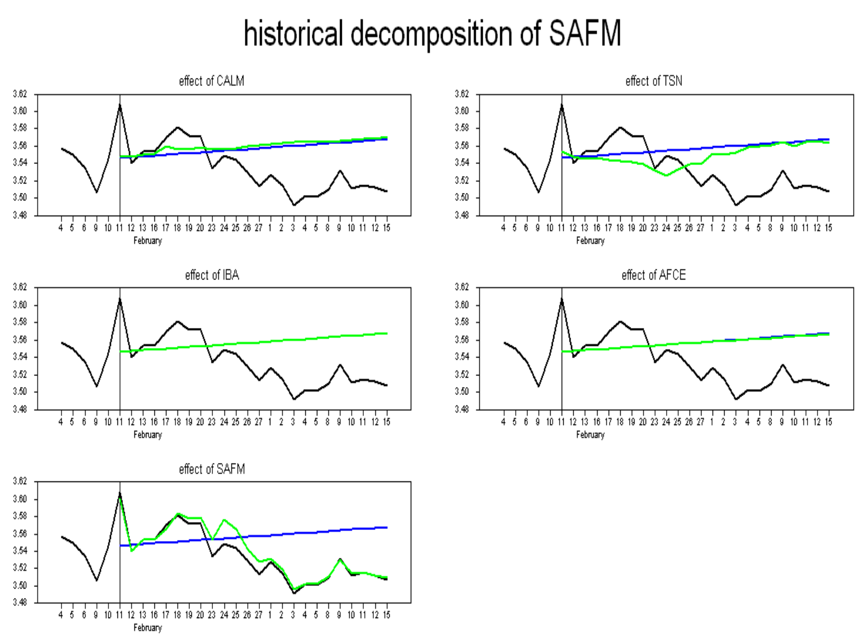


Figure 12. Plots of historical decompositions of Sanderson Farms from 11 February 2004 to 15 March 2004

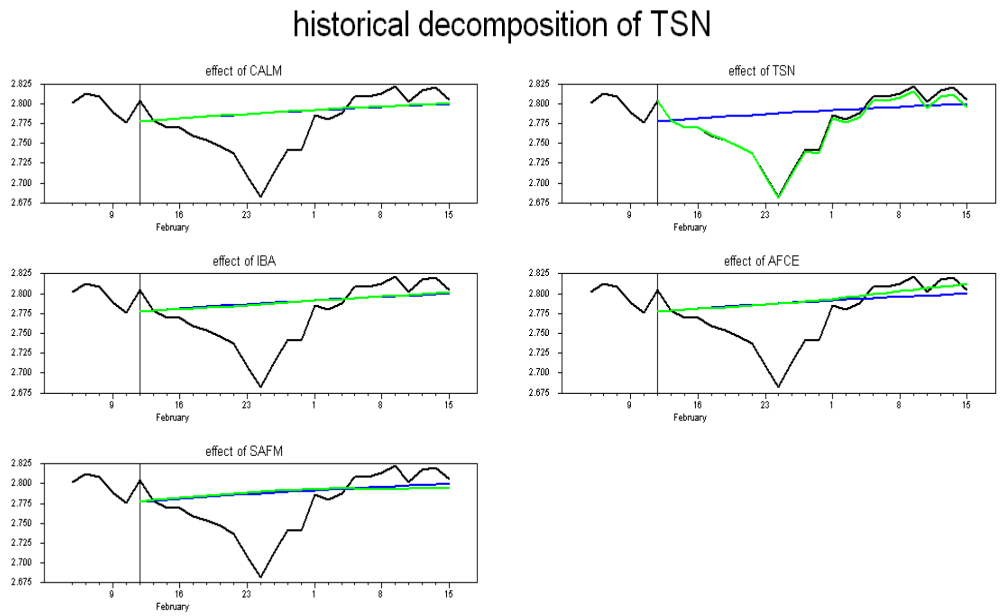


Figure 13. Plots of historical decompositions of Tyson Foods from 11 February 2004 to 15 March 2004

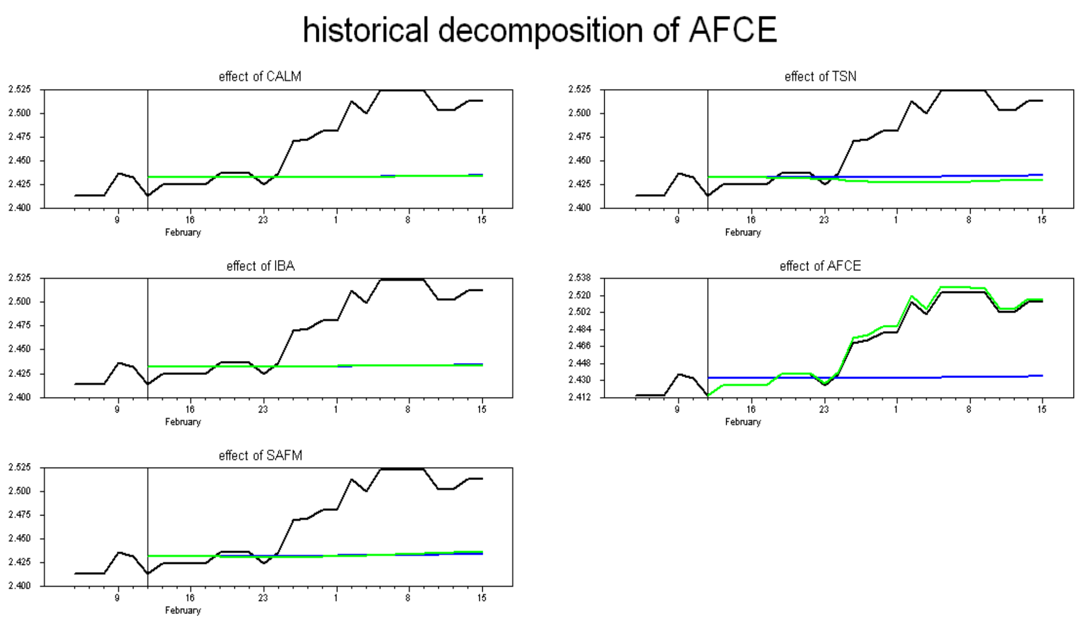


Figure 14. Plots of historical decompositions of AFC Enterprises from 11 February 2004 to 15 March 2004

Figure 14 presents the decomposition for AFC Enterprises during the AI events in the United States. AFC Enterprises had a growing trend of price following the first announcement of US AI infection. Its growth rate of price and average daily return are 10.47% and 0.44% shown in Table 11. Thus, the AI events in the United States raised the stock price of AFC Enterprises. This finding is consistent with the theoretical impact in Table 1. And other firm almost had no impacts on AFC enterprises.

The empirical impacts of AI outbreaks support the expected impacts of AI outbreaks we obtain in this study.

Conclusions

This paper explores the impact of AI events on some poultry-related stock prices. At first, this study employs the partial equilibrium analysis to deduce expected impacts of AI outbreaks inside or outside a poultry exporting country as they influence poultry meat or egg producers and poultry food producers; then it investigates how AI outbreaks in Asia and US affected five poultry-related firms publicly traded in the US stock market through the historical decomposition analysis and vector error correction model. Recent developments in search method of cointegration rank and directed graphs are applied in this study as well. Empirical results support the expected results: AI outbreaks inside the country drop stock prices of poultry meat producers and raise stock prices of poultry food producers; AI outbreaks in other poultry meat exporting countries raise stock prices of poultry meat producers and drop stock prices of poultry food producers. The change of international trade after AI outbreaks may cause the behavior changes of those firms' stock prices. This study is the first one to theoretically and empirically investigate the firm-level AI outbreaks impacts. It is the first one to employ the historical decomposition to analyze stock price behaviors. These findings have not been documented in previous literature.

This study has some other empirical findings on these five firms under study. First, this study finds a long-run equilibrium among these five firms. Tyson Foods, Sanderson Farms, Industrias Bachoco and AFC Enterprises are tied together by this dynamic equilibrium relation, whereas Cal-Maine Foods are excluded. That finding is reasonable because main products of the firms tied together are related to poultry meat while Cal-Maine is an egg producer, not a poultry meat producer. Second, Tyson Foods and Industrias Bachoco and AFC Enterprises respond to the deviations from their long-run equilibrium and make some adjustments. It looks that Sanderson Farms is a market leader, and Tyson Foods, Industrias Bachoco and AFC Enterprises are market followers when an outside shock affect these four stock prices. Third, the adjustment speed of Tyson Foods is about twice as big as the one of Industrias Bachoco; the speed of AFC enterprises is one and half times as big as the one of Industrias Bachoco. It could be that Tyson Foods and AFC Enterprises are US firms and more sensitive to the change of other related US firms. Finally, the contemporaneous causal structure is discovered among the five firms using the graphs analysis: Tyson Foods→Sanderson Farms; AFC Enterprises → Industrias Bachoco → Cal-Maine Foods → Sanderson Farms.

The findings of this study carry some important implications. First, this study provides evidence that AI outbreaks in different countries have significant different effects on stock price behaviors of poultry-related firms. Second, the model and its results in this study can be used to analyze the impacts of other animal diseases or food safety events on related firms. Finally, this study can help understand how the change of international trade affects stock prices of the related firms.

With respect to further research, this study only examines poultry-related firms. Actually the firms affected by AI outbreaks are not limited in poultry-related firms. More firms in other industries can be included into research target group, like medicine production, insurance and tourism.

CHAPTER III

DO AVIAN INFLUENZA OUTBREAKS CAUSE STRUCTURAL BREAKS OF COINTEGRATED VAR MODEL?

This essay extends the first one and examine whether the AI causes multiple structural changes in a cointegrated vector autoregressive model (Cointegrated-VAR) of stock prices assuming unknown break dates.

Hansen and Johansen (1999) and Seo (1998) studied some structural change tests for one break point in cointegrated-VAR model with an unknown break date. Hansen (2003) did the multiple-break test with known break dates. And Bai (2000) and Qu and Perron (2007) provided the break date estimation method of multiple structural changes in VAR or multiple equation system with unknown break dates and without cointegrating variables in models. Awokuse, Chopra and Bessler (2009) used rolling cointegration test to examine the cointegration rank change with unknown change dates. Thus this article is the first one to compute break dates in cointegrated-VAR model with multiple breaks and unknown break dates.

This article finds two break points, 20 March 2003 and 08 March 2005. These break points divide the whole sample into three parts. Comparing the long run, short run and contemporaneous relationship of the data sample in each sub-period, this study proves these three sub-sample are significantly different along with discussion on models in each sub-period. The avian influenza outbreaks are not the events to cause breaks. Invading Iraq on 20 March 2003 and Banning Canadian live cattle from entering the US could be the most possible event to cause these two breaks.

The remainder of this essay is organized as follows. The section provides empirical research methodology. The third part describes the data and events of avian influenza outbreak. The fourth section presents empirical results of the structural changes. Conclusions are offered in the last section.

Research Methodology

The Statistical Model

The cointegrated VAR model, or ECM, with constant coefficients is expressed as follow:

(3.1) $$\Delta P_t = \alpha\beta' P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \Phi D_t + \varepsilon_t \qquad t = 1, \ldots, T,$$

Here P_t is a vector of n variables under study; Δ is the difference operator ($\Delta P_t = P_t - P_{t-1}$); Both α and β are ($n \times r$) matrices; Γ are $n \times n$ parameter matrix; D_t is a vector of deterministic variables such as a constant, linear trend, seasonal or intervention dummies, and exogenous variables; Φ is a parameter matrix of D_t; and ε_t is a vector of innovation (error) terms with $iid(0, \Omega)$ and a ($n \times n$) covariance matrix Ω.

Following Hansen (2003), this work assumes that there are m break points during the studied time period: $T_1, \ldots, T_m$, where $0 < T_1 < \cdots < T_m < T$. The coefficients in the model are changed in the 1break points. Thus the model (1) are generalized as

(3.2) $$\Delta P_t = \alpha(t)\beta(t)' P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i(t) \Delta P_{t-i} + \Phi(t) D_t + \varepsilon_t \qquad t = 1, \ldots, T,$$

The coefficients are constant within each broken time section, and different between those sections and expressed by

(3.3) $\alpha(t)\beta(t)' = a_1\beta_1' 1_{1t} + \cdots + \alpha_{m+1}\beta_{m+1}' 1_{m+1t}$,

(3.4) $\Gamma_i(t) = \Gamma_{1,t} 1_{1t} + \cdots + \Gamma_{m+1,i} 1_{m+1t}, \quad i = 1,\ldots,k-1,$

(3.5) $\Phi(t) = \Phi_1 1_{1t} + \cdots + \Phi_{m+1} 1_{m+1t}$,

where $1_{jt} \equiv 1(T_{j-1} + 1 \leq t \leq T_j), \quad j = 1,\cdots,m+1$ with $T_0 \equiv 0$ and $T_{m+1} \equiv T$. Let $Z_0 = \Delta P_t$, $Z_{1t} = (1_{1t} P_t', \cdots, 1_{m+1t} P_t')'$, $\tilde{Z}_{2t} = (\Delta P_{t-1}', \cdots, \Delta P_{t-k+1}')'$, and $Z_{2t} = (1_{1t}\tilde{Z}_{2t}, \cdots, 1_{mt}\tilde{Z}_{2t})'$. Further, this study sets $A = (\alpha_1, \cdots, \alpha_{m+1})$, $B = diag(\beta_1, \cdots, \beta_{m+1})$ and $C = (\Psi_1, \cdots, \Psi_{m+1})$, where $\Psi_j = (\Gamma_{j,1}, \cdots, \Gamma_{j,k-1}, \Phi_j)$, $j = 1,\cdots,m+1$. The equation (2) can be transformed into

(3.6) $Z_{0t} = AB'Z_{1t} + CZ_{2t} + \varepsilon_t, \quad t = 1,\ldots,T,$

This study continues to transform equation (6) into:

(3.7) $R_{0t} = \alpha\beta' R_{1t} + \hat{\varepsilon}, \quad t = 1,\ldots,T,$

where $M_{ij} = T^{-1}\sum_{t=1}^{T} Z_{it} Z_{jt}'$, $R_{0t} = Z_{0t} - M_{02} M_{22}^{-1} Z_{2t}$, and $R_{1t} = Z_{1t} - M_{12} M_{22}^{-1} Z_{2t}$. The equation (6) is a reduced rank regression. Its estimations of α, β are Ω are expressed as $\alpha(\beta) = S_{01}\beta(\beta' S_{11}\beta)^{-1}$, $\hat{\Omega}(\beta) = S_{00} - S_{01}\beta(\beta' S_{11}\beta)^{-1}\beta' S_{10}$, and β is the eigenvector of $\left|\lambda S_{11} - S_{10} S_{00}^{-1} S_{01}\right| = 0$, where $S_{ij} = T^{-1}\sum R_{it} R_{jt}'$.

