

IMPACT OF CHANGES IN DIETARY PREFERENCES ON U.S. RETAIL  
DEMAND FOR BEEF: HEALTH CONCERNS AND THE ROLE OF MEDIA

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Title

Impact of Changes in Dietary Preferences on U. S. Retail

Demand for Beef: Health Concerns and the Role of Media



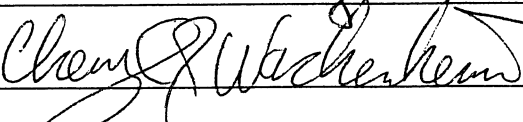
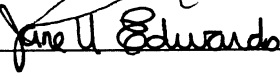
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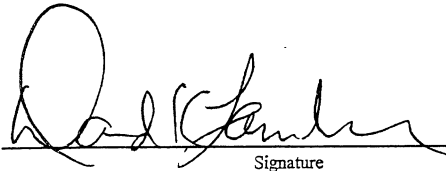
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## ABSTRACT

Mostad, Daniel Alfred; M.S.; Department of Agribusiness and Applied Economics; College of Agriculture, Food Systems, and Natural Resources; North Dakota State University; November 2005. Impact of Changes in Dietary Preferences on U.S. Retail Demand for Beef: Health Concerns and the Role of Media. Major Professor: Dr. Dragan Miljkovic.

This study uses econometric tools to determine the effect changing dietary preferences has on farm-level price and production of red meat. The study will determine how and what affects changes in the beef index. Causality and cointegration tests have been performed on the data to solve two underlying questions of which factor causes which response and what is the total effect of those changes.

The results of the tests will help better explain if changes to dietary preferences in United States citizens have an effect on the demand for beef. The study also looked into how the role of media affects changes in dietary preferences. These results will allow us to make conclusions as to if media causes changes in dietary preferences or if the changes cause more media reports on the topic. This will give insight into how the role of media “frenzies” can, in turn, affect demand for beef.

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## TABLE OF CONTENTS

ABSTRACT.....	iii
ACKNOWLEDGEMENTS.....	iv
LIST OF TABLES.....	vii
LIST OF FIGURES.....	viii
CHAPTER 1. STATEMENT OF PROBLEM.....	1
Introduction.....	1
Background Information About Low-Carb Diets.....	2
Obesity in the United States.....	3
Problem Statement and Objectives.....	5
Hypothesis.....	5
Organization.....	6
CHAPTER 2. LITERATURE REVIEW.....	7
Introduction.....	7
Low-Carbohydrate Diets.....	7
Beef Demand.....	12
Economic Herding.....	16
CHAPTER 3. THEORETICAL MODELS.....	19
Introduction.....	19
Augmented Dickey Fuller Test.....	19
Cointegration Test.....	21
Granger Causality and Vector Error Correction.....	23
Impulse Response Function.....	25

CHAPTER 4. DATA AND RESULTS .....	27
Introduction.....	27
Data.....	27
Long-Run Link Between Health Concerns and Demand for Beef .....	30
The Causality Between the Media Coverage of Specific Diet Types and the Demand for Beef: Short-Run Link .....	35
Herd Behavior: An Explanation for Short-Run Causality Results .....	38
CHAPTER 5. SUMMARY AND CONCLUSIONS.....	40
Problem.....	40
Procedures and Data .....	40
Results.....	42
Conclusions and Implications.....	43
REFERENCES .....	45

**LIST OF TABLES**

<u>Table</u>	<u>Page</u>
1. Summary Statistics .....	30
2. Augmented Dickey-Fuller Results.....	31
3. Cointegration Analysis: Multivariate Johansen Test .....	32
4. Pairwise Granger Causality Tests .....	35

**LIST OF FIGURES**

<u>Figure</u>	<u>Page</u>
4.1. Frequency of Newspaper Articles Published on Major Diets.....	29
4.2. Beef Index 1990:I-2004:IV (1998=100).....	29
4.3. Impulse Response Functions .....	33

## **CHAPTER 1**

### **STATEMENT OF PROBLEM**

#### **Introduction**

Demand for red meat is affected by many different factors. These circumstances can include agricultural policy, foreign demand, and prices of substitutes. Another source that can affect the price and production of red meat is the way in which the population eats. Dietary preferences have an effect on the demand for red meats.

U.S. beef producers faced a significant and serious decline in the domestic demand for beef products between 1980 and 1998. According to Schroeder (2000) and Marsh (2003), per capita retail beef demand declined by almost 50 percent between 1980 and 1998. In 1998, a Beef Demand Study Group (BDSG) was formed in an attempt to stabilize or increase consumer demand for beef. Since a measure of demand was needed, BDSG economists developed an annual retail beef demand index with the series starting in 1980 (Genho, 1998). The index measures yearly shifts in retail beef demand. Its purpose was to be used for planning and budgeting in accomplishing the BDSG goal. This index showed a steady decline in the retail demand for beef. Similar results can be found in publications by the Research Institute on Livestock Pricing (RILP) at Virginia Tech ([www.aaec.vt.edu/rilp/demandtop.html](http://www.aaec.vt.edu/rilp/demandtop.html)). Several studies have documented negative structural shifts in retail beef demand (e.g., Eales and Unneveher, 1988, 1993; Moschini and Meilke, 1989; Purcell, 1989; Purcell and Lusk, 2003; Schroeder, 2000). These negative structural shifts were attributed to a number of factors, including changing demographics, changing consumer preferences (e.g., food safety, health, or inconsistent quality), and changing meat prices.

A different phenomenon became observable in the late 1990s and during the first four years of this decade. According to BSDG or RILP (2004), retail demand index for beef increased rather significantly during that period of time. While this positive structural shift has not been formally analyzed yet, it has been speculated that the popularity of so called low-carb diets is responsible for it (e.g., Plain, 2004). Considering the fact that the majority of Americans (61 percent) today are either overweight or obese [Center for Disease Control (CDC) Behavioral Risk Survey, 2003], it comes as no surprise that many of them are on a weight-reducing diet program of some sort. The early 1990s brought a low-fat, low-cholesterol bonanza, and the New Diet Revolution of Dr. Robert Atkins has certainly been the most popular diet in the United States during the last 5-6 years. The low-fat, low-cholesterol diet has been accepted as a way to improve overall health and reduce weight. The low-carbohydrate diet has been used to lower weight for more cosmetic reasons than improving overall health. The Atkins diet is one of the so called low-carb diets. More than 17 percent of Americans were on a low-carb diet in 2004 (<http://www.acnielsen.com>). The low-carb diet limits the intake of carbohydrates (primarily grains, fruits, and milk) while promoting the increase in consumption of other foods (primarily meat, cheese, and eggs).

### **Background Information About Low-Carb Diets**

Low-carbohydrate diets have been around for many years, but only in the past ten to fifteen years have they become popular. The major source of popularity of these diets was the publication of a book entitled "Dr. Atkins New Diet Revolution," by Dr. Robert Atkins in 1992. This book detailed the first commercialized low-carbohydrate

diet that contradicted the USDA's Food Pyramid. Since the introduction of the "Atkins" diet, many other low-carbohydrate diets have been introduced. The list of low-carbohydrate diets is long, and most of these diets promote an increased level of protein. These proteins come from many different sources including red-meat, poultry, pork, fish, nuts, and eggs. Nearly 17% of Americans have reported someone in their household is participating in a low-carbohydrate diet (ACNielsen.com). This number of Americans is one of the leading reasons for this research.

### **Obesity in the United States**

According to the Surgeon General (2001), 61 percent of adults in the United States were overweight or obese. Obesity is measured commonly by the body mass index (BMI) which is weight in kilograms divided by height in meters squared. The convention is that overweight people have BMI above 25, while obese people have a BMI above 30. Thirteen percent of children aged 6 to 11 years and 14 percent of adolescents aged 12 to 19 years were overweight in 1999. This prevalence has nearly tripled for adolescents in the past 2 decades. The increases in overweight and obesity cut across all ages, racial and ethnic groups, and both genders. Approximately 300,000 deaths each year in the United States are associated with obesity. Obesity and being overweight are associated with heart disease, certain types of cancer, type 2 diabetes, stroke, arthritis, breathing problems, and psychological disorders, such as depression.

According to a few estimates, economic cost of obesity in the United States was about \$117 billion in 2000 alone (e.g., Lakadawalla and Philipson, 2002; Anderson et al., 2003; Cutler et al., 2003). The direct cost of obesity-related disease was estimated at \$61 billion, while indirect costs were estimated at \$56 billion. Direct costs, for

instance, are healthcare costs associated with physician visits and hospitalizations. Indirect costs are the value of lost wages by those who cannot work due to sickness or disability and foregone earnings due to premature death. Furthermore, overweight and obese people receive lower wages than those without weight problems. This may be because obesity-related illness reduces productivity or because of employer discrimination (Averet and Korenman, 1996; Cawley, 2000). Next, Cutler et al. (2003) argue that there might be 'internalities,' the costs borne by individuals themselves because of their higher weights. These internalities exist in the presence of self-control or addiction problems: people would like to eat less than they do, but have difficulty limiting their consumption. They are similar to externalities because they result from individuals who are consuming food and not internalizing the impact on their future happiness.

Cutler et al. (2003) further argue that people are willing to spend large amounts of money to try to lose weight. Survey evidence indicates that desired BMI rises much more slowly than actual BMI, suggesting that most overweight people would like to weigh less than what they do. If their finding is correct, there are two ways to accomplish the goal of losing weight. Considering the basic relationship of calories in versus calories out, people get heavier if they consume more calories or expend fewer calories. But many people are unwilling or unable to make the sacrifice of eating less and/or exercising more, and the actual question they are asking is: How can I lose weight without eating less and/or exercising more? This is the point where many dietary wizards come into play with proposed diets, often based on questionable scientific studies, which will supposedly resolve the problem of obese and overweight

people. The solution they often propose is to change the diet. The same foods have often been “healthy” at one time and “unhealthy” at a different time. Beef is one of the prime examples: it has been the main culprit in the low-fat, low-cholesterol boom during the early and mid 1990s, and the food of choice during the low-carb diet domination in the late 1990s and early 2000s. In this rollercoaster process, individual agricultural industries, including the beef industry, went through both major adversity and prosperity periods.

### **Problem Statement and Objectives**

This study was conducted to answer a few major questions. Is there a long run link between media coverage of a specific diet and the demand for beef? Another question that will be answered is if media coverage of popular diets (media frenzy) causes the change in retail demand for beef, or if it simply reports the facts about the changes in consumer dietary preferences. There have been many inferences made as to how the low-carb diet has affected beef demand, but a study of this type has not been provided conclusive evidence as to the answer to these questions. The case presented will focus on beef, but a study such as this can be tailored to any commodity that may be affected by any source of change in dietary preference.

### **Hypothesis**

It is expected that the change in consumers’ dietary preference, by way of using a low-carb diet, will have a positive affect on the demand for beef. This should be shown in both the long-term and short-term. This hypothesis is made based on the increase in protein in the diet and the lowering of carbohydrates and calories due to

restricted food choices. We also hypothesize that media can influence dietary preferences. The more exposure and attention the media gives a certain diet, the more influence it will have on changing dietary preferences in the consumers of that media.

### **Organization**

Chapter 2 will more thoroughly discuss the history and background of low-carb diets. The chapter will also describe the recent history of beef demand and will discuss a herd behavior model used in economics. Chapter 3 will detail and give some background on the econometric tests used in this study. The data and procedures used will be addressed in chapter 4. The whole study will be wrapped up in chapter 5, ending with conclusions and implications.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **Introduction**

The increase in the number of Americans who are overweight has increased the utilization of “fad” diets in America. This has also increased curiosity on how a specific type of diet (e.g. low-carb diet) affects demand for certain commodities it promotes. There are many versions of the low-carb diet and each has its own specific guidelines, but a common theme among them is to eat more foods high in protein and fewer foods high in carbohydrates. This chapter provides background on low-carb diets, recent history of beef demand, a brief review of the econometric tests used in this study and background information on economic herding.

#### **Low-Carbohydrate Diets**

A low carbohydrate diet is a diet that limits the intake of carbohydrates. However, low-carb diets are not always directly defined as high protein diets. The amount of carbohydrates consumed per day in each diet is different, but the majority of the low-carbohydrate diets allow around 50 grams of carbohydrates per day. Protein is a substitute for carbohydrates in many of these diets. The diet of fewer carbohydrates is supposed to induce the body to use fat and some protein for energy instead of relying on carbohydrates for energy.

Low-carb diets have been around for many years. There are reports that the first low-carb diet was implemented in 1864. They have recently gained popularity, along with criticism. Dr. Robert Atkins was the first to commercialize a low-carb diet, and he also was the first to criticize the USDA's Food Pyramid for containing 6-11 servings of

carbohydrates. Dr. Atkins diet plan was first marketed in 1972, but took off in popularity in 1992 when he released his book entitled, "Dr. Atkins New Diet Revolution," (Atkins, 1992).

There are many different types of commercialized low-carb diets. The first diet is the most popular and well known low-carb diet, "The Atkins Diet." This diet plan almost completely removes carbohydrates from your diet for the first 14 days. During that time the participant consumes meat, cheese, non-starchy vegetables, eggs, and nuts. After the first 14 days, the participant slowly reintroduces carbohydrates into the diet, but at lower levels than before the diet was started. The participant is also encouraged to drink plenty of water during the diet. The water flushes the body's cells of fat and toxins (Low Carb Café).

The next diet is called "Protein Power." This diet is similar to "The Atkins Diet," but puts more emphasis on eating protein. This diet limits carbohydrate intake to 30 – 50 grams a day. The diet has a formula that calculates how much protein a day you should consume. The determining factors in the calculation are your ideal body weight, lean body mass, and level of physical activity. The proteins in this diet come mostly from meats and eggs (Eades, 1996).

The "Carbohydrate Addict's Diet" is a diet that does not take carbohydrates completely out of your diet, but decreases the amount of carbohydrates each participant consumes in a day. The plan is to eat two low carbohydrate meals a day and one regular meal, which consists of an equal amount of vegetables, protein and carbohydrates. The idea behind this diet is to not deprive the participant of the carbohydrates they enjoy, but limit them (Heller, 1993).

"The Zone" diet is a diet of balance. The participants in this diet are told to eat the right balance of foods broken down into three categories: carbohydrates, proteins, and fats. This balance is determined by a calculation for each participant. The plan of the diet is to reach the determined balance, and at that point, your body will enter "The Zone" of optimal health and weight (Sears, 1997).