Method to Estimate Break Dates

When estimating multiple break points, the estimated break points $(T_1, \cdots, T_m)$ should expressed as

(3.8) $$(T_1, \cdots, T_m) = \arg\min_{(T_1, \cdots, T_m)} S_T(T_1, \cdots, T_m),$$

Bai and Perron (1998, 2003b) advocated the dynamic programming algorithm to compute the global minimization of the overall sum of squared residuals in a single equation with multiple breaks; Qu and Perron (2007) employed this algorithm in a multiple-equations system with multiple breaks. The application of the dynamic programming in estimating structure breaks is thoroughly described in Bai and Perron (2003b) and Hawkins (1976). Thus the detail of applying this algorithm is omitted in this study.

Test Statistics for Multiple Breaks

The information criterion is commonly used to select the model. Yao (1988), Kim (1997) and Bai (2000) suggested Bayesian information criterion (BIC) can be used to detect the number of structural breaks:

(3.9) $$\hat{q} = \arg\min_{q \le q_{\max}} BIC(q),$$

(3.10) $$BIC(q) = \log(\Omega(q)) + [k + q(k+1)]\frac{\log T}{T},$$

where k is the number of regressors and $q_{\max}$ is a given upper bound for the true break number, q. And $\hat{q}$ is a consistent estimator of q.

Bai and Perron (1998) developed a test of q versus $q+1$ breaks. This test concludes for a rejection in favor of a model with $q+1$ breaks if the overall minimal value of the sum of squared residuals from the $q+1$ break model is sufficiently smaller than the sum of squared residuals from the q break model. This test is defined by

$$F_T(q+1|q) = \left\{S_T\left(\hat{T}_1, \cdots, \hat{T}_q\right) - \min_{1 \le i \le q+1} \inf S_T\left(\hat{T}_1, \cdots, \hat{T}_{i-1}, \tau, \hat{T}_i, \hat{T}_q\right)\right\} / \hat{\sigma}^2,$$

where τ is the additional break point. And $\hat{\sigma}^2$ is a consistent estimate of variance of residuals from the q break model. Bai and Perron (1998) also provided a table for asymptotic critic values of this test.

Data and AI Outbreaks

This study focuses on poultry-related firms listed in the US public stock market. The data in this study are the daily adjusted stock closing prices from 1 June 2001 to 16 April 2007. There are 1532 observations in each price series. The original data were obtained from Yahoo Finance (2009) and transformed into natural logarithmic form. Due to data availability, only five firms are chosen: AFC Enterprises (AFCE), Cal-Maine Foods (CALM), Industrias Bachoco (IBA), Sanderson Farms (SAFM), and Tyson Foods (TSN).

Cal-Maine Foods, an US egg producer and processor.

Sanderson Farms, a US top 5 poultry producer and packer.

Tyson Foods, the biggest US producer and packer of chicken, beef and pork.

AFC Enterprises, a US poultry-related restaurant owner that runs Popeye’s Chicken and Biscuits restaurant in North America, Europe and Asia.

Industrias Bachoco, the biggest Mexican poultry producer and processor.

During the period from 1 June 2001 to 16 April 2007, AI outbreaks which caused poultry and human infections clustered in two periods: the first one from December 2003 to April 2004 in East Asia and the second from January 2006 to April 2006 simultaneously in Asia, Africa and Europe. The human infections or deaths could lead to the reduction of poultry consumption, while the poultry infections and slaughter could cause the decrease of poultry production. Thus AI outbreaks are able to make stock prices of poultry-related firms to fluctuate in a big range in the short run. The related research is done in Huang (2008). This article further studies whether AI outbreaks cause the structural breaks of model which describes movements of these five stock prices.

Empirical Results

During the whole sample period, these five stock price series are nonstationary in levels and stationary in first differences, as Dickey-Fuller tests and Augmented Dickey-Fuller tests indicated. Both Schwartz information criterion and Hannan and Quinn's Φ measures determine that the optimal lag number is one for a vector autoregression of these five stock prices in levels. The cointegration rank is one among these five price series in term of trace tests and the cointegration search method proved by Bessler and Wang (2005). The cointegration vector is $\left(-0.004 \quad -0.34 \quad 1.01 \quad -2.01 \quad 1.00\right)$ in the whole sample period. The detail on these results is available in Huang (2008).

Dates and Statistics of Structural Change Points

For the purpose of simplicity of test, this article assumes that in each sub-sample the cointegration rank is one as in the whole sample. The rolling cointegration rank test with

200-day window also supports the assumption of one rank in each sub-sample. The result of rolling cointegration test is shown in Appendix H and I. And the model is assumed to confront the full structural change. That means all the coefficients vary in each sub-sample, including cointegration vector, adjustment vector, coefficient vector of lag dependent variables and exogenous variables. However, the break points are unknown in this study. Hansen and Johansen (1999) and Seo (1998) also studied some structural change tests for one break point in cointegrated-VAR model with unknown break dates. Hansen (2003) did the multiple-break test with known breaks.

Table 12. Dates and Statistics of Break Points, 06/012001-04/16/2007

Number of break points	Break dates	RSS	SIC	H&Q	AIC
= 0		0.3522	-37.544	-37.621	-37.712
= 1	23 Jan.2004	0.02757	-39.924	-40.076	-40.259
= 2	19 Mar2003, 07Mar 2005	0.00536	-41.394*	-41.622*	-41.897*

Note: the break dates are determined by the global minimum of sum of squared residual (RSS) when there are 0, 1 or 2 break points respectively in the whole period. And the values of Schwartz information criterion (SIC) and Hannan and Quinn's Φ (H&Q) are calculated from a cointegrated-VAR model with known break dates obtained in the second column.

This article uses the dynamic programming algorithm to compute the global minimum of sum of squared residuals for the cointegrated-VAR model of these five stock prices when one break or two breaks with unknown dates exist respectively. Table 12 gives the computed results of break dates with the global minimum of sum squared residuals. The break date is 23 January 2003 for the case of only one break point. At that day Thailand declared the H5N1 avian influenza outbreaks in its inland at the first time. And its poultry export was banned in the following days. In the two break points case, 19 March 2003 and 07 March 2005 are selected as the break dates. 20 March 2003 is the day on which US army invaded into Iraq. Around that period the worldwide stock markets confronted huge fluctuation of their stock prices, including US stock markets. On 3 March 2005, a federal court requested to bar Canadian cattle from entering the US That is good news for US beef producers, and also indirectly benefits poultry producers in the US because of substitute effect.

How can we choose the number of break points? Yao (1988), Kim (1997) and Bai (2000) used Bayesian information criterion (BIC) to detect the number of structural breaks. This article uses Akaike information criterion (AIC), BIC and Hannan and Quinn's Φ (H&Q) to pick up the optimal number of structural changes. Their estimation results are shown in the table 1 too. The values of three information criterions for two breaks are less than the values for one break or no break in model. Thus the selected model prefers two breaks than one break. That means avian influenza outbreaks in early 2004 did not change the long run movement relationship among these five prices, or did not change the structure of model for these five prices. The structural changes on 20 March 2003 and 08 March 2005 are more significant than the one on 23 January 2004. And why does the one break test not choose one of dates the two break test picks up? That could be that both the two breaks are too strong. The test can not distinguish which one is more significant, so picks up a point between these two dates.

Comparison Analysis among Three Sub-samples

In term of the previous analysis, the whole sample period is divided into three sub-sample periods on the date of 20 March 2003 and 08 March 2005. These two break points should be caused by some events happening around these two dates. The two events mentioned previously could be or not be the real events to break the model's structure. We examine the model in each sub-sample, and find what different variations happening in each period. Through those differences, we can check the whether the structural break test works well, and can also find the clues to identify which events could be the true reason of structural breaks.

This study uses the Dickey-Fuller test and Augmented Dickey-Fuller test to examine the data in these three sub-periods respectively, and finds all the five stock price series are still nonstationary in levels and stationary in the first differences at the significance level of 5%. And both Schwartz information criterion and Hannan & Quinn's Φ pick up one as the optimal number of lags in the level VAR model for these five price series in each sub-periods.

Table 13 gives the results of trace test, a cointegration rank test, for these five stock prices in the first sub-period from 01 June 2001 to 19 March 2005. Table 14 provides their test results in the second sub-period. Table 15 does the same in the third sub-period too. These test results show that the cointegration rank is zero for these five prices in the first period and the third at the significance level of 5%. In other words, these prices have no statistically significant long run equilibriums among them. The cointegration rank is one in the second period from 20 March 2003 to 07 March 2005. Awokuse, Chopra and Bessler (2009) found that major events in global financial markets caused the intensified cointegration relation among international stock markets. Elyasiani and Kocagil (2001) observed that the intensified cointegration among currency markets coincided with major events in the national or global financial markets. Thus this finding of cointegration relation implies that something happening around 20 March 2003 intensified the cointegration relation among these prices.

Table 13. Tests of Cointegration Rank among Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 06/01/2001-03/19/2003

R	P-R	T*	C (5%)*	D*	T	C (5%)	D
0	**5**	71.31	**75.74**	**F#**	68.33	**68.68**	**F**
1	**4**	35.77	**53.42**	**F**	33.32	**47.21**	**F**
2	**3**	21.63	**34.80**	**F**	19.32	**29.38**	**F**
3	**2**	9.84	**19.99**	**F**	7.61	**15.34**	**F**
4	**1**	2.76	**9.13**	**F**	1.61	**3.84**	**F**

Note: The trace test statistics from an ECM model of these five stocks without any dummy or exogenous variables.

Note: The number of cointegrating vectors (r) is tested using the trace test with the constant within and outside the cointegrating vectors. The test statistic (T) is the calculated trace test, associated with the number of cointegrating vectors given in the left-hand-most column. The critical values (C(5%)) are taken from Table B.2 (within) and Table B.3 (outside) in Hansen and Juselius (1995, p.80-81). The tests results presented in columns marked by an asterisk are associated with a constant within the cointegrating vectors. The un-asterisked columns are associated with tests on no constant in the cointegrating vectors, but a constant outside the vectors. The column labeled "D" gives our decision to reject (R) or fail to reject (F), at a 5 per cent level of significance, the null hypothesis of the number of cointegrating vectors (r=0, $r \leq 1, \ldots, r \leq 7$). Following Johansen (1992), we stop testing at the first "F" (failure to reject) when starting at the top of the table and moving sequentially across from left to right and from top to the bottom. The symbol (#) indicates the stopping point. Here we fail to reject the hypothesis that we have one cointegrating vectors with constants in the cointegrating vectors. Recent work on the selection of the number of cointegrating vectors has focused on the use of information criteria (AIC or Schwarz loss). Such criteria can be successfully applied to solve both the lag length and rank problem; see Kapetanios (2003) and Aznar and Salvador (2002).

Table 14. Tests of Cointegration Rank among Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 03/20/2003-03/07/2005

R	P-R	T*	C (5%)*	D*	T	C (5%)	D
0	5	92.67	75.74	R	80.77	68.68	R
1	4	46.11	53.42	F#	36.85	47.21	F
2	3	22.63	34.80	F	16.90	29.38	F
3	2	7.65	19.99	F	6.93	15.34	F
4	1	0.98	9.13	F	0.28	3.84	F

Note: The trace test statistics from an ECM model of these five stocks without any dummy or exogenous variables.

Note: The number of cointegrating vectors (r) is tested using the trace test with the constant within and outside the cointegrating vectors. The test statistic (T) is the calculated trace test, associated with the number of cointegrating vectors given in the left-hand-most column. The critical values (C(5%)) are taken from Table B.2 (within) and Table B.3 (outside) in Hansen and Juselius (1995, p.80-81). The tests results presented in columns marked by an asterisk are associated with a constant within the cointegrating vectors. The un-asterisked columns are associated with tests on no constant in the cointegrating vectors, but a constant outside the vectors. The column labeled “D” gives our decision to reject (R) or fail to reject (F), at a 5 per cent level of significance, the null hypothesis of the number of cointegrating vectors (r=0, $r \leq 1, \ldots, r \leq 7$). Following Johansen (1992), we stop testing at the first “F” (failure to reject) when starting at the top of the table and moving sequentially across from left to right and from top to the bottom. The symbol (#) indicates the stopping point. Here we fail to reject the hypothesis that we have one cointegrating vectors with constants in the cointegrating vectors. Recent work on the selection of the number of cointegrating vectors has focused on the use of information criteria (AIC or Schwarz loss). Such criteria can be successfully applied to solve both the lag length and rank problem; see Kapetanios (2003) and Aznar and Salvador (2002).

Table 15. Tests of Cointegration Rank among Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 03/08/2005-04/16/2007

R	P-R	T*	C (5%)*	D*	T	C (5%)	D
0	5	54.72	75.74	F#	50.88	68.68	F
1	4	31.58	53.42	F	27.97	47.21	F
2	3	15.56	34.80	F	13.07	29.38	F
3	2	7.45	19.99	F	4.96	15.34	F
4	1	2.48	9.13	F	0.01	3.84	F

Note: The trace test statistics from an ECM model of these five stocks without any dummy or exogenous variables.

Note: The number of cointegrating vectors (r) is tested using the trace test with the constant within and outside the cointegrating vectors. The test statistic (T) is the calculated trace test, associated with the number of cointegrating vectors given in the left-hand-most column. The critical values (C(5%)) are taken from Table B.2 (within) and Table B.3 (outside) in Hansen and Juselius (1995, p.80-81). The tests results presented in columns marked by an asterisk are associated with a constant within the cointegrating vectors. The un-asterisked columns are associated with tests on no constant in the cointegrating vectors, but a constant outside the vectors. The column labeled “D” gives our decision to reject (R) or fail to reject (F), at a 5 per cent level of significance, the null hypothesis of the number of cointegrating vectors ($r=0$, $r \leq 1, \ldots, r \leq 7$). Following Johansen (1992), we stop testing at the first “F” (failure to reject) when starting at the top of the table and moving sequentially across from left to right and from top to the bottom. The symbol (#) indicates the stopping point. Here we fail to reject the hypothesis that we have one cointegrating vectors with constants in the cointegrating vectors. Recent work on the selection of the number of cointegrating vectors has focused on the use of information criteria (AIC or Schwarz loss). Such criteria can be successfully applied to solve both the lag length and rank problem; see Kapetanios (2003) and Aznar and Salvador (2002).