The list of low-carb diets is long, but the one thing that is similar in most of these diets is the increased level of protein in the diets. These proteins come from many different places including red meat, poultry, pork, fish, nuts, and eggs. Many of these diets also promote the consumption of healthy oils such as fish and olive oils ("Low Carb Café").

There are benefits and drawbacks to low-carb diets, just like any other diet. These pros and cons have been studied heavily since the popularity of the low-carb diet started to increase. However, there are no long-term studies that show how these diets will affect the body. The benefits and drawbacks presented are only from short-term studies. These studies have all taken place in under one year's time. However, some of these drawbacks and benefits are related to studies done when the body is deficient of certain nutrients. A major benefit of these diets is that they limit the number of foods one can eat. The reduction in carbohydrates reduces the response from the carbohydrate load insulin. There are also a few drawbacks to the low-carb diet. The first is that it is a hard diet to maintain; therefore, long-term weight control is poor. Also, the diet limits the intake of micronutrients, dietary fiber, and phyto-chemicals which are important in reducing one's risk of chronic disease. The diet has been proven to not be good for those who are athletically active because there is a lack of whole foods that the body

needs when performing strenuous activity (Eisenstein et al., 2002). A big concern about low carb diets from dietitians is the lack of calcium intake due to a lack of dairy products. This has a negative affect on the health of human bones. Cheese products can be consumed in these diets because the carbohydrates from milk are removed from the cheese as whey.

Low-carbohydrate diets have been compared to conventional diets to see how each performs on a similar group of participants. A 1-year study resulted in severely obese persons losing a greater amount of weight on the low-carb diet in the first 6-months. After the year was complete the weight loss between the two groups was comparable, but the effects on certain health measures such as triglyceride level, HDL cholesterol level, and glycemic control favored the low-carbohydrate diet. This was a short term study, but a long-term comparison is needed to show the true effectiveness of low-carb diets compared to conventional diet plans. The resulting higher weight loss from the low-carb diets was also thought to be a result of the lower caloric intake of this diet (Stern et al., 2004).

Many nutritionists and dietitians have been against low-carbohydrate diets from the start. Reasons for this are based on conventional wisdom and scientific research that the best diets for heart disease are diets low in saturated fat and high in starch (found in foods with high carbohydrates). This has been somewhat disproved as diets high in certain fats have not been shown to prove this wisdom. A variety of studies have proven that fat intake cannot predict risk of cancer and fat intake does not predict coronary heart disease. Also, the intake of certain fatty acids is very important to a person's health. The low-carb diet developed by Dr. Atkins works well, but nutritionists

do not think unlimited amounts saturated fats from meat, cheese and butter is good for their overweight patients (Willett, 2004).

Obesity amongst Americans from the age of 20 to 74 years old has risen from 13.4% in 1960 to 30.9% in 2000. This dramatic increase has created a demand for diets that work effectively and safely to lower the weight of people that are obese. Low-carbohydrate diets have been a popular way for these people to lose the weight. A systematic review of 94 different diets found insufficient evidence to make a recommendation to the public whether or not to participate in low-carbohydrate diets for a long period of time. These results show that more long-term research is still needed (Bravata et al., 2003).

A phone survey conducted in July 2004 by Opinion Dynamics Corporation found that 11 to 12% of American adults were participating in a low-carbohydrate diet. A majority of the respondents who said they were participants in these diets said that they were loyal to the low-carbohydrate diet and they have lost weight on the diet. The latest survey found that 32% of Americans were attempting to limit the number of carbohydrates that they consume. This number of adults who have a low-carbohydrate lifestyle (adults attempting to intake fewer carbohydrates) is a declining portion of the population. However, there is also greater participation in low-carbohydrate diets among families with higher incomes. They also found that even though many of the low-carbohydrate diets are also high-fat diets, the participants may also reduce the amount of fat in their diets. In addition the survey found that 66% of people who have lost weight on a low-carbohydrate diet have kept the weight off or are continuing to lose weight. Low-carbohydrate diets have an effect on certain food items. Low-

carbohydrate diets are specific as to what to consume and what foods to avoid. The survey showed that 42% of low-carbohydrate participants never eat pasta and 46% only consume pasta occasionally. Forty-one percent of low-carbohydrate participants never consume potatoes and 42% of those same participants only eat potatoes occasionally. This shows that the majority of low-carbohydrate participants are not consuming foods that are high in carbohydrates (Shiman, 2004).

### **Beef Demand**

A study was conducted from 1970-79 using data provided by Economic Research Service of the USDA (Chavas, 1983). Research conducted studying the structure of meat demand in the United States showed a decrease in price elasticity and income elasticity for beef. The decrease was very sharp from 1970-75. This decrease explains that consumers show a more consistent approach to their purchasing of beef. Pork did not show a change in overall demand during the time of the studying. The study used a linear model with randomly changing parameters.

A study determining the impact of declining beef demand on farm-level price and production used several inverse demands and primary supplies from the feeder cattle and slaughter cattle industries (Marsh, 2003). Annual data from 1970-1999 were used in the model. The biggest change that occurred in the time period 1975-1999 was the demand index for beef decreased by 65.9%. The measured effect on the price of beef was a decrease, in that same time period, of 39.8% for real slaughter cattle (includes: heifers, steers, bulls, dairy and beef cows) prices and 47.7% decrease for real feeder cattle prices. These lower prices caused a decrease in the overall margin that the producer received. The overall results of the study show that when the demand for beef

increases, so does the real slaughter price and supply as well as the feeder cattle price and supply. The study also looked at how promotional efforts from the government and other entities have affected the producers', packers', and retailers' margins. An increase in promotional efforts would positively impact all three parties, but the producers would have the least positive benefit of the group.

Gianacarlo Moshini and Karl D. Meilke performed a study trying to model the pattern of structural change in U.S. meat demand. They studied the affect of price and income on the consumption patterns of Americans. They used a linear model called an almost ideal demand system (AIDS). The data that were used were quarterly data ranging from 1967 to 1987 and used fish, beef, pork, and chicken demand from the USDA. The model and output provided the conclusion that price and income cannot explain the reasons for the fluctuations in the meat consumption (Moschini and Meilke, 1989).

The AIDS model was used in another study to test the endogeneity of prices and demand of meat in the U.S (Eales and Unneveher, 1993). This version of the AIDS model was different than in the Moschini study, because it was the inverse of the AIDS. This model produced results that tested for endogeneity in terms of prices, quantities or both. The data used in the study was the demand for beef, pork, chicken, non-meat food and all other food, from 1965 to 1989 (annually). The endogeneity test on the estimations helped determine if any of the prices can be predetermined by the quantities demanded for that meat. The tests on the models show that meat prices could not be predetermined in the meat market. The price and quantity for all meats are endogenous. The study also looked at the abrupt shift in demand that occurred after 1975. Eales and

Unneveher thought the abrupt shifts were due to supply-side shocks. The IAIDS (inverse AIDS) model showed that they cannot rule out a change in the demand structure. They concluded that the abrupt shift was due to supply-side shock as the supply-side instruments in the model showed significant changes in demand during that period.