Table 16. Tests on Exclusion from the Cointegration Space for Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 03/20/2003-03/07/2005

Firm	Beta	Chi-squared test	P-value	Decision
AFCE	1.00	24.22	0.00	R
CALM	-0.087	7.27	0.01	R
IBA	-0.510	15.29	0.00	R
SAFM	-0.113	0.53	0.47	F
TSN	0.009	0.00	1.00	F

Note: Tests are on the null hypothesis that the particular series listed in the far-left-hand column is not in the cointegration space. The heading 'decision' relates to the decisions t to reject (R) or fail to reject (F) the null hypothesis at a 5% level of significance. Under the null hypothesis, the test statistic is distributed chi-squared with eight degree of freedom (exclusion from the entire cointegration space would imply one restriction, as , based on results from Table 5, we have one cointegration vector).

Table 17. Tests on Weak Exogeneity from the Cointegration Space for Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 03/20/2003-03/07/2005

Firm	Alpha	Chi-squared test	P-value	Decision
AFCE	-0.096	23.71	0.00	R
CALM	0.005	0.03	0.86	F
IBA	0.019	3.44	0.06	R
SAFM	0.042	4.95	0.03	R
TSN	0.028	5.42	0.02	R

Note: Tests are on the null hypothesis that the particular series listed in the far left hand column is weakly exogenous, i.e., that series does not respond to perturbations in the cointegration space. The heading 'Decision' relates to the decision to reject (R) or fail to reject (F) the null hypothesis at a 10% level of significance. Under the null hypothesis, the test statistic is distributed chi-squared with one degree of freedom. The null hypothesis, that firm does not respond, implies one zero restriction (on the alpha matrix of the error correction representation, see text for further discussion).

Further, this study does the exclusive test and weakly exogenous test for the second sub-sample to identify which prices involve the cointegration relation or long run equilibrium among these five series and which prices follow the variation of this long run equilibrium. Table 16 shows the exclusive test results. It indicates that the prices of Cal- Maine Foods, Industrias Bachoco and AFC Enterprises are rejected from the exclusive test at the significance level of 99%. The prices of Sanderson Farms and Tyson Foods fail to be rejected by the exclusive test at the significance level of 10%. Thus both Sanderson Farms and Tyson Foods are not involved in the long run equilibrium found in the previous paragraph.

Table 17 shows the results of weakly exogenous test. It points out that the prices of AFC Enterprises, Sanderson Farms and Tyson Foods are rejected by the weakly exogenous test at the significance level of 5%. The price of Industrias Bachoco is rejected by the test at the significance level of 10%. Both AFC Enterprises and Industrias Bachoco vary following the variation of their long run equilibrium. Sanderson Farms and Tyson Foods also are influenced by the variation of long run equilibrium even though both of them are not involved in that equilibrium. And the price of Cal-Maine Foods fails to be rejected at the significance level of 10%. This failure shows Cal-Maine Foods does not follow the change of long rum equilibrium. This study concludes that Cal-Maine Foods behaves like a leader in this long run relation, and both Industrias Bachoco and AFC Enterprises behave like followers. After the price of Cal-Maine moves, their long-run equilibrium changes into an inequilibrium, and Cal-Maine Foods and Tyson Foods change their prices to rebuild a new equilibrium among three of them.

Thus this finding of long run relationship supports the existence of structural changes on these two dates.

In addition to examining the long run relationship, this article also explores the contemporaneous interrelationship between these five prices in the three sub-periods. In term of whether the cointegration relation exists, this study builds a Vector Autoregressive (VAR) model for the sub-sample in the first and third sub-periods, and a cointegrated-VAR mode in the second period. The innovations from the estimations of these three models are used to analyze the contemporaneous relation in each sub-period through the directed acyclic graphs (DAG). The correlation matrices of innovations are expressed below.

$$\begin{matrix} & CALM & IBA & SAFM & TSN & AFCE \end{matrix}$$

$$Corr(\hat{\varepsilon}_t) = \begin{bmatrix} 1.000 & & & & \\ 0.005 & 1.000 & & & \\ -0.029 & 0.068 & 1.000 & & \\ -0.009 & 0.041 & 0.107 & 1.000 & \\ -0.062 & 0.157 & 0.054 & 0.065 & 1.000 \end{bmatrix}_{t \le 19\ Mar\ 2003 \quad t}$$

$$\begin{matrix} & CALM & IBA & SAFM & TSN & AFCE \end{matrix}$$

$$Corr(\hat{\varepsilon}_t) = \begin{bmatrix} 1.000 & & & & \\ 0.039 & 1.000 & & & \\ 0.097 & 0.016 & 1.000 & & \\ 0.080 & -0.005 & 0.081 & 1.000 & \\ -0.070 & 0.063 & -0.022 & 0.018 & 1.000 \end{bmatrix}_{20\ Mar\ 2003 \ \le t \le 07\ Mar\ 2005 \quad t}$$

$$
\begin{array}{c}
\qquad\qquad\quad CALM \qquad IBA \qquad SAFM \qquad TSN \qquad AFCE \\
Corr(\hat{\varepsilon}_t) = \begin{bmatrix} 1.000 & & & & \\ 0.118 & 1.000 & & & \\ 0.067 & 0.039 & 1.000 & & \\ 0.021 & 0.031 & 0.371 & 1.000 & \\ 0.048 & -0.051 & 0.083 & 0.044 & 1.000 \end{bmatrix}_{t \geq 08\ Mar\ 2005}
\end{array}
$$

Figure 15 graphs their contemporaneous causal relation in the first sub-period at 2% significance level. In the graphs there are four possibilities between any two variables (for instance, P_i and P_j): (a) there is no causal relation between P_i and P_j (the edge is removed); (b) P_i causes P_j ($P_i \rightarrow P_j$); (c) P_i and P_j are both caused by a common omitted variable ($P_i \leftrightarrow P_j$); (d) causal direction can not be identified between P_i and P_j (P_i — P_j). Figure 1 does not determine the causal directions between Industrias Bachoco and Sanderson Farms and between Industrias Bachoco and AFC Enterprises. The appendix D shows that the price shock of Industrias Bachoco transits to Sanderson Farms' price; Indutrias Bachoco's shock also transits to AFC Enterprises' price. Thus their causal relation can be formulated into: Tyson Foods → Sanderson Farms ← Industrias Bachoco → AFC Enterprises ← Cal-Maine Foods. Tyson Foods, Industrias Bachoco and Cal-Maine Foods work as information sources; both Sanderson Farms and AFC Enterprises works as information sinks.

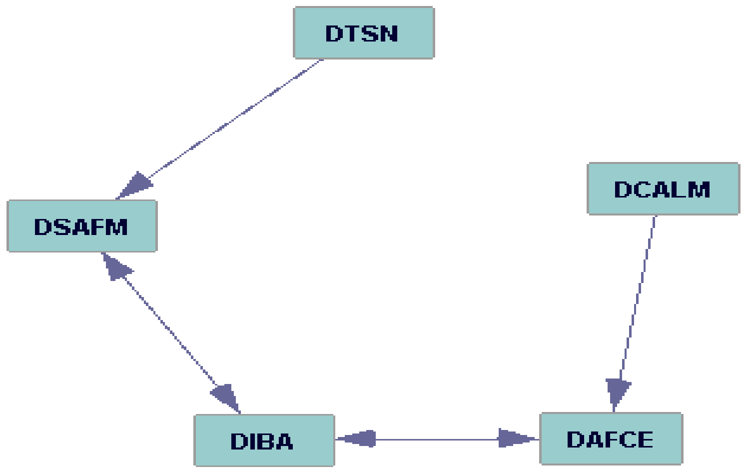


Figure 15. Contemporaneous interrelationship at 2% significance level, 06/01/2001-03/19/2003

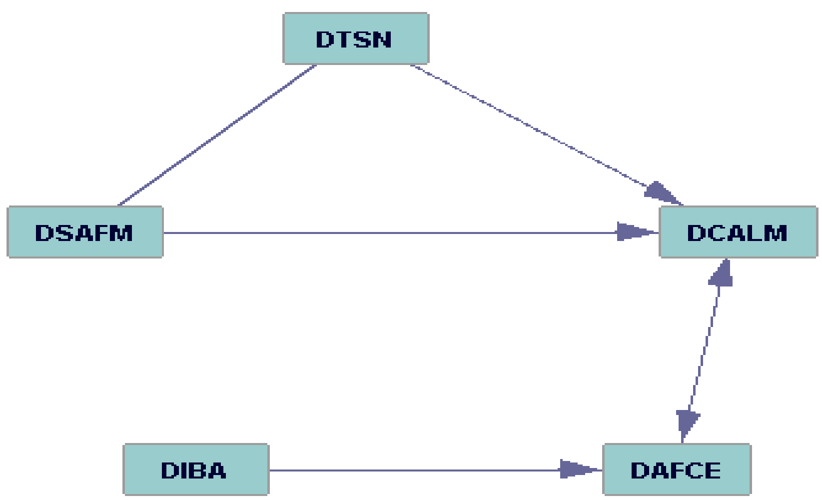


Figure 16. Contemporaneous interrelationship at 2% significance level, 03/20/2003-04/16/2003

Figure 16 plots the contemporaneous relation in the second sub-period. The direction between Tyson Foods and Sanderson Farms is not determined along with the direction between Cal-Maine Foods and AFC Enterprises. Both the appendix E and F help to discover their directions that Tyson Foods' shock transits to Sanderson Farms' price, and AFC Enterprises' shock impact Cal-Maine Foods' Price. Thus in the second sub-period the contemporaneous relation is expressed as: Tyson Foods → Cal-Maine Foods, Tyson Foods → Sanderson Farms → Cal-Maine Foods ←AFC Enterprises ← Industrias Bachoco. Cal-Maine Foods can be regarded as an information sink. Any shock from other firms finally and always transits to Cal-Maine Foods. Both Tyson Foods and Industrias Bachoco work as information sources, which never receive shock information from other firms.

Figure 17 draws the contemporaneous relation in the third sub-period. The direction of information flow between Sanderson Farms and Cal-Maine Foods is not determined on a 2% significance level. According to the appendix G, the information flows from Cal-Maine Foods to Sanderson Farms. The contemporaneous relation is expressed: Tyson Foods → Sanderson Farms ← AFC Enterprises; Industrias Bachoco → Cal-Maine Foods → Sanderson Farms. Sanderson Farms looks like information sink, which has no contemporaneous impact on other firms. Tyson Foods, AFC Enterprises and Industrias Bachoco behave like information sources.

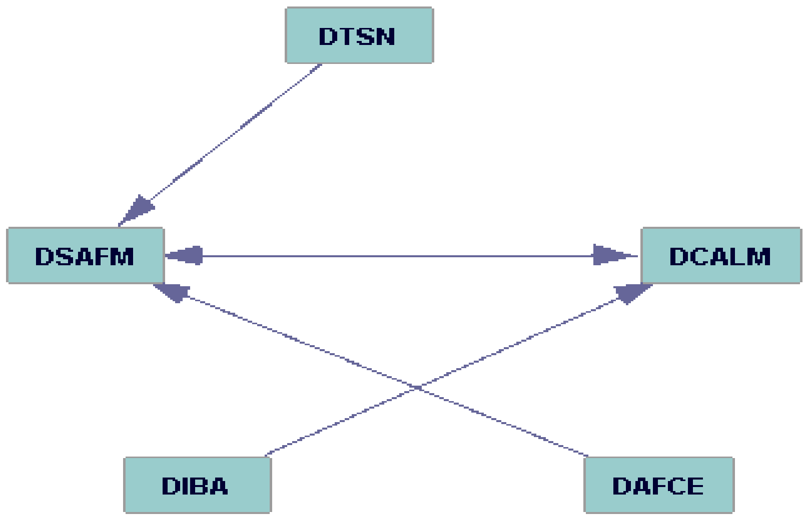


Figure 17. Contemporaneous interrelationship at 2% significance level, 03/08/2005-04/16/2007

Table 18. Comparison of Innovation Correlation Matrix among Three Sub-samples Based on Jennrich Homogeneity Test

	Jennrich test	P-value	Homogeneous?
1st subperiod vs. 2nd subperiod	$J_{12} = 10.17$	42.6%	Yes
2nd subperiod vs. 3rd subperiod	$J_{23} = 39.11$	0.00%	No
1st subperiod vs. 3rd subperiod	$J_{13} = 40.92$	0.00%	No

Note:

1.
$$J_{12} = 0.5 \times trace(Z_{12}^2) - diag(Z_{12})' S_{12}^{-1} diag(Z_{12})$$
$$Z_{12} = c_{12}^{0.5} \overline{R}_{12}^{-1}(R_1 - R_2)$$
$$c_{12} = n_1 n_2 /(n_1 + n_2)$$
$$\overline{R}_{12} = (n_1 R_1 + n_2 R_2)/(n_1 + n_2)$$
$$S_{12} = I + R_{12}^{-1}.* R_{12}$$

Jennrich test is a chi-square test with degree freedom $k(k-1)/2$. k is the dimension of matrix, which equal 5 here.

Comparing the figures of 15, 16 and 17, this study finds that Tyson Foods and Industrias Bachoco behave like information sources in all the three sub-periods. Sanderson Farms works as information sink in the first and third period. And Cal-Maine Foods works as information sink only in the second sub-period. The causal direction between Tyson Foods and Sanderson Farms never changes during these three sub-periods, and only weakens in the second period. This could imply the first break is not caused by an event related to poultry or beef industry.

Jennrich homogeneity test could be used to examine the homogeneity of correlation matrix (Jenrrich 1970). This homogeneity tests show that the homogeneity is failed to reject between the innovation correlation matrix during the first and second sub-periods at the significance level of 10%. The homogeneity of innovation correlation matrix is rejected between the second and third sub-periods, and between the first and third sub-periods. These results partially support previous results on two breaks and DAGs. The detailed information about Jennrich tests are obtained in the table 18.

This article continues to compare the short run dynamic relationship among these five prices in the three sub-periods. The short run relation is described by the forecast error variance decomposition (FEVD) of these five prices. The FEVD shows how the forecast error variance of each series at any horizon is decomposed in term of shocks from each series. The FEVD uncovers both time-lagged information transmission and contemporaneous information transmission, and works out economics significance of dynamic linkages between the related series. Computation of FEVD requires the innovations from model are orthogonal among them. Swanson and Granger (1997) shows the contemporaneous relation discovered by DAG can be used to rebuild new orthogonal innovations for the model. This article employs the contemporaneous relation found previously to compute the FEVD in the two sub-periods.