The increasing technology used to produce genetically modified crops and hormones for cattle has raised some questions. Will consumers demand or reject genetically modified and hormone free meat? A study performed in France, Germany, the United Kingdom and the United States tried to determine each country's preferences to genetically enhanced meat (Lusk et al., 2003). The researchers conducted a survey to gather data for their model. The survey asked participants to pick between two steaks described by four different quality variables and one price variable. The survey also came with information describing the quality variables. The four variables were tenderness rating, marbling, if the animal had been produced with growth hormones, and if the animal had been fed genetically modified corn. The respondent could also choose neither of the two steaks. In the spring of 2000, there were 2500 surveys mailed out in the U.S., and 1000 mailed out in each France, Germany and the United Kingdom. The response rates were as follows: U.S. 29%, France 12%, Germany 7% and United Kingdom 15%. After the surveys were collected the data was then modeled in two separate models. The first being a conventional multinomial logit model, and the second being a random parameters logit. The second model was used to allow for individual preferences towards the steak attributes to deviate. The results of the surveys and models show that only France has a statistical

difference in that they would not eat meat that came from an animal that had been produced with growth hormones. However, France, Germany and the United Kingdom would all pay more for meat produced from animals that had not been fed genetically enhanced corn. The United States' respondents were less willing to pay more for meat that was produced without genetically modified corn or growth hormones. These results may affect meat exports to the European Union from the United States due to the high level of producers in the U.S. using growth hormones and genetically modified crops.

Reed and Clark (1998) tried to determine the trends related to retail and farm prices. This study used farm input price, output price, non-farm input price, and demand shift. The data series that were used were beef, poultry pork, eggs, dairy, fresh fruit, and fresh vegetables. The results of this study show that the consumer demand for these foods positively affects the price received for these commodities at the farm-level.

A study by Bessler and Akleman (1998) determined how shifts in supply and demand for beef and pork affect the retail-to-farm price ratio using directed graphs. This study used beef and pork prices and producer prices (inputs) from 1980 to 1997. The directed graphs helped determine the major factors in determining the retail price of the two commodities. The study has shown that innovations in the production of beef and pork at the farm-level are the largest factors in the price variation. This study gives evidence that farm-level production costs and procedures have an impact on the retail price of their commodities.

## **Economic Herding**

Herding is an economically irrational behavior when banks base their portfolio allocation decisions on the decisions of other banks. This behavior had not been empirically tested until a study was conducted by Jain and Gupta (1987). The study tested to see if small banks blindly followed the lead of larger, international banks in their lending behavior. The time of the data used was from 1977-82. The data sets of this time period were divided into three categories of different size banks for each of the top twenty borrowing countries. The data was then pooled due to a low number of observations. A Granger Causality test was applied on the data sets to determine the cause of the lending behavior. The results of the tests proved inconclusive to showing definite herd behavior amongst banks of different sizes. These results did not agree with the casual observations of the banking industries' "leaders" lending behavior. It was also concluded that the size of the bank does not always determine if it is a "leader" bank.

Herding behavior has been found to hold true in many social and economic situations. These situations are based on the theory that a person or persons makes a decision based on a decision of a previous person or persons. Examples of herd behavior can range from what a person orders at restaurant to what investments a persons will make. A study done by Abhijit V. Banerjee developed a simple model to study the rationale behind herd behavior (1992). A classic example of herd behavior is used: the choice between two restaurants (A and B) one hundred participants are given a signal as to which restaurant is better, 99 are told B is better and 1 is told A is better. The person that was told A is better gets to enter the restaurant first and the second

person will know the previous person's decision. The quality of the signals is identical. The choice of the second person is to follow the first person into restaurant A and therefore ignoring the signal to go to B. The result would be that everyone would end up at restaurant A. The model developed to test this behavior is based on a group of people given a signal as to which choice is the best. This signal can be the right choice or can be the wrong choice. The game is sequential as was the example game, and each person has to decide immediately, but the persons following the first can observe the previous decision. There are a few assumptions made about the behavior of the players, including a player with no signal will choose the previous players choice, a player who is indifferent between his or her signal and the previous player's signal will choose his or her own signal, and a player indifferent as to how many players choose a certain choice will follow the player with the highest value. The results of the model show that the equilibrium decision rule is that players will abandon their signal to follow others when they are not sure if the previous person is correct and that this decision will be the decision of all subsequent players. This study shows that people, regardless of the signals that are given to them or are known by them, will do what the person who moves previous to them does. This is because they think that the person knows something that they do not know. This model works following those assumptions, given that there are two choices to be made by the players.

Perfect herding is when rational agents act alike with no counteracting force. The reasons that this can take place are described by Devenow and Welch (1996) as direct payoff externalities, principal-agent problems, and informational learning. They also tell how herding cannot take place without a coordination mechanism. These

mechanisms are either in the form of a signal or simple observation. A signal is a widespread mechanism that alerts the agent that something is happening. A simple observation is a singular mechanism used when an agent observes what actions an industry leader or competitor is making. There are also two forms of herding: rational and non-rational (irrational). The irrational form of herding is characterized by blind movements without a decision making process. Rational herding occurs when incentives or other externalities are present. There have been many models developed to describe “rational herding.” These models have modeled bank runs, liquidity in markets, information acquisition, investment decisions, and cascades. These models all provide insight into how herding is started and how it affects the decisions of the agents involved in them. The conclusion of this paper is that herding is not solely based on blind movements, but in many cases has taken place for reasons that are calculated and beneficial to the agent.

## CHAPTER 3

### THEORETICAL MODELS

#### Introduction

The purpose of this chapter is to explain which econometric models were used to test the hypothesis for this thesis. There are also applications of each test given to provide examples of how they have been used. The Augmented Dickey Fuller test was used to determine the stationarity of the time series used in the project. Cointegration tests were performed using methodology developed by Johansen (1991) and tested for a long-term link between health concerns and the demand for beef. Granger Causality was the test performed on the time series data to test for causality. The test for causality was used to determine if there was a short-term link between media coverage of specific diets and beef demand.

#### Augmented Dickey Fuller Test

It has been long recognized that many time series variables are non-stationary. Any equilibrium relationship among a set of non-stationary variables implies that their stochastic trends must be linked. The equilibrium relationship means that the variables cannot move independently of each other. The Augmented Dickey Fuller test (Dickey and Fuller, 1979) was used to determine if the time series were stationary or not.

The test used an autoregressive model shown below:

$$Y_t = \rho Y_{t-1} + \varepsilon_t, t = 1, 2, \dots, \quad (1)$$

where  $Y_0 = 0$ ,  $\rho$  is a real number, and  $\varepsilon_t$  is a series of random numbers derived with a mean of zero and a variance of  $\sigma^2$ . If the absolute value of  $\rho$  is equal to one, then the

time series is not stationary, and the variance is  $t\sigma^2$ . This is also referred to as a random walk. The time series can also be non-stationary if the absolute value of  $\rho$  is less than one. As  $t$  increases, the variance in this case will grow exponentially with  $t$ .

The Augmented Dickey Fuller (ADF) test has been used in many studies to determine “the stationarity” of the data set. Thompson, Sui, and Bohl (2002) used the ADF test to test their data on the law of one price (LOP) from France, Germany, and the United Kingdom for unit roots. Their first test with a basic ADF concludes that the LOP from Germany contains a unit root. The second test however used a seemingly unrelated regression-augmented Dickey-Fuller (SURADF) and rejected the null hypothesis of a unit root at the 10% level. SURADF was used to reflect comovements of the deviations from the LOP in the countries.

The ADF test was also used by Gamber and Joutz (1993) in their study showing the dynamic effects of aggregate demand and supply disturbances. The Vector Autoregression which was used assumed the data to be stationary. The data used was quarterly unemployment rate for males over 20 year’s old and average hourly wages in a manufacturing setting from 1928-1990. They ran the test and found that after they differenced the log of both sets that they were stationary.