Table 19 shows the FEVD in the first sub-period. In this sub-period, more than 97% of the forecast error variance of each price comes from its own innovation during the first 44 days following a shock. Thus each stock price has little influence on others in the short term.

Table 20 describes the FEVD in the second period. This FEVD finds that Cal-Maine Foods is almost not affected by other firms' shock and only affects AFC Enterprises more than 6% of its error variance at the horizon of 43-days ahead. Industrias Bachoco was only influenced significantly by AFC Enterprises about 7% of its error variance at the horizon of 43 days ahead. It impacts on more than 20% of AFC Enterprises' error variance. Both Sanderson Farms and Tyson Foods have very a little effect on other firms. Both of them are strongly impacted by AFC Enterprises about 12% of their own error variances. Thus it looks that AFC Enterprises is the most active in the short term relation during the second sub-period.

Table 21 shows the FEVD in the third sub-period. This FEVD indicates that most of firms do not strongly affect other firms and are not significantly by others in contemporaneous and short term time. Only Tyson Foods strongly impacts on about 13.5% error variance of Sanderson Farms. This significant influence could imply that something causing the second break is related to beef industry, and indirectly affect poultry industry. So the event of a federal court requesting to bar Canadian live cattle from entering the US is a good target around the break date of 07 March 2005

Finally, this article compares the estimation results for the models in these three sub-samples and discusses their economic meanings. Table 22 provides the estimation result for the VAR model in the first sub-period. Table 23 shows the result of the cointegrated-VAR model for the second sub-sample. Table 24 does for the third sub-sample.

In Table 10 only coefficients of differenced S&P500 index are statistically significant from zero on 1% level on equations of Sanderson Farms, Tyson Foods and AFC Enterprises respectively; other coefficients are insignificant.

Table 19. Forecast Error Decompositions on Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 06/01/2001-03/19/2003

Horizon	CALM	IBA	SAFM	TSN	AFCE
CALM					
0	100.000	0.000	0.000	0.000	0.000
1	99.287	0.292	0.369	0.005	0.022
21	99.287	0.309	0.369	0.012	0.023
43	99.287	0.309	0.369	0.012	0.023
IBA					
0	0.000	100.000	0.000	0.000	0.000
1	0.067	98.313	0.293	1.327	0.000
21	0.072	98.290	0.300	1.337	0.001
43	0.072	98.290	0.300	1.337	0.001
SAFM					
0	0.000	0.362	98.643	0.995	0.000
1	0.101	1.239	97.489	1.099	0.073
21	0.101	1.240	97.484	1.102	0.073
43	0.101	1.240	97.484	1.102	0.073
TSN					
0	0.000	0.000	0.000	100.000	0.000
1	0.563	0.018	0.063	99.198	0.158
21	0.566	0.019	0.071	99.186	0.159
43	0.566	0.019	0.071	99.186	0.159
AFCE					
0	0.399	2.463	0.000	0.000	97.138
1	0.399	2.462	0.004	0.044	97.092
21	0.399	2.462	0.004	0.044	97.092
43	0.399	2.462	0.004	0.044	97.092

Note: Decompositions at each step are given for a “Bernanke” factorization of the innovation correlation/covariance matrix. The decompositions sum to one hundred in any row. The order of presentation and abbreviations for each firm is as follows: Cal-Maine Foods (CALM), Industrias Bachoco (IBA), Sanderson Farms (SAFM), Tyson Foods (TSN), and AFC Enterprises (AFCE).

Table 20. Forecast Error Decompositions on Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 03/20/2003-03/07/2005

Horizon	CALM	IBA	SAFM	TSN	AFCE
CALM					
0	98.033	0.000	0.798	0.652	0.517
1	98.189	0.061	0.694	0.794	0.262
21	98.241	0.125	0.649	0.954	0.033
43	98.215	0.141	0.622	0.947	0.034
IBA					
0	0.000	100.000	0.000	0.000	0.000
1	0.004	99.461	0.142	0.377	0.015
21	0.020	95.415	0.046	0.427	4.093
43	0.042	92.713	0.023	0.369	6.854
SAFM					
0	0.000	0.000	99.372	0.628	0.000
1	0.390	0.001	97.680	1.713	0.216
21	0.472	0.428	87.166	3.249	8.685
43	0.365	0.723	82.193	3.461	13.258
TSN					
0	0.000	0.000	0.000	100.000	0.000
1	0.138	0.160	0.379	99.199	0.123
21	0.111	1.255	0.163	90.569	7.902
43	0.064	1.697	0.086	86.251	11.902
AFCE					
0	0.000	0.440	0.000	0.000	99.560
1	0.129	0.356	0.044	0.448	99.023
21	2.996	9.107	0.936	0.641	86.320
43	6.141	20.800	2.616	0.526	69.918

Note: Decompositions at each step are given for a “Bernanke” factorization of the innovation correlation/covariance matrix. The decompositions sum to one hundred in any row. The order of presentation and abbreviations for each firm is as follows: Cal-Maine Foods (CALM), Industrias Bachoco (IBA), Sanderson Farms (SAFM), Tyson Foods (TSN), and AFC Enterprises (AFCE).

Table 21. Forecast Error Decompositions on Daily Stock Prices for Five Poultry Related Firms Publicly Traded in US Stock Markets, 03/08/2005-04/16/2007

Horizon	CALM	IBA	SAFM	TSN	AFCE
CALM					
0	98.319	1.351	0.329	0.000	0.000
1	97.526	1.403	0.617	0.218	0.236
21	97.520	1.407	0.617	0.218	0.238
43	97.520	1.407	0.617	0.218	0.238
IBA					
0	0.000	100.000	0.000	0.000	0.000
1	0.089	99.467	0.003	0.420	0.022
21	0.089	99.449	0.005	0.430	0.026
43	0.089	99.449	0.005	0.430	0.026
SAFM					
0	0.000	0.000	86.054	13.534	0.412
1	0.000	0.095	85.960	13.520	0.425
21	0.000	0.096	85.959	13.520	0.425
43	0.000	0.096	85.959	13.520	0.425
TSN					
0	0.000	0.000	0.000	100.000	0.000
1	0.371	0.163	0.116	98.425	0.924
21	0.374	0.165	0.119	98.415	0.927
43	0.374	0.165	0.119	98.415	0.927
AFCE					
0	0.000	0.000	0.000	0.000	100.00
1	0.390	0.001	0.105	0.582	98.921
21	0.399	0.006	0.107	0.582	98.905
43	0.399	0.006	0.107	0.582	98.905

Note: Decompositions at each step are given for a “Bernanke” factorization of the innovation correlation/covariance matrix. The decompositions sum to one hundred in any row. The order of presentation and abbreviations for each firm is as follows: Cal-Maine Foods (CALM), Industrias Bachoco (IBA), Sanderson Farms (SAFM), Tyson Foods (TSN), and AFC Enterprises (AFCE).

Table 22. Estimation of VAR Model, 06/01/2001-03/19/2003

Dependent Variable	Independent Variable				
	ΔP_{CALM}	ΔP_{IBA}	ΔP_{SAFM}	ΔP_{TSN}	ΔP_{AFCE}
ΔP_{SP500}	-0.024	0.076	0.373	0.536	0.616
	(0.82)	(0.11)	(0.00)	(0.00)	(0.00)
Constant	-0.0007	0.0010	0.0011	-0.0005	-0.0000
	(0.63)	(0.16)	(0.33)	(0.67)	(0.99)

Note: the values in the brackets are the P-values of corresponding coefficients.

Table 23. Estimation of Cointegrated-VAR Model, 03/20/2003-03/07/2005

Dependent Variable	Independent Variable				
	ΔP_{CALM}	ΔP_{IBA}	ΔP_{SAFM}	ΔP_{TSN}	ΔP_{AFCE}
E.C. Term	0．011	0.017	0.040	0.029	-0.096
	(0.67)	(0.07)	(0.01)	(0.01)	(0.00)
ΔP_{SP500}	0.803	0.265	0．857	0.882	0.554
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-0.004	-0.009	-0.022	-0.016	0.059
	(0.85)	(0.12)	(0.01)	(0.01)	(0.00)

Note: E.C. Term refers to the error correction term, which is expressed as $\left(0.082P_{CALM} + 0.506P_{IBA} + 0.104P_{SAFM} + 0.016P_{TSN} - 1.00P_{AFCE}\right)$. And the values in brackets are P-values of corresponding coefficients.

Table 24. Estimation of VAR Model, 03/08/2005-04/16/2007

Dependent Variable	Independent Variable				
	ΔP_{CALM}	ΔP_{IBA}	ΔP_{SAFM}	ΔP_{TSN}	ΔP_{AFCE}
ΔP_{SP500}	0.581	0.299	1.110	0.763	1.069
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
Constant	0.0004	0.0012	0.0007	0.0001	0.0003
	(0.68)	(0.10)	(0.40)	(0.83)	(0.73)

Note: the values in the brackets are the P-values of corresponding coefficients.

In the table 22 the coefficients of error correction term are different from zero on 1% or 10% significance level in all the equations but the one of Cal-Maine Foods. The coefficients of differenced S&P500 index are different from zero on 1% significance level. The constant term is different from zero in the equations of Sanderson Farms, Tyson Foods and AFC Enterprises on 1% significance level; it is insignificantly different from zero at 10% level in the equations of Cal-Maine Foods and Industrias Bachoco.

In the table 23, only the coefficients of differenced S&P500 are different from zero on 1% significant level. Other coefficients are insignificantly different from zero on 10% level. These differences between models support there are breaks during the whole sample.

In these three models, the difference of stock price or index could be regarded as stock return or market return because they are actually in logarithm form; the error correction term can be regarded as some specific risk premium related to these five firms. In term of Capital Asset pricing Model (CAPM) the constant term is related to the risk free return; the coefficients of differenced S&P500 index is the sensitivity of the stock return to market returns, or it is called as beta coefficient; the coefficients of error correction term is the sensitivity of stock return to some specific risk premium.

Comparing the tables of 22 and 23, this article finds the sensitivity of stock return to market return significantly increase after the first break date. The sensitivity of stock return to some specific risk premium significantly increases also after the first break date. This risk premium is not directly related to the US poultry or beef industry because both Sanderson Farms and Tyson Foods are not involved in that long run equilibrium. And the risk free rate also looks to vary after the break date of 20 March 2003. These findings may imply that the event causing the break around that time is related to the whole financial market. This study examines the news around that period and found that invading Iraq could be the most suspected target to cause the beak. other events can take that kind of effects, like banning live cattle to import from Canada to the US in 2003 May, SARS outbreaks from late 2002 to early 2003 and avian influenza outbreaks late 2003 to early 2004 and so on.

Comparing the tables of 23 and 24, this study finds that the sensitivity of stock return to market return do not to vary significantly. In addition, the short run relation between Tyson Foods and Sanderson Farms strengthened after second break date, which is found previously. The event which causes the second break is not related to the whole market, and only directly related to beef industry and poultry industry. Thus US banning Canadian live cattle from entering is an ideal explanation for the second break.

Conclusions

This study wants to examine whether avian influenza outbreaks in early 2004 have a long run effect on five stock price movements, or whether avian influenza outbreaks cause structural breaks in those prices. This study employs the dynamic programming algorithm and the reduced regression method of cointegrated-VAR model to compute the break dates for the data sample from 01 June 2001 to 16 April 2007. This study find the avian influenza outbreak in the early 2004 does not cause the structural breaks of model. The model with two breaks are selected by AIC, SIC and H&Q's Φ. These two break dates are 20 March 2003 and 08 March 2005. This study continues to compare the data properties such as their long run relation, short run relation and contemporaneous relation, and their model estimations in these three sub-periods. And this study finds these three sub-sample are significantly different and the breaks were caused by the events of invading Iraq on 20 March 2003 and banning Canadian live cattle from entering the US on 03 March 2005, not by the event of avian influenza outbreaks in early 2004 or other possible events around relative period.

CHAPTER IV

DID AVIAN INFLUENZA OUTBREAK AFFECT AGRICULTURAL COMMODITY FUTURES TRADED IN JAPANESE FUTURES MARKETS?

This essay studies the effects of avian influenza outbreaks on the economy of importing country using data from Japanese futures markets. This study extends the literature in that most previous work has been set in an exporting country. Some previous study found food safety events have little effect on related agricultural commodity futures. (Lusk and Schroeder, 2002). TSE and Hackard (2006) found the effects of mad cow announcement on agricultural commodity futures using the data sample in minute.

This study uses daily futures prices sample of egg, broiler, non-GMO soybean and corn. And it combines the event study method with auto regressive (VAR) model to examine the abnormal return and cumulative abnormal return of these four futures around the announcement date of avian influenza outbreak in Japan. Only the egg futures is found to raise its return significantly in the window. This findings is consistent with the result of Ishida, Ishikawa and Fukushige (2006). The three futures price series were not found to be affected significantly. The different effects of avian influenza outbreaks may be reasonable because the avian influenza outbreaks in Japan only affect Japan’s exports, not its imports. Japan is one of the biggest egg exporters in the world, and one of the larger broiler, soybean and corn importers.

The reminder of this paper is organized as follows. The second section reveals the research methodology; the third section describes data sample, the four futures contracts, and avian influenza event in Japan. The fourth section presents the empirical results of analysis. Conclusions and suggestions on future research are offered in the last section.

Research Methodology

The methodology of event study is a common tool to explore the effects of some event on security return. Let the event take place on t = 0. For the security i, the return of the security time t relative to the event, R_{it}, is expressed as:

(4.1) $$R_{it} = \overline{R}_{it} + e_{it}$$

where $\overline{R}_{it}$ is the normal return, or the expected or predicted return given a particular model. e_{it} is called as abnormal return. The abnormal return is the difference between the realized return and normal return. In other words, e_{it} is the difference between the return conditional on the event and the expected return unconditional on the event. The abnormal return is a direct measure of the unexpected change of security return associated with the event. The normal return can be formulated as market model, constant mean model and capital asset pricing model. The abnormal return is the deviation from the expected return model.

Rather than modeling abnormal return as the deviation from the expected return model, the abnormal return can be modeled as regression coefficients.

(4.2) $$R_{it} = \sum_{j=1}^{k} \theta_{i,j} x_{it,j} + \rho_{it} E_t + e_{it}$$

where the variable $x_{it,j}$ is non-event related explanatory variables that may affect the return. E_t is a variable taking the value of one on event days and a value of zero on non-event days. ρ_{it} is interpreted as the average abnormal return of security i on the event day t. $\sum_{m=t_1}^{t_2} \rho_{im}$ is the cumulative abnormal return during the window from t_1 to t_2. The tests have to be taken to examine whether both the abnormal return and the cumulative abnormal return are statistically significant from zero.

Event Study, VAR Model and Asymmetric GARCH-M Model

The traditional event study of commodity futures employs an individual-commodity model to compute the normal return and abnormal return. Cortazar, Milla and Severino (2008) prove that the multi-commodity model catches more information to model normal return and abnormal return, and obtains stable more stable spreads of commodities because of the correlation of commodity futures prices. And Liu (2005) found the cointegration relationship among hog, corn and soybean meal futures. Thus this study builds a VAR (vector autoregressive) model or cointegrated VAR model to explore the effect of avian influenza outbreaks on commodity futures prices if the cointegration relation is found among the commodity futures studied.

(4.3) $$\Delta P_t = \Pi P_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \Phi D_t + \Theta E_t + \varepsilon_t \qquad t = 1, \ldots, T,$$

(4.4) $$E\{\varepsilon_t \varepsilon_t'\} = \Sigma .$$

Here P_t is a vector of n futures prices in logarithm form under study. As the general cointegrated VAR model, Δ is the difference operator ($\Delta P_t = P_t - P_{t-1}$) and ΔP_t is return of futures; Π and Γ are $n \times n$ parameter matrices; D_t is a vector of deterministic variables such as a constant, linear trend, seasonal, and exogenous variables; Φ is a parameter matrix of D_t; and ε_t is a vector of innovation (error) terms with a (5×5) covariance matrix Σ. However, E_t is the indication variable of event which equal one on event days and zero otherwise; Θ is coefficient vector and is to model the average abnormal return.

Engle (1982) proposed Autoregressive Conditional Heteroscedasticity (ARCH) to explain the tendency of large residuals to cluster together. Volatility seems to be a little bit persistent in ARCH(1) model. Bollerslev (1986) built the GARCH model to develop the ARCH model. In a GARCH model, the variance term depends on the lagged variances and lagged residuals. This allows for persistence in volatility with a relatively small number of parameters. Equity returns exhibit asymmetrical conditional variance behavior. That is, that positive values of the residuals have a different effect than negative ones. Glosten, et. al(1993) developed the standard GARCH model as GJR model to explain the asymmetric characteristics. Engle, Lilien and Robins(1987) generalized the ARCH model into GARCH-M model, which absorb the variance itself as a regressor to explain the effect of variances on equity returns. Thus, this study employs the asymmetric GARCH-M model to investigate the relation among these four futures prices. The asymmetric GARCH-M model is expressed as follow. The equation (5) is the mean equation and the equation (6) is the variance equation.

(4.5)
$$\Delta P_t = \varphi E_t + X_t\beta + h_t\alpha_0 + h_{t-1}\alpha_1 + u_t$$

(4.6)
$$h_t \equiv \text{var}(u_t) = c + au_{t-1}^2 + bh_{t-1} + du_{t-1}^2 I_{u<0}(u_{t-1})$$

where I is an indicator function, in this case for $u < 0$. In this formulation, a positive value of d means negative residuals tend to increase the variance more than positive ones. E_t is the dummy variable to present the event occurrence.

Data and AI Events

This study uses the nearby futures prices obtained from the database of EconStats (2009). All of the selected futures are traded in Japanese futures market to capture the effect of avian influenza on Japan's economy. the data sample covers from 30 November 2001 to 12 February 2004 for the data availability and market liquidity.

The egg futures contract is traded at the Central Japan Commodity Exchange; its price quotation is Yen per kilogram; its contract month covers the whole year from January to December. The broiler Futures is traded at Fukuoka Futures Exchange before December 2006 and at Kansai Commodity Exchange; its price quotation is Yen per kilogram; its contracts month also cover from January to December. The corn futures is traded at the same exchange as the boiler future is before December 2006 and then is removed; its price quotation is yen per 1,000 kilograms; its contract month covers February, April, June, August, October and December within a twelve-month period. The non-GMO soybean futures is traded at the Tokyo Grain Exchange; its price quotation is yen per 1,000 kilograms; its contract month covers January, March, May, July, September and November within a twelve-month period.

The first case of avian influenza virus of H5N1 is announced on 12 January 2003 in Japan. And its announcement is seven days before the announcement of avian influenza outbreaks in Taiwan, and four days later than the announcement of avian influenza outbreaks in Vietnam. Thus the event window is designed from 9 January 2004 to 16 January 2004 to avoid the noise from avian influenza outbreaks in other countries. The whole window is a six business day range since both January 10 and 11 are weekend in 2004.

Empirical Results

Figure 18 plots these four futures contracts' prices and the dates of avian influenza outbreaks during the period from 30 November 2001 to 12 February 2004. This figure gives a whole and simple picture on relations between price series and events. There is no obvious correlation between prices and events.

Table 25 provides the descriptive statistics of these four futures contracts' prices. The boiler futures contract has the maximum value of 0.385 in the coefficient of variation (CV) among these four contracts. The corn futures contract holds the minimal value of CV among these four contracts, which is 0.105. This findings implies that the contract of broiler futures is the riskiest among these four contracts, and the corn has less risk than other three contracts.

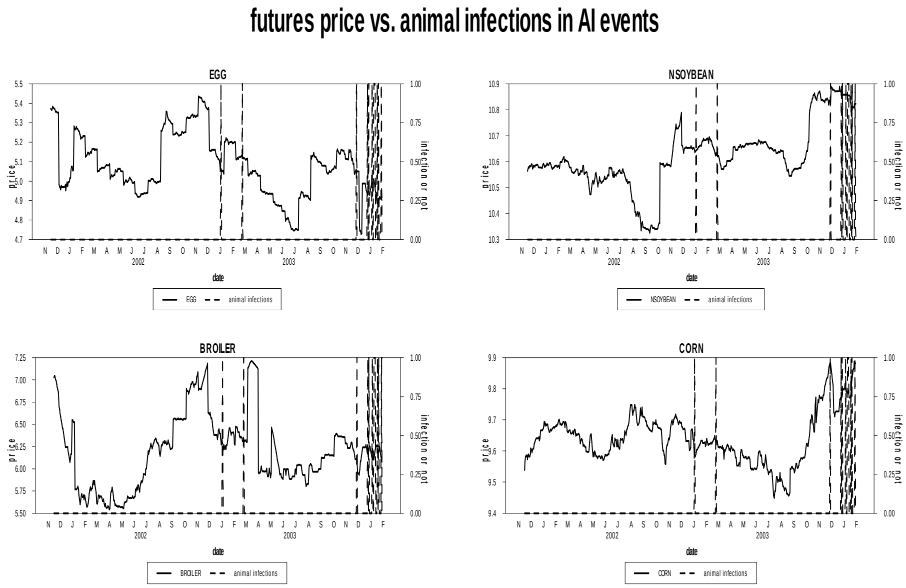


Figure 18. Plot of nearby futures contracts' prices, 11/30/2001-02/12/2004

Table 25. Summary Statistics among Daily Futures Contract Prices for Agricultural Commodities Traded in Japanese Futures Markets, 11/30/2001-02/12/2004

Agricultural futures	Mean	Minimum	Maximum	Standard Deviation	Coefficient Variation
Egg	167.2	112.9	283.2	32.8	0.196
Broiler	526.6	262	1329	202.6	0.385
Non-GMO Soybean	42927.4	28740	66380	7144.8	0.166
Corn	16257.2	13060	21800	1704.5	0.105

Note:

1) Observed data are daily adjusted close futures contract prices for each agricultural commodity as Japanese Yen per kilogram for egg and broiler and Japanese Yen per 1000 kilograms for others.

2) The coefficient of variation is calculated as SD/Mean for each firm.

Table 26. Tests for non-stationarity of levels and first differences of among daily close prices for agricultural futures contracts traded in Japanese futures markets, 11/30/2001-02/12/2004

Firms		Dickey –Fuller Test (DF)		Augmented Dickey Fuller Test (ADF)	
		t-statistics	Q(3)-statistics (p-value)	t-statistics (k)	Q(3)-statistics (p-value)
Levels Of Data	Egg	-2.257	2.35 (0.502)	-2.35 (1)	1.044 0.790)
	Broiler	-2.954	8.44 (0.037)	-2.70 (1)	1.55 (0.669)
	Nsoybean	-0.031	19.98(0.0001)	-0.206(1)	5.51 (0.137)
	Corn	-1.702	9.34 (0.025)	-1.735(1)	0.367(0.946)
1st Difference Of Data	Egg	-27.16	0.612 (0.893)	-1.23 (1)	0.588(0.899)
	Broiler	-26.077	1.53 (0.675)	-18.74 (1)	0.725(0.867)
	Corn	-24.937	5.42 (0.143)	-17.20 (1)	1.419(0.701)
	Nsoybean	-23.27	7.94 (0.047)	-16.91 (1)	6.392(0.094)

Note: The columns under the heading "DF" refer to the Dickey-Fuller test on the null hypothesis that the price data from the market class listed in the far left-hand-most column are non-stationary in levels (non-differenced data). The test for each series of price data is based on an ordinary least squares regression of the first differences of prices from each market on a constant and one lag of the levels of prices (non-differenced prices) from each class. The t-statistic is associated with the estimated coefficient on the lagged levels variable from this regression. Under the null hypothesis the statistic is distributed in a non-standard t. Critical values are given in Fuller (1976). The 5% critical value is –2.86. We reject the null for observed t values less than this critical value. The associated Q-statistic is the Ljung-Box statistic on the estimated residuals from the above-described regression. Under the null hypothesis of white noise residuals Q is distributed chi-squared with 30 degrees of freedom. The p-value associated with the Q-statistic is given in parentheses, immediately to the right of the Q-statistic. We reject the null hypothesis for large values of Q or for low p-values (i.e. p-values less than .05). The columns listed under the heading "ADF" refer to the Augmented Dickey Fuller test associated with the null hypothesis that price data from the class listed in the far left-hand-most column are non-stationary in levels (same null as above). Here the test is of the same form as that described above, except that k lags of the dependent variable are added to the right-hand side of the DF regression. Here, the value for k is determined by minimizing Schwarz loss metric and Hannan Quinn's measure on values of k ranging from 1 to 6. [The ADF regression was run with lags of the dependent variable ranging from one lag to six lags. The Schwarz loss metric and Hannan Quinn's measure were minimized at the value given in the column headed by the label "k."] Again the critical value of the t-statistic is –2.86 and we reject for values of the calculated statistic less than this critical value.

Table 27. Loss Metrics on the Order of Lags (k) in a Log-levels Vector Autoregression among Daily Futures Prices for Agricultural Commodities Traded in Japanese Futures Markets, 11/30/2001–02/12/2004

Lag = k	**AIC**	**SIC**	**H&Q**
0	-15.33	-15.36	-15.31
1	-28.90	**-28.68***	**-28.77***
2	-28.94	-28.54	-28.70
3	-28.96	-28.37	-28.61
4	-29.02	-28.25	-28.56
5	-29.06	-28.11	-28.50
6	-29.11	-27.97	-28.45
7	-29.12	-27.80	-28.35
8	-29.14	-27.64	-28.26
9	-29.16	-27.48	-28.18
10	-29.18	-27.32	-28.09

Note: Metrics considered are Schwarz-loss (SL) and Hannan, and Quinn's M measure on lag length of a levels vector autoregression:
AIC = log (|Γ|) + (6 k)*2 / T

SIC = log (|Γ| + (6 k) (log T) / T,

H&Q = log (|Γ| + (2.01)* (6k) log (log T)) / T

where Γ is the error covariance matrix estimated with 8k + 1 (the 1 represents a constant) regressors in each equation, T is the total number of observations on each series, the symbol " | | " denotes the determinant operator, and log is the natural logarithm. We select that order of lag that minimizes the loss metric.
The asterisk("* ") indicates minimum.

Table 26 shows the unit root test statistics about these four futures prices. The common unit root tests are the Dickey-Fuller test and the Augmented Dickey-Fuller test. These two tests have a 5% critical value of -2.86 in term of Fuller (1976). Thus the Dickey-Fuller test points out that the futures price of broiler is stationary at 5% significance level. However, the Augmented Dickey-Fuller does not support that the broiler futures price is stationary at a 5% significance level. This study prefers the results of Augmented Dickey-Fuller test. Other prices in levels are nonstationary at the significance level of 5% in term of these two tests. All these four prices in the first differences are nonstationary at a 5% significance level in term of the tests.

Table 27 gives the results of optimal lag number of VAR model in levels for these four prices. The information criterion is used to pick up the optimal lag number of model such as Akaike information criterion (AIC), Schwarz Loss criterion (SIC) and Hanna and Quinn's Φ (H&Q). SIC and H&Q reach their minimum values at the model with one lag. The model needs more than ten lags if AIC reach its minimal value. Thus this study chooses the results of SIC and H&Q. The optical lag number is one.

Table 28 shows the results of cointegration rank test for these four futures prices. The trace test is used to examine their cointegration rank. The test results find that these four prices have no cointegration relation at 5% significance level. In other words, these four prices can not reach a long run equilibrium during the sample period. Liu (2005) found the cointegration relation among hog futures, corn futures and soybean meal futures. These four prices failing to show a cointegration relation could be caused by the seasonality of sample or structural change of sample. The cointegration tests are very sensitive to those two characters of sample.