Mehra (1991) used the ADF to test for unit roots price, wage, and output gap regressors. The data sets were composed of quarterly data from 1961– 1989. The variables were used by Mehra to study wage growth and the inflation process. The results of the test show that the price and wage regressors have two unit roots and the output-gap regressor has one unit root. These unit roots were alleviated when the time series were first differenced.

### Cointegration Test

Johansen's (1991, 1995) methodology is used to determine whether the group of non-stationary time series are cointegrated. Two or more non-stationary time series are said to be cointegrated if the linear combination of the two are stationary (Maddala and Kim, 2000). The presence of a cointegrating relation forms the basis of the Vector Error Correction (VEC) specification. These are VAR-based cointegration tests. Consider a VAR of order  $p$ :

$$y_t = A_1 y_{t-1} + \dots + A_p y_{t-p} + B x_t + \varepsilon_t \quad (2)$$

where  $y_t$  is a  $k$ -vector of non-stationary I(1) variables,  $x_t$  is a  $d$ -vector of deterministic variables, and  $\varepsilon_t$  is a vector of innovations. We may rewrite this VAR as

$$\Delta y_t = \Pi y_{t-1} + \dots + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-1} + B x_t + \varepsilon_t, \quad (3)$$

where

$$\Pi = \sum_{i=1}^p A_i - 1, \quad \Gamma_i = - \sum_{j=i+1}^p A_j \quad (4)$$

Granger's representation theorem asserts that if the coefficient matrix  $\Pi$  has reduced rank  $r < k$ , then there exist  $k \times r$  matrices  $\alpha$  and  $\beta$  each with rank  $r$  such that  $\Pi = \alpha\beta'$  and  $\beta' y_t$  is I(0).  $r$  is the number of cointegrating relations (the cointegrating rank) and each column of  $\beta$  is the cointegrating vector. The elements of  $\alpha$  are the adjustment parameters in the VEC model. Johansen's method is to estimate the  $\Pi$  matrix from an

unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of  $\Pi$ .

A study by Lopez (1999) used the Johansen test for cointegration to help determine and show changes in foreign exchange rates in different time periods coinciding with changes in central bank behavior caused by regime changes. Lopez used the multivariate procedure introduced and expanded on by Johansen (1991, 1995). The results of this study show that there is a long-term relationship between shifts of behavior due to regime shifts and foreign exchange market rates. The study does not specifically address the problem, but shows how changes can be modeled with structural breaks at certain behavior changes. However the conclusion was made that regime changes did have a long-term impact on foreign exchange markets.

Johansen's test for cointegration was used in a study trying to determine if agricultural prices overshoot in an open economy. This study by Saghaian, Reed, and Marchant (2002) reveals that there are 3 cointegrating vectors present among the 6 possible sets. The tests only were part of the study. Unit root tests, causality tests, and a vector error correction model were also used to help determine that agricultural prices adjust faster than industrial prices to movements in the money supply and innovations.

A study done by Cushman (2000) examines the exchange rate model in the long run using the Johansen cointegration test. The test for cointegration used long run movements in the Canadian and U.S. Dollar. The outcome of the study disproves an exchange rate model developed by Kouretas (1997). It is disproved by the test because of the lack of cointegrating vectors. Cushman believes that the previous exchange rate model left out many important factors that are captured in the Johansen test.

## Granger Causality and Vector Error Correction

Causality is often found necessary by researchers to explain relationships and effects between two or more time series data sets. There are two assumptions made when using a causality model. The first is that the future cannot cause the past. The second is that unique information is contained in the cause that is unavailable anywhere else. Granger defines causality as if  $x$  is causing  $y$ , then we are better able to predict  $y$  using all available information we have involving  $x$ . There are also situations when  $x$  causes  $y$ , but also  $y$  causes  $x$  (Greenberg, 1983). These cases are called feedback. In these circumstances there are other factors affecting both  $x$  and  $y$ . Note that two-way causation is frequently the case:  $x$  Granger causes  $y$  and  $y$  Granger causes  $x$ .

The procedure for testing Granger Causality is to test if  $x$  causes  $y$ . We would need to set up an unrestricted regression with  $y$  as the dependent variable and lagged values of  $y$  and lagged values of  $x$  as the independent variables. A restricted regression would use  $y$  values as the dependent variable and lagged values of  $y$  as the independent variables. The regression would be testing the null hypothesis that “ $x$  does not Granger cause  $y$ .” An F test would determine if the values of  $x$  have a significant contribution to explain  $y$  in the first regression (Pindyck, 1998). The simplest form of the unrestricted model is shown in equation 5.

$$Y = \sum_{i=1}^m a_i Y_{t-i} + \sum_{i=1}^m \beta_i X_{t-i} + \varepsilon_t \quad (5)$$

The causality test can also be run to test null hypothesis that “ $y$  does not Granger cause  $x$ ”. This can be done by switching the  $y$  and  $x$  variables on both sides of the regression.

Since we will try to statistically find that the time series in question are stationary, it will prevent us from using the standard version of the Granger causality test. That is, it would be inappropriate to test for causality in levels with nonstationary series that are known to be cointegrated. The Vector Error Correction (VEC) model is appropriate in this case because it has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term is called the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. We will consider here a simple case of a two variable ( $y_1$  and  $y_2$ ) system with one cointegrating equation and lagged difference terms.

$$\Delta y_{1,t} = \alpha_{1,0} + \alpha_1 (y_{2,t-1} - \beta y_{1,t-1}) + \sum \alpha_{1,1}(i) \Delta y_{1,t-i} + \sum \alpha_{1,2}(i) \Delta y_{2,t-i} + \varepsilon_{1,t} \quad (6)$$

$$\Delta y_{2,t} = \alpha_{2,0} - \alpha_2 (y_{2,t-1} - \beta y_{1,t-1}) + \sum \alpha_{2,1}(i) \Delta y_{1,t-i} + \sum \alpha_{2,2}(i) \Delta y_{2,t-i} + \varepsilon_{2,t} \quad (7)$$

Again,  $\varepsilon_{1,t}$ ,  $\varepsilon_{2,t}$ , and all terms involving  $\Delta y_{1,t-i}$  and  $\Delta y_{2,t-i}$  are stationary. Thus, the linear combination of two variables ( $y_{2,t-1} - \beta y_{1,t-1}$ ) must also be stationary. In this simple model, the only right-hand side variable is the error correction term. In long-run equilibrium, this term is zero. However, if  $y_1$  and  $y_2$  deviate from the long-run equilibrium, the error correction term will be nonzero and each variable adjusts to partially restore the equilibrium relation. Finally, the coefficient  $\alpha_i$  measures the speed of adjustment of the  $i$ -th endogenous variable towards the equilibrium.

Martin et al. (2004) used Granger Causality to study revenue and expenditures of the 16 Swiss canton<sup>1</sup> governments. The study was the first to use Granger Causality to test levels of revenues and expenditures on a canton level. The outcome of the study was that revenue influences expenditure in a majority of the cantons. The implication of these results was said to show that, by reducing expenditure, the canton could lower its deficit. This was explained to be more effective than increasing revenue.