Table 28.Tests of Cointegration Rank among Daily Futures Prices for Agricultural Commodity Contracts Traded in Japanese Futures Markets, 11/30/2001-02/12/2004

R	P-R	T*	C(5%)*	Decision	T	C(5%)	Decision
0	**4**	36.631	**53.423**	**F#**	34.841	**47.208**	**F**
1	**3**	20.117	**34.795**	**F**	18.905	**29.376**	**F**
2	**2**	5.940	**19.993**	**F**	5.491	**15.340**	**F**
3	**1**	1.422	**9.133**	**F**	0.983	**3.841**	**F**

Note: The number of cointegrating vectors (r) is tested using the trace test with the constant within and outside the cointegrating vectors. The test statistic (T) is the calculated trace test, associated with the number of cointegrating vectors given in the left-hand-most column. The critical values (C(5%)) are taken from Table B.2 (within) and Table B.3 (outside) in Hansen and Juselius (1995, p.80-81). The tests results presented in columns marked by an asterisk are associated with a constant within the cointegrating vectors. The un-asterisked columns are associated with tests on no constant in the cointegrating vectors, but a constant outside the vectors. The column labeled “D” gives our decision to reject (R) or fail to reject (F), at a 5 per cent level of significance, the null hypothesis of the number of cointegrating vectors (r=0, $r \leq 1, \ldots, r \leq 7$). Following Johansen (1992), we stop testing at the first “F” (failure to reject) when starting at the top of the table and moving sequentially across from left to right and from top to the bottom. The symbol (#) indicates the stopping point. Here we fail to reject the hypothesis that we have one cointegrating vectors with constants in the cointegrating vectors. Recent work on the selection of the number of cointegrating vectors has focused on the use of information criteria (AIC or Schwarz loss). Such criteria can be successfully applied to solve both the lag length and rank problem; see Kapetanios (2003) and Aznar and Salvador (2002).

Table 29. Forecast Error Decompositions on Daily Prices for Four Futures Contracts Publicly Traded in Japanese Futures Markets, 11/30/2001-02/12/2004

Horizon	Egg	Broiler	Non-GMO soybean	Corn
Egg Futures				
0	100.000	0.000	0.00	0.000
1	99.829	0.112	0.005	0.054
2	99.829	0.112	0.005	0.054
22	99.829	0.112	0.005	0.054
Broiler Futures				
0	0.000	100.000	0.00	0.000
1	0.005	99.974	0.017	0.004
2	0.005	99.973	0.017	0.005
22	0.005	99.973	0.017	0.005
Non-GMO Soybean Futures				
0	0.000	1.389	96.091	0.000
1	0.007	1.376	95.449	2.520
2	0.007	1.376	95.439	3.178
22	0.007	1.376	95.438	3.179
Corn Futures				
0	0.000	0.000	0.000	100.000
1	0.017	0.004	0.114	99.864
21	0.018	0.004	0.116	99.862
43	0.018	0.004	0.116	99.862

Note: Decompositions at each step are given for a “Bernanke” factorization of the innovation correlation/covariance matrix. The decompositions sum to one hundred in any row.

Table 30. Abnormal Returns and Cumulative Abnormal Returns in the Event Window, 01/09/2004-01/16/2004

	AR_{-1}	AR_0	AR_{+1}	AR_{+2}	AR_{+3}	AR_{+4}	AR_{+5}	$CAR_{-1,+5}$
Egg	0.008 (0.359)	0.001 (0.931)	-.017** (0.047)	-0.000 (0.976)	0.026* (0.002)	0.017** (0.046)	0.018** (0.033)	0.053** (0.021)
Broiler	0.054*** (0.064)	-0.00 (0.995)	0.040 (0.171)	-0.003 (0.930)	-0.047 (0.104)	-0.012 (0.682)	-0.037 (0.204)	-0.005 (0.946)
Non-GMO soybean	-0.010 (0.222)	0.001 (0.869)	0.003 (0.685)	0.001 (0.909)	0.000 (0.985)	0.000 (0.970)	0.000 (0.994)	-0.005 (0.837)
Corn	0.011 (0.337)	-0.002 (0.878)	0.022** (0.046)	-0.003 (0.790)	-0.002 (0.864)	0.004 (0.689)	0.014 (0.198)	0.044 (0.128)

Note: AR denotes the abnormal return. AR_{-1} is the abnormal return on 09January 2004; AR_0 is the abnormal return on 12 January 2004, the date of announcing the first case of avian influenza virus of H5N1 in Japan. $CAR_{-1,+5}$ is the cumulative abnormal return for the whole window. The values in the brackets are the P-values of corresponding AR, (*) indicates 1% significance level; (**) indicates 5% significance level; (***) indicates 10% significance level.

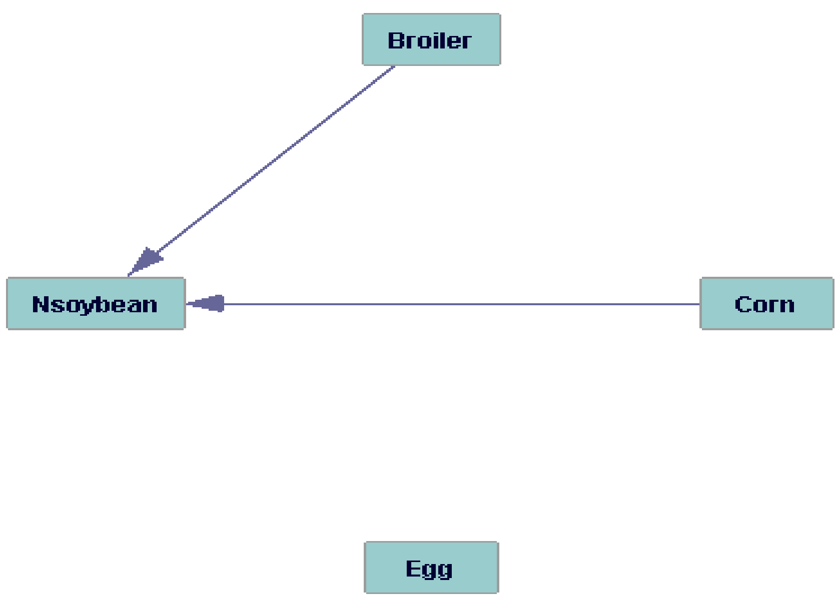


Figure 19. Plot of contemporaneous causal relationship among these four futures contracts, 11/30/2001-02/12/2004

There is no cointegration relation among these four futures. Thus this study employs a VAR with asymmetric GARCH model to estimate the abnormal returns (AR) of events, avian influenza outbreaks in Japan. Their estimation results are shown in the table 30. Only the cumulative abnormal return (CAR) of egg futures contract is statistically significant at 5% levels. Others' CARs are not different from zero at the 10% significance level.

The abnormal returns of egg futures are statistically different from zero at 5% significance levels on the first, third, fourth and fifth days following the announcement. The broiler futures only have statistically significant abnormal return at a 10% significance level on the business day ahead of the announcement day. That positive return of 0.054 may indicate the information leakage of avian influenza outbreaks in Japan. The Non-GMO soybean futures contract has no daily abnormal returns significantly different from zero. The corn futures contract only has a statistically significant abnormal return on the first day following the announcement day. Its value is 0.022.

Thus, this study finds the announcement of avian influenza outbreaks in Japan only affects the price of egg futures contract in 6-days window. The announcement has little significant effect on other three futures contracts. The possible reason for this different response of contracts is that Japan is an egg producer and exporter, and importer of broiler, soybean and corn. The positive value of cumulative abnormal return of egg futures supports the findings of Ishida, Ishikawa and Fukushige (2006). They found that the avian influenza outbreaks in Japan increase the spot price of poultry in Japan even though the demand for poultry does not change too much.

This study finally examines the contemporaneous interdependence among these four futures. The result is given in the figure 19. The egg futures is independent from others. Both the broiler futures and corn futures affect the non-GMO soybean futures, and formulate an information fork.

Table 31 show the main coefficient estimation in the asymmetric GARCH-M model. This study finds that the return of egg futures are affected by the one lag return of itself and broiler futures, and its own current and one lag variances. And the asymmetric effect is examined in its variance equation. However, positive residual, negative residual and one lag variance help reduce future volatility. The return of broiler futures is not influenced by other futures return, and even its own current and lagged variances. In its variance equation, positive residual and lagged variance increase future variance without asymmetric effect. The return of Non GMO soybean futures are affected by its own lagged return and variance, and other futures lagged return. the asymmetric effect is found in its variance equation. The return of corn futures is only impacted by its own lagged return. the asymmetric effect is not found in its variance equation. The detailed information can be obtained in the table 31.

Conclusions

This study explores the effects of avian influenza announcement in Japan on the agricultural commodity futures contracts traded in Japanese futures markets. Both the cointegrated-VAR model and the event study method are used to examine whether avian influenza outbreaks significantly affect the agricultural commodity futures market in Japan. Our findings point out that only the avian influenza outbreak impacts the egg futures contract, raising its contract price. The price increase is consistent with the findings of Ishida, Ishikawa and Fukushige (2006). The futures contracts of broiler, non GMO soybean and corn are not affected by avian influenza outbreaks in Japan. This difference could be caused by that the different status of Japan in importing and exporting agricultural commodity. And the six-day window may be too short to examine the avian influenza outbreaks' effects.

The future research will test long run effect of avian influenza outbreaks in Japan. The model is constructed considering the structural change and high frequency volatility.

Table 31. Estimation of Asymmetric GARCH-M Model

	Mean Equation						Variance Equation			
	R^{egg}_{t-1}	$R^{broiler}_{t-1}$	$R^{soybean}_{t-1}$	R^{corn}_{t-1}	GARCH	GARCH (-1)	constant	Residual (+)	Variance (-1)	Residual (-)
R^{egg}_{t}	-0.015 (0.003)	0.011 (0.015)	-0.026 (0.350)	-0.037 (0.503)	53.312 (0.000)	3.384 (0.000)	0.0001 (0.000)	-0.007 (0.000)	-0.075 (0.000)	-0.002 (0.000)
$R^{broiler}_{t}$	0.008 (0.796)	0.015 (0.154)	-0.072 (0.258)	-0.026 (0.793)	-1.565 (0.789)	-1.980 (0.552)	0.0002 (0.000)	0.309 (0.004)	0.206 (0.042)	0.210 (0.271)
$R^{soybean}_{t}$	0.012 (0.000)	-0.001 (0.000)	0.066 (0.000)	-0.065 (0.000)	5.943 (0.107)	-11.484 (0.000)	0.0001 (0.000)	-0.030 (0.000)	-0.324 (0.000)	0.004 (0.000)
R^{corn}_{t}	-0.011 (0.351)	0.004 (0.375)	-0.004 (0.885)	0.142 (0.001)	11.101 (0.542)	15.535 (0.306)	0.000 (0.002)	0.172 (0.014)	0.679 (0.000)	-0.011 (0.858)

CHAPTER V

GENERAL CONCLUSION AND DISCUSSION

This study investigates the impacts of bird flu outbreaks as manifest in financial markets within the US and Japan. The study is composed of three essays each looking at different aspects of the issue.

The first essay explores the impact of AI events on some poultry-related stock prices. Initially, this study employs the partial equilibrium analysis to develop expectations about impacts of AI outbreaks inside or outside a poultry exporting country in term of effects on poultry meat or egg producers and poultry food producers; then it empirically investigates how actual AI outbreaks in Asia and US affected five poultry-related firms publicly traded in the US stock market using historical decomposition analysis and the vector error correction model. Recent developments in search method of cointegration rank and directed graphs are applied in this study as well. Empirical results support the expected results: AI outbreaks inside the country drop stock prices of poultry meat producers and raise stock prices of poultry food producers; AI outbreaks in other poultry meat exporting countries raise stock prices of poultry meat producers and drop stock prices of poultry food producers. This study is the first one to investigate the firm-level stock price consequences of AI outbreaks impacts. It is the first one to employ the historical decomposition to analyze stock price behaviors. The findings of this study carry some important implications. First, it provides evidence that AI outbreaks in different countries have significantly different effects on stock price behaviors of poultry-related firms depending on whether the outbreak is in or outside of the country. Second, the model and its results in this study can be used to analyze the impacts of other animal diseases or food safety events on stock prices of related firms. Finally, this study can help understand how the change of international trade affects stock prices of the related firms.

The second essay examines whether avian influenza outbreaks in early 2004 had a long run effect on the stock price investigated in essay one, or whether avian influenza outbreaks cause structural breaks in models of their stock price behavior. This study employs dynamic programming algorithm and reduced regression method for a cointegrated-VAR model to compute the break dates for data from 01 June 2001 to 16 April 2007. This study find the avian influenza outbreak in the early 2004 did not cause the structural breaks of model. The estimated model was found to have two structure breaks as selected by AIC, SIC and H&Q's Φ. These two break dates are 20 March 2003 and 08 March 2005. This study continues to compare long run relations, short run relations and contemporaneous relations, plus model behavior in the three sub-periods divided by breaks. We find behavior in the three sub-sample is significantly different and that the breaks were likely caused by the invasion of Iraq on 20 March 2003 and the BSE induced ban of Canadian live cattle imports to the US on 03 March 2005, not by the event of avian influenza outbreaks in early 2004 or other possible events around relative period.

The third essay explores the effects of avian influenza outbreak announcements on the agricultural commodity futures contracts traded in Japanese futures markets. Both the cointegrated-VAR model and the event study method are used to examine whether avian influenza outbreaks significantly affect the agricultural commodity futures market prices in Japan. Our findings point out that avian influenza outbreak only impacted the egg futures contract, raising its contract price. The price increase is consistent with the findings of Ishida, Ishikawa and Fukushige (2006). The futures contract prices for broiler, non GMO soybean and corn were not affected by bird flu outbreaks in Japan. This difference could be caused by that the different status of Japan in importing and exporting agricultural commodity. Also the six-day window may be too short to examine the avian influenza outbreaks' effects.

These three essays find that outbreaks of avian influenza have significant impacts on poultry-related stock prices and futures markets. These examined impacts change the movement of those financial equity prices in the short run, but not in the long run. However, investors and poultry-related producers still encounter huge financial risk and loss. Further research should take steps to measure the quantity of possible risk and loss.

REFERENCES

Awokuse T.O., A. Chopra, and D. A. Bessler. 2009. “Structural Change and International Stock Market Interdependence: Evidence from Asian Emerging Markets.” *Economic Modelling* 26: 549-559.

Bai, J. 2000. “Vector Autoregressive Models with Structural Changes in Regression Coefficients and in Variance-Covariance Matrices.” *Annals of Economics and Finance* 1:301-336.

Bai, J., and P. Perron. 1998. “Estimating and Testing Linear Models with Multiple Structural Changes.” *Econometrica* 66:47-78.

--- 2003. “Computation and Analysis of Multiple Structural Change Models.” *Journal of Applied Econometrics* 18:1-22.

Bessler, D.A. and S. Lee. 2002. “Money and Prices: US Data 1969-1914 (A Study with Directed Graphs).” *Empirical Economics* 27, 427-446.

Bollerslev, T. 1986. "Generalized Autoregressive Conditional Heteroskedasticity." *Journal of Econometrics* 31: 307-327.

Brown S., D. Madison, H. L. Goodwin, and F. D. Clark. 2007. “The Potential Effects on United States Agriculture of An Avian Influenza Outbreak.” *Journal of Agricultural and Applied Economics* 39(2), 335-343.

Chopra, A., and D. A. Besssler. 2005. “Impact of BSE and FMD on Beef Industry in U.K.” Working Paper, Department of Agricultural Economics, Texas A&M University.

Cortazar, G., C. Milla, and F. Severino. 2008. "A Multicommodity Model of Futures Prices: Using Futures Prices of One Commodity to Estimate The stochastic Process of Another." *The Journal of Futures Markets* 28(6):537-560.

Demiralp, S. and K. D. Hoover. 2003. "Searching for the Causal Structure of a Vector Autoregression." *Oxford Bulletin of Economics and Statistics* 65(Suppl), 227-271.

Djunaidi, H., and C. M. Djunaidi. 2007. "The Economic Impacts of Avian Influenza on World Poultry Trade and the US Poultry Industry: A Spatial Equilibrium Analysis." *Journal of Agricultural and Applied Economics* 39(2), 313-323.

ECLAC (The Economic Commission for Latin America and the Caribbean of the United Nation). 2006. Latin America and the Caribbean in the World Economy in 2005 and 2006. New York: United Nations Publications.

Econstats. The Nearby Commodity Futures Prices. Accessed on 29 January 2009, http://www.econstats.com/fut/index.htm

Elyasiani, E., and A.E. Kocagil. 2001. "Interdependence and Dynamics in Currency Futures Markets: A Multivariate Analysis of Intraday Data." *Journal of Banking and Finance* 25:1161-1186.

Engle, R. F. 1982. "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of U.K.Inflation," Econometrica 50: 987-1008.

Engle, R. F., D. M. Lilien, and R. P. Robins. 1987. "Estimating Time Varying Risk Premia in the Term Structure: The ARCH-M Model." *Econometrica* 55: 391-407.

Glosten, L. R., R. Jagannathan, and D. Runkle. 1993. "On the Relation between the Expected Value and the Volatility of the Nominal Excess Return on Stocks." *Journal of Finance* 48: 1779-1801.

Gourieroux, C. and J. Jasiak. 2001. Financial *Econometrics: Problem, Models and Methods*. New Jersey: Princeton University Press.

Hamilton, J.D. 1983. "Oil and the Macroeconomy since World War II." *Journal of Political Economy* 91(2): 228-248.

Hansen, P.R. 2003. "Structural Changes in the Cointegrated Vector Autoregressive Model." *Journal of Econometrics* 114:261-295.

Hansen, H., and S. Johansen. 1999. "Some Tests for Parameter Constancy in Cointegrated VAR-models." *Econometrics Journal* 2： 306−333

Hawkins, D.M. 1976. "Point Estimation of the Parameters of Piecewise Regression Models." *Applied Statistics* 25:51-57.

Henson, S. H., and M. Mazzocchi. 2002. "Impact of Bovine Spongiform Encephalopathy on Agribusiness in the United Kingdom: Results of an Event Study of Equity Prices." *American Journal of Agricultural Economics* 82: 370-386.

Ishida, T., N. Ishikawa, and M. Fukushige. 2006. "Impact of BSE and Bird Flu on Consumers' Meat Demand in Japan." Working Paper, Graduate School of Economics, Osaka University.

Jennrich, R.L. 1970. "An Asymptotic Chi-square Test for the Equality of Two Correlation Matrices." *Journal of American Statistical Association* 65:904-912.

Jin, H.J. and J. Kim. 2008. "The Effects of the BSE Outbreak on the Security Values of US Agribusiness and Food Processing Firms." *Applied Economics* 40: 357-372.

Johansen, S. 1991. "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models." *Econometrica* 59: 1551-1580.

Johansen, S. 1992. “Determination of Cointegration Rank in the Presence of Linear Trend.” *Oxford Bulletin of Economics and Statistics* 52:169-210.

Johansen, S. 1995. *Likelihood-Based Inference in Cointegrated Vector Autogressive Models*. New York: Oxford University Press Inc.

Johansen, S., and K. Juselius. 1990. “Maximum Likelihood Estimation and Inference on Cointegration with Application to the Demand for Money.” *Oxford Bulletin of Economics and Statistics* 52: 169-210.

---. 1994. “Identification of Long-run and Short –run Structure: Application to ISLM Model.” *Journal of Econometrics* 63: 7-63.

Juselius, K. 1995. “Do Purchasing Power Parity and Uncovered Interest Rate Parity Hold in the Long Run? An Example of Likelihood Inference in a Multivariate Time-Series Model.” *Journal of Econometrics* 69: 211-240.

Kennedy, S., J. Thomson, and P. Vujaovic. 2006. A primer on the macroeconomic effects of an influenza pandemic, Working Paper, Australian Department of Treasure.

Kim, I. 1997. “Detecting the Number of Structural Breaks.” *Economics Letters* 57:145-148.

Liu, Q. 2005. “Price Relations among Hog, Corn, and Soybean Meal Futures.” *The Journal of Futures Markets* 25(5):491-514.

Lusk, J.L. and T.C. Schroeder. 2002. “Effects of Meat Recalls on Futures Market Prices.” *Agricultural And Resource Economics Review* 31(1):47-58.

Nicita, A. 2008. “Avian Influenza and the Poultry Trade.” Working Paper, The World Bank.

Obayelu, A.E. 2007. “Socio-economic analysis of the impacts of avian influenza epidemic on households’ poultry consumption and poultry industry in Nigeria: Empirical investigation of Kwara State.” *Livestock Research for Rural Development* 19(4). Retrieved August 2, 2009, from http://www.lrrd.org/lrrd19/1/obay19004.htm.

Paarlberg, P.L., A. H. Seitzinger and J. G. Lee. 2007. “Economic Impacts of Regionalization of a Highly Pathogenic Avian Influenza Outbreak in the United States.” *Journal of Agricultural and Applied Economics* 39 (2): 325-333.

Qu, Z., and P. Perron. 2007. “Estimating and Testing Structural Changes in Multivariate Regressions.” *Econometrica* 75:459-502.

Rushton J., R. Viscarra, E. Guerne Bleich, and A. McLeod. 2005. “Impact of Avian Influenza Outbreaks in the Poultry Sectors of Five South East Asian Countries (Cambodia, Indonesia, Lao PDR, Thailand, Viet Nam) Outbreak Costs, Responses and Potential Long Term Control.” *World's Poultry Science Journal* 61:491-514.

Saghaian, S. H., L. J. Maynard and M. R. Reed. 2007. “The Effects of E.Coli 0157:H7, FMD and BSE on Japanese Retail Beef Prices: a Historical Decomposition.” *Agribusiness* 23: 131-147.

Scheines, R., P. Spirtes, C. Glymour, C. Meek, and T. Richardson. 1996. *Tetrad III Tools for Causal Modeling: User’s Manual*. Accessed on 29 July 2009, http://www.phil.cmu.edu/projects/tetrad/tet3/master.htm.

Seo, B. 1998. “Tests for Structural Change in Cointegrated Systems.” *Econometric Theory* 14:222-259.

Swanson, N.R., and C.W. J. Granger. 1997. “Impulse Response Functions Based on a Causal Approach to Residual Orthogonalization in Vector Autoregressions.” *Journal of the American Statistical Association* 92:357-367.

Tse, Y., and J.C. Hackard. 2006. “Holy Mad Cow! Facts or (Mis)Perceptions: A Clinical Study.” *The Journal of Futures Markets* 26(4):315-341.

Wang, Z. and D. A. Bessler. 2005. “A Monte Carlo Study on the Selection of Cointegrating Rank Using Information Criteria.” *Econometric Theory* 21: 593-620.

Yahoo Finance. The Daily Adjusted Stock Closing Prices. Accessed on 28 July 2009, http://finance.yahoo.com/

Yang, J. and D. A. Bessler. 2008. “Contagion around the October 1987 Stock Market Crash.” *European Journal of Operational Research* 184: 291- 310.

Yao, Y. 1988. “Estimating the Number of Change-points via Schwarz’ Criterion.” *Statistics & Probability Letters* 6:181-189.

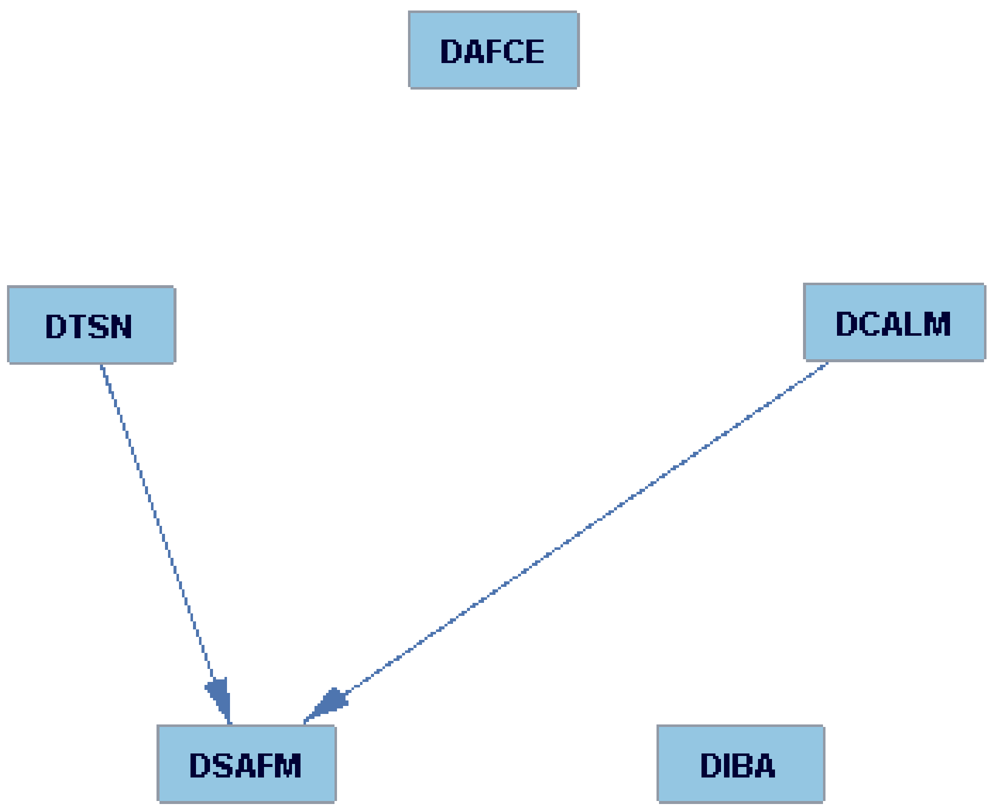
APPENDIX A

Timeline and countries and virus types of AI outbreaks during January 8, 2004 to March 15, 2004.

Timeline	Country	Virus Type
January 8, 2004	Vietnam	H5N1
January 11, 2004	Japan	H5N1
January 20, 2004	Taipei China	H5N1
January 23, 2004	Thailand	H5N1
January 26, 2004	Cambodia, and Hong Kong	H5N1
January 27, 2004	Laos	H5N1
February 2, 2004	Indonesia	H5N1
February 4, 2004	China	H5N1
February 11, 2004	Delaware, USA	H5N2
February 19, 2004	Canada	H7N2
February 23, 2004	Texas, USA	H7N2
March 15, 2004	Canada	H7N2

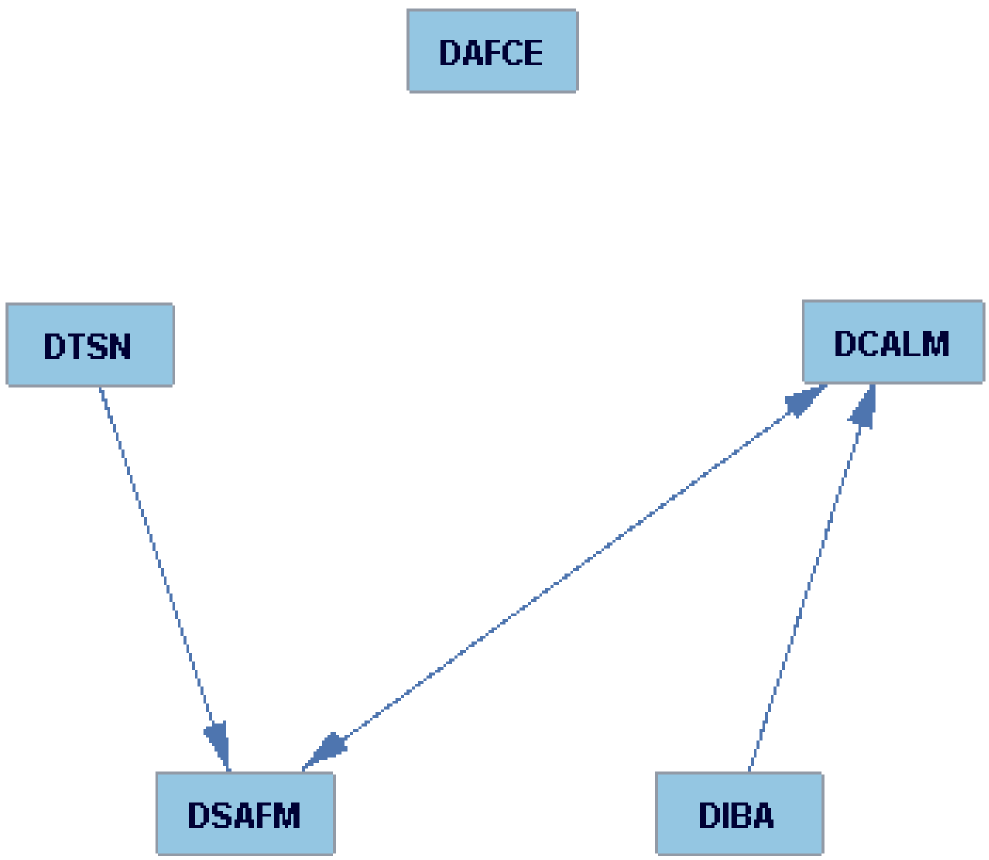
APPENDIX B

Pattern found with PC algorithm with its P-value = 0.03 on innovations from a VEC model on daily stock prices for five poultry related firms publicly traded in US stock markets, 06/01/2001–04/16/2007