Loizidies and Vamvoukas (2004) used Granger Causality to study government expenditure and economic growth. The study used many different variables from the United Kingdom, Ireland, and Greece regarding both government expenditures and economic growth indicators. The study used the time series data and both trivariate and bivariate causality tests. The tests gave many conclusions. The first being that, when all countries increase government expenditures, they will also Granger cause both long-term and short-term growth in the national income. Loizidies and Vamvoukas also proved a hypothesis that increased private sector output will cause an increase in public expenditure. Greece and the United Kingdom show strong causality from national income to public spending, however, this is not shown in Ireland.

### **Impulse Response Function**

Interaction between time series data helps determine how certain changes in one time series have an effect on another series of data. The impulse response function traces the response of a variable of interest to an exogenous shock. The responses are often plotted graphically with the horizon on the horizontal axis and the response on the vertical axis. The impulse response function is derived from the vector moving average

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<sup>1</sup> “Canton” is defined as a division of a country, ex: Swiss federal state.

(VMA) of the vector autoregression. This VMA is written with the  $\varepsilon_{yt}$  and  $\varepsilon_{zt}$  representing the shocks which affect the coefficients of  $\Phi_i$ . This moving average representation is simplified below in equation 8.

$$X_t = \mu + \sum_{i=0}^{\infty} \Phi_i \varepsilon_{t-1} \quad (8)$$

There are impact multipliers that represent the instantaneous impact of a one unit change in  $\varepsilon_{zt}$  on  $y_t$ . These impact multipliers are shown as  $\Phi_{jk}(0)$ . The affects on  $\varepsilon_{yt}$  and/or  $\varepsilon_{zt}$  are obtained and called the impulse response functions. These summations are represented in equation 9.

$$\sum_{i=0}^{\infty} \Phi_{jk}^2(i) \quad (9)$$

The sets of  $\Phi_{jk}(i)$  coefficients are called the impulse response functions. This however is not sufficient to identify all shocks and responses. An additional restriction on the two-variable VAR system must be imposed to truly identify the impulse responses. A form of this restriction is to constrain the system by having the contemporaneous value of  $y_t$  have no contemporaneous effect on  $z_t$ . The restriction is shown by the following,  $b_{21} = 0$ . Equation 10 and 11 show how this will look and effect the error terms.

$$\varepsilon_{1t} = \varepsilon_{yt} - b_{12} \varepsilon_{xt} \quad (10)$$

$$\varepsilon_{2t} = \varepsilon_{xt} \quad (11)$$

This will show that the  $\varepsilon_{zt}$  shocks account for all of the observed error in the  $e_{2t}$  sequence.

## **CHAPTER 4**

### **DATA AND RESULTS**

#### **Introduction**

This chapter will detail the rationalization for data used and also where that data was retrieved from. Also, included in this chapter are the results derived from the econometric tests detailed in the previous chapter. Finally a plausible explanation will be given as to why the short run results turned out the way they did. Herd behavior will be briefly discussed as an explanation and a tool for further research.

#### **Data**

We will first define time frame and the variables representing retail demand for beef in the United States and consumers' dietary health concerns. The time span considered in the study is the period between 1990:I and 2004:IV. The beginning of the period is chosen because it represents the time when obesity was increasing recognized as a potential health issue in the United States (CDC National Center for Chronic Disease Prevention and Health Promotion, <http://www.cdc.gov/nccdphp/dnpa/obesity/trend/maps/index.htm>) and when the low-fat, low-cholesterol diet became the most popular diet to promote healthy eating habits and to fight obesity.

The quarterly retail demand index for beef developed by RILP ([www.aaec.vt.edu/rilp/demandtop.html](http://www.aaec.vt.edu/rilp/demandtop.html)) is used in this study. RILP used per-capita consumption and retail beef price data from the Livestock Marketing Information Center website (<http://lmic1.co.nrcs.usda.gov/>) to calculate the index. The index calculation is based on demand with constant prices compared to 1980 (base year) using

an elasticity of -0.67. Notice that the index values are a function of the -0.67 retail level demand elasticity, but the index does not change drastically for elasticity parameters of -0.5 to -0.8 which represents the range of own-price elasticities estimated in a number of influential studies on retail demand for beef (e.g., Marsh, 2003; Eales and Unneveher, 1988, 1993). The index is also rescaled to 1998=100 so that the improvements since demand bottomed in 1998 can be easily monitored. For example, an index of 121.962 for 2004:I would mean that demand in the first quarter of 2004 increased by 21.962 percent since 1998. The index values show how demand is changing but give no information on why it is changing.

Consumers' dietary health concerns and in turn related dietary preferences are difficult to measure. Ideally, one would like to have access to the number of individuals who were on low-fat, low-cholesterol and low-carb diets during the time period under consideration. Unfortunately, there are no reliable sources which would provide the time series we need for the analysis. A good approximation for the number of people on these diets would be the number of newspaper articles and magazine features on low-fat, low-cholesterol and low-carb diets published in the United States between 1990:I and 2004:IV. The assumption here is that the newspapers and magazines will report and inform about these diets only if that represents news defined as current information and happenings or new information about specific and timely events (*Merriam-Webster's Collegiate Dictionary*, 2004). The source of this information is NewsLibrary.com (<http://nl.newsbank.com>), considered the world's largest news archive. Approximately 600 major newspapers and magazines published in the United States were searched for articles and features related to low-fat, low-cholesterol and low-carb diets published

between 1990:I and 2004:IV. The frequencies of articles published related to these two types of diets are, therefore, considered to be two variables measuring or approximating the consumers' dietary health concerns and in turn preferences. Graphs of the three time series under consideration are presented in Figures 4.1 and 4.2. Summary statistics including simple correlations are presented in Table 1.

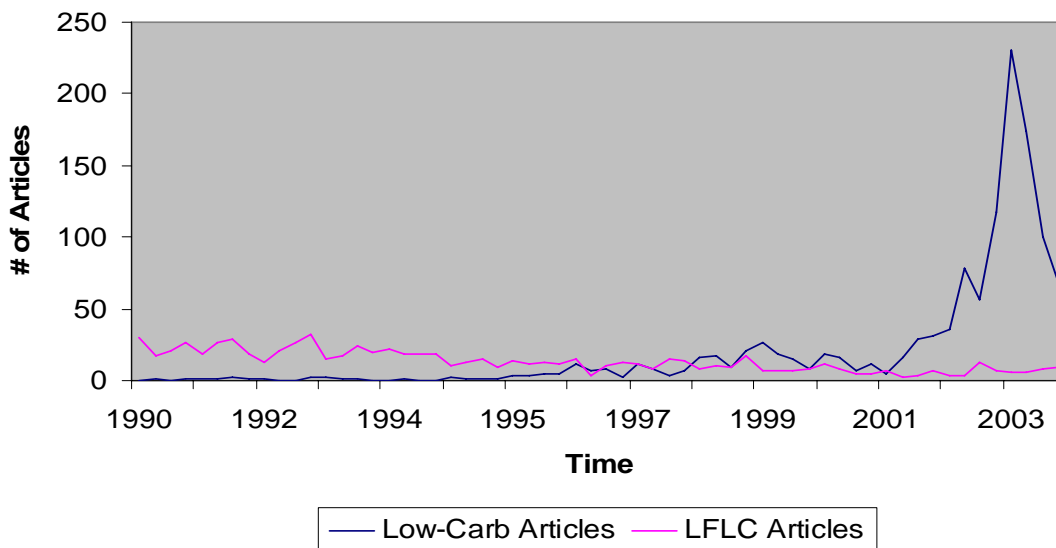


Figure 4.1. Frequency of Newspaper Articles Published on Major Diets.

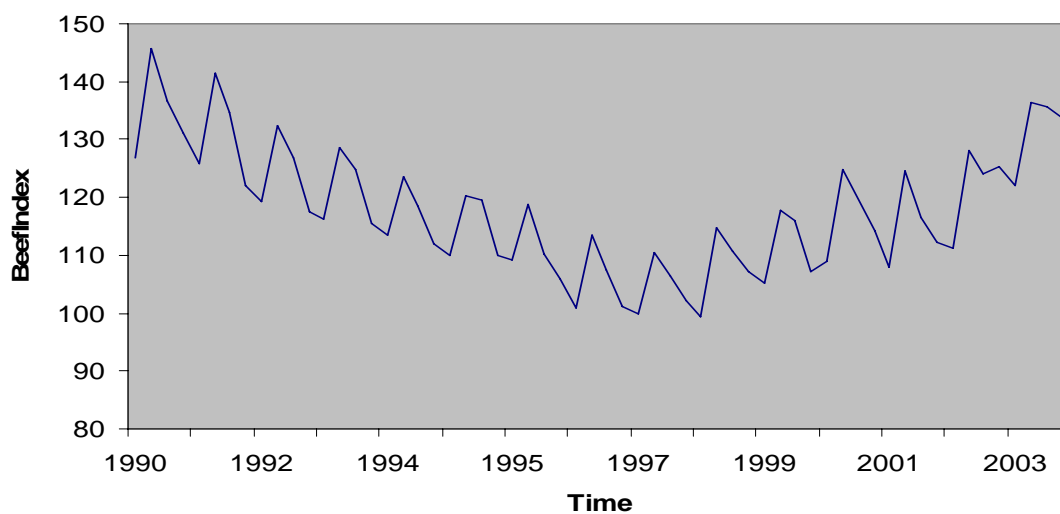


Figure 4.2. Beef Index 1990:I-2004:IV (1998=100).

Table 1. Summary Statistics

	LC <sup>1</sup>	LCLF <sup>2</sup>	BeefIndex <sup>3</sup>
Mean	20.37	13.3	118.02
Standard Error	5.39	0.96	1.4
Median	5	12	116.98
Mode	3	7	N/A
Standard Deviation	41.82	7.44	10.87
Range	229	30	46.31
Minimum	1	2	99.34
Maximum	230	32	145.65

Simple Correlations	LC	LCLF	BeefIndex
LC	1.00		
LCLF	-0.39	1.00	
BeefIndex	0.24	0.32	1.00

<sup>1</sup> LC - Number of newspaper articles published on the low-carb diet.

<sup>2</sup> LCLF - Number of newspaper articles published on the low-fat, low-cholesterol diet.

<sup>3</sup> BeefIndex - Index for retail demand for beef in the United States.

### **Long-Run Link Between Health Concerns and Demand for Beef**

The Augmented Dickey-Fuller test (Dickey and Fuller, 1979) is used in order to test if the time series under consideration are stationary or not. The null hypothesis is one of non-stationarity or the variable having a unit root. We were unable to reject the null hypothesis for any of the three variables when tested at the 5 percent significance level. The times series were first differenced. The null hypothesis was rejected at the 1 percent significance level. Thus, each variable is I(1). Notice that, in all three cases, exogenous variables were constant and had a linear trend. The lag length based on both SIC or AIC criteria was 6 for the Beef Index; 1 for the low-fat, low-cholesterol variable; and 9 for the low-carb variable. These results are reported in Table 2.

Table 2. Augmented Dickey-Fuller Results

First test			
Series	ADF- <i>t</i>	Critical Value at 1%	Critical Value at 5%
BI	0.0226	-4.1383	-3.4952
LC	-0.0449	-3.5653	-2.9202
LCLF	-2.2975	-3.5457	-2.9118
Second test (1st differenced)			
Series	ADF- <i>t</i>	Critical Value at 1%	Critical Value at 5%
BI	-4.5892	-4.1420	-3.4969
LC	-4.4984	-3.5682	-2.9215
LCLF	-10.2860	-3.5478	-2.9127

After establishing that all three time series under consideration are  $I(1)$ , the cointegration analysis was pursued. The results of the cointegration analysis are reported in Table 3. The multivariate cointegration test was carried out with one lag in differences (two lags in levels). Based on the results of both trace statistics and maximum eigenvalue statistics, we can conclude that the three variables representing consumers' dietary health concerns and their demand for beef are cointegrated with  $p$ -values being below 0.01 considering one cointegrating vector and below 0.05 considering two cointegrating vectors.

When finding more than one cointegration vector in a multivariate system, the estimated cointegration vectors are often hard to interpret. According to Johansen and Juselius (1994), restrictions motivated by economic theory can be used to detect structural relationships in the cointegration vectors. In this case, however, there is no economic theory that would direct us towards looking more deeply into structural relationships. The lack of a more precisely defined structural relationship does not represent a problem in this case since the main purpose of this portion of the analysis

Table 3. Cointegration Analysis: Multivariate Johansen Test

H <sub>0</sub> : rank = p	Trace Test Statistic	0.05 Critical Value	p-value**
p = 0*	67.17430	35.01090	0.0000
p ≤ 1*	29.55124	18.39771	0.0009
p ≤ 2*	4.12612	3.84147	0.0422
H <sub>0</sub> : rank = p	Max. Eigenvalue Statistic	0.05 Critical Value	p-value**
p = 0*	37.62279	24.25202	0.0005
p ≤ 1*	25.42513	17.14769	0.0025
p ≤ 2*	4.126115	3.841466	0.0422

Both Trace and Max. Eigenvalue Tests indicate 3 cointegrating equations at the 0.05 level.

\* Denotes rejection of the hypothesis at the 0.05 level.

\*\*MacKinnon et al. (1999) p-values.

was to determine that these three variables are not moving independently of each other. To summarize, the two variables approximating the health-dietary concerns (i.e., newspaper and magazine articles published concerning low-fat, low-cholesterol and low-carb diets and retail demand for beef in the United States) follow the same stochastic trend and are not moving independently of each other. This indicates that U.S. consumers are health concerned. They perceive how changing their dietary habits and reducing their weight is one way of improving their health. In turn, this change in dietary habits leads to a change in demand for beef.

However, the time series analysis can be pursued even further in order to answer not only the question whether media and health/diet changes have impacted beef demand but also how media and health/diet changes have impacted beef demand. The issue whether these events are correlated can be forced to quantifying the measure of how they are related. The Vector Error Correction (VEC) model is appropriate in the case with nonstationary series that are known to be cointegrated. As in traditional Vector Autoregression (VAR) analysis, Lutkepohl and Reimers (1992) showed that

innovation accounting (i.e., impulse responses) can be used to obtain information concerning the interactions among the variables. As a practical matter, the two innovations  $\varepsilon_{y_t}$  and  $\varepsilon_{z_t}$  may be contemporaneously correlated if  $y_t$  has a contemporaneous effect on  $z_t$  and/or  $z_t$  has a contemporaneous effect on  $y_t$ . In obtaining impulse response functions, Choleski decomposition is used to orthogonalize the innovations. Results from the impulse response analysis are presented in Figure 4.3.

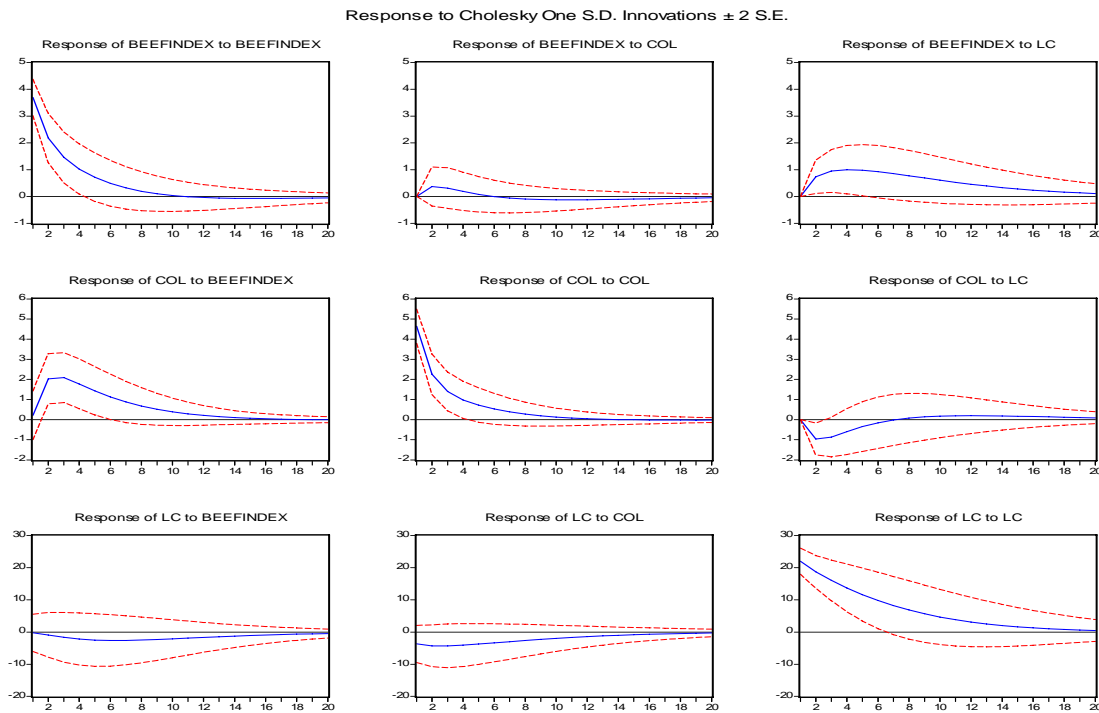


Figure 4.3. Impulse Response Functions.

Note: COL is the number of newspaper articles published on the low-fat, low-cholesterol diet, LC is number of newspaper articles published on the low-carb diet; BEEFINDEX is index for retail beef demand in the United States.

The graphs in Figure 4.3 trace out the effects of one-unit shocks to all  $\varepsilon_t$  on the time paths of the BEEFINDEX, COL, and LC sequences. While all results are interesting and informative, we are naturally most interested in the effects of one unit-

shocks in  $\varepsilon_{COL,t}$  and  $\varepsilon_{LC,t}$  on BEEFINDEX sequence. It is clear from the graphs titled, “Response of BEEFINDEX to COL” and “Response of BEEFINDEX to LC” that the contemporaneous effect in the case of a one unit-shock in low-fat, low-cholesterol diet reports on beef demand index is three times smaller than the effect of a one unit-shock in low-carb diet reports on beef demand index. Moreover, the contemporaneous effect of a shock in low-fat, low-cholesterol diet media reporting on beef demand is very modest. That may indicate how a sudden shock in writing about low-fat, low-cholesterol diets or in a number of followers of this diet does not represent “big” news that would alter significantly the beef demand pattern. That cannot be said about the shock to low-carb diet media reports variable indicating how contemporaneous beef demand is much more affected by this shock. Also, the autoregressive nature of the system is such that  $t+1$  values of the BEEFINDEX do not immediately return to their long-run values. However, the response of BEEFINDEX to COL graph indicates that demand for beef remains very close to (while slowly converging) its long-run values throughout twenty quarters following the time of the shock. On the other hand, the response of BEEFINDEX to LC graph indicates a very slow convergence pattern following the shock where no full convergence is reached, *i.e.*, the values of the demand for beef BEEFINDEX do not return to the long-run values completely even after twenty quarters following the shock. Thus the effects of a sudden increase in low-carb diets popularity had a long-lasting effect on demand for beef.

### The Causality Between the Media Coverage of Specific Diet Types and the Demand for Beef: Short-Run Link

The causality between the media coverage of specific diet types and demand for beef can be tested using the Granger approach (Granger, 1969; Hamilton, 1983, 1994). The bivariate causality is what we will try to determine in this case: Does the causality run: (a) from the change in the number of articles published to the change in demand for beef, (b) from the change in demand for beef to the change in the number of articles published, or (c) both ways. After estimating VEC model, one can do the Pairwise Granger causality tests. In the context of a cointegrated system Granger causality test must be reinterpreted (Enders, p.371). For instance, in a cointegrated system  $y_2$  does not Granger cause  $y_1$  if lagged values  $\Delta y_{2,t-i}$  do not enter the  $\Delta y_{1,t}$  equation and if  $y_{1,t}$  does not respond to the deviation from long-run equilibrium. The appropriate test statistic is Wald ( $\chi^2$ ) statistic for the joint significance of each of the other lagged endogenous variables in that equation. The results are shown in Table 4.

Table 4. Pairwise Granger Causality Tests

Null Hypothesis	$\chi^2$ - Statistic	P- value	d.f.
LFLC <sup>1</sup> does not Granger Cause BEEFINDEX <sup>3</sup>	5.807	0.76	9
BEEFINDEX does not Granger Cause LFLC	18.097**	0.03	9
LC <sup>2</sup> does not Granger Cause BEEFINDEX	23.153*	0.01	9
BEEFINDEX does not Granger Cause LC	36.667*	0.00	9
LC does not Granger Cause LFLC	29.559*	0.00	9
LFLC does not Granger Cause LC	29.007*	0.00	9

\*and\*\* Denote statistical significance at 1 percent and 5 percent, respectively.

<sup>1</sup> LFLC - Number of newspaper articles published on the low-fat, low-cholesterol diet.

<sup>2</sup> LC - Number of newspaper articles published on the low-carb diet.

<sup>3</sup> BEEFINDEX - Index for retail beef demand in the United States.

Two sets of results that are of interest are Pairwise Granger causality tests between LFLC (number of newspaper articles published on the low-fat, low-cholesterol diet) and BEEFINDEX, and LC (number of newspaper articles published on the low-carb diet) and BEEFINDEX. The third set of results related to the Granger causality test between LFLC and LC is not something we originally intended to do, but it turned out to be interesting and worthy of our attention. The lag length was set at 9 to match the highest number of lags selected according to AIC or SIC criteria.

In the first case, the causality between LFLC and BEEFINDEX is examined. The presence of bivariate causality is determined. Based on the test results, we reject (at the 5 percent significance level) the hypothesis that BEEFINDEX does not Granger cause LFLC. The hypothesis that LFLC does not Granger cause BEEFINDEX cannot be rejected at any standard significance level. These results seem to be intuitive. The low-fat, low-cholesterol diet has been around for many years. Most medical professionals will routinely advise their patients to decrease the intake of high cholesterol foods such as beef. And most patients will comply, at least to some extent. However, a steady but large number of people who follow this type of diet represent information that media cannot ignore and therefore that is being reported by the media. Reverse causality on the other hand, running from news reports on the low-fat