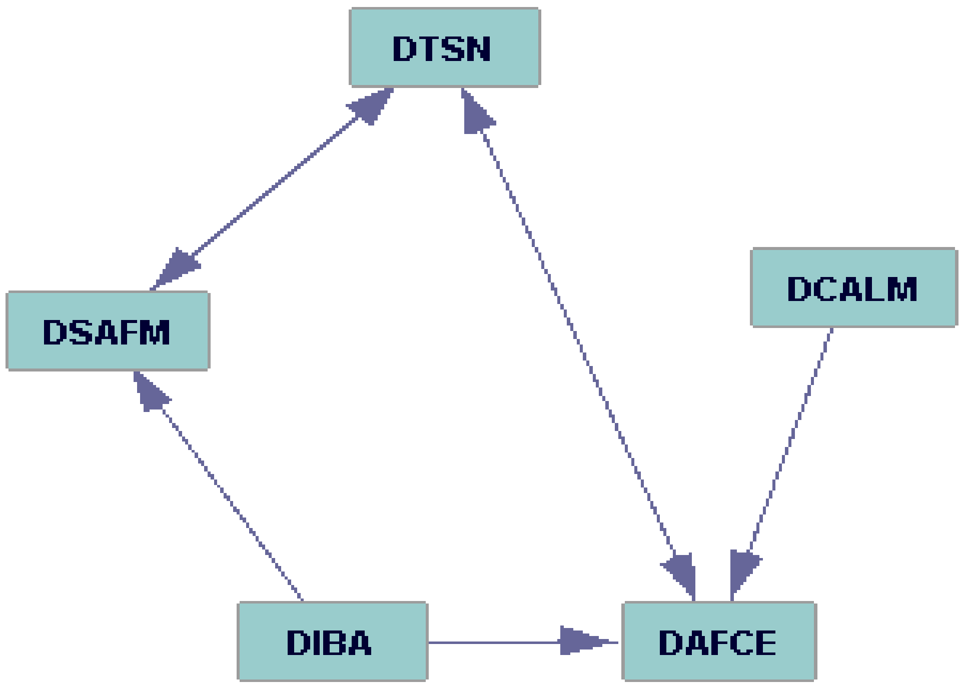
APPENDIX C

Pattern found with PC algorithm with its P-value = 0.05 on innovations from a VEC model on daily stock prices for five poultry related firms publicly traded in US stock markets, 06/01/2001–04/16/2007



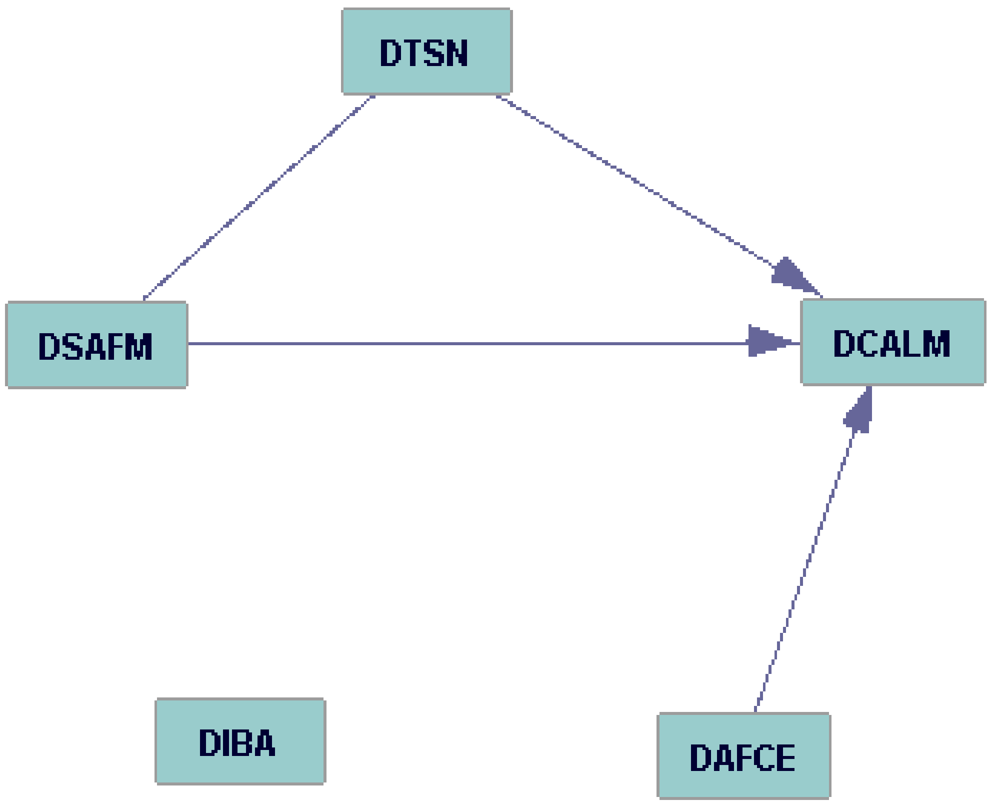
APPENDIX D

Contemporaneous interrelationship at 5% significance level, 06/01/2001-03/19/2003



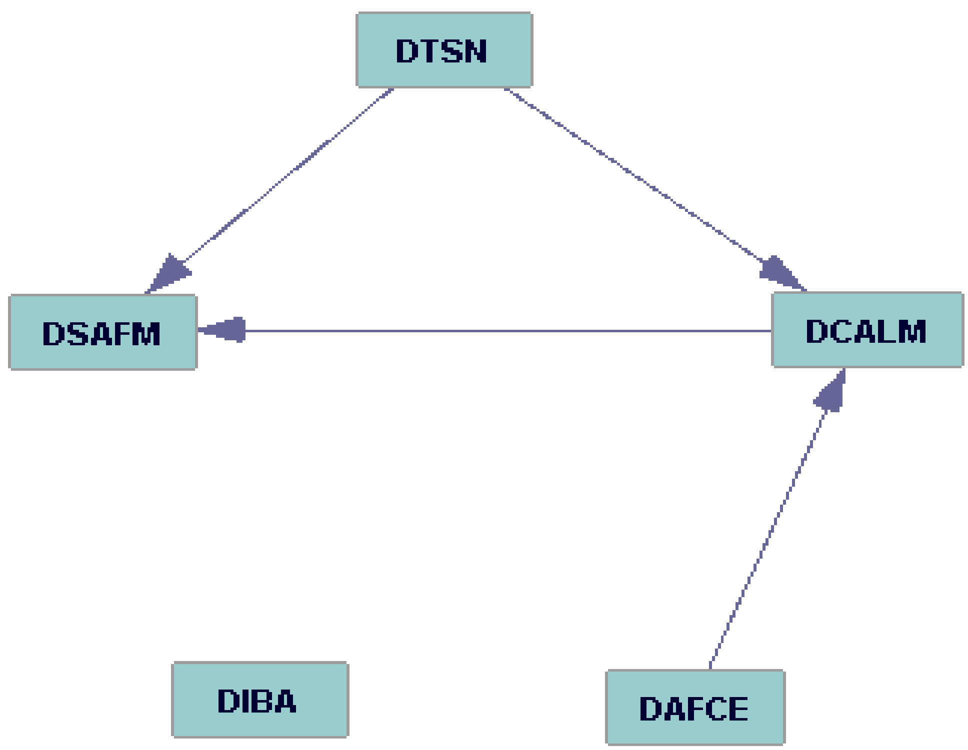
APPENDIX E

Contemporaneous interrelationship at 1% significance level, 03/20/2003-04/16/2003



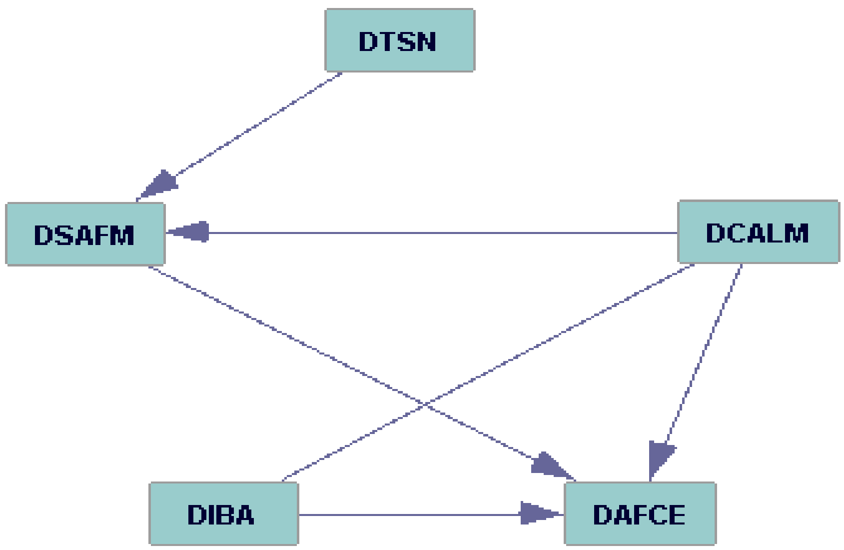
APPENDIX F

Contemporaneous interrelationship through GES algorithm, 03/20/2003-06/16/2003



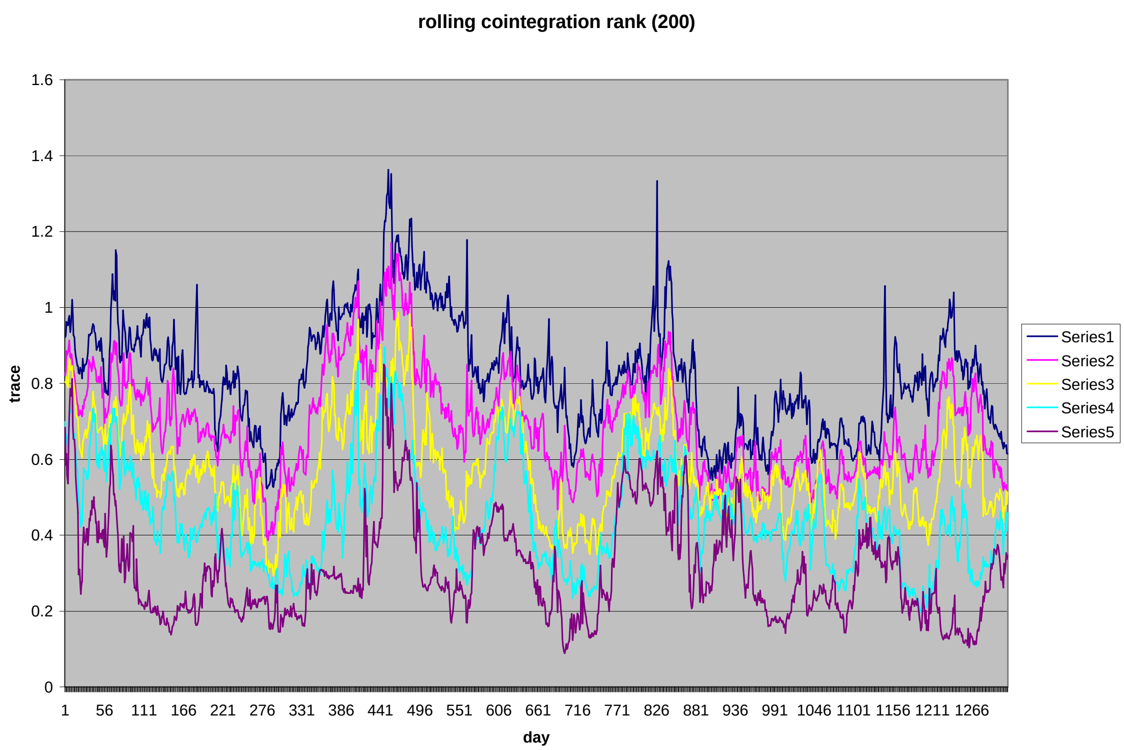
APPENDIX G

Contemporaneous interrelationship at 15% significance level, 03/08/2005-04/16/2007



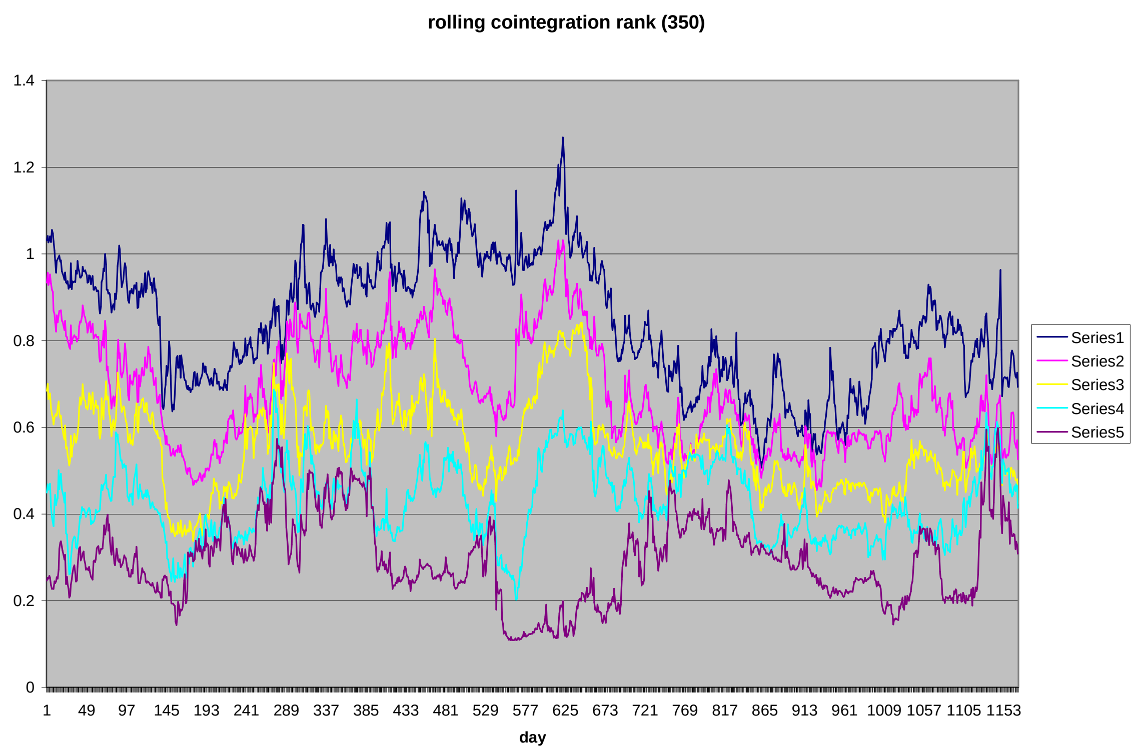
APPENDIX H

Rolling cointegration rank test with 200-day window



APPENDIX I

Rolling cointegration rank test with 350-day window



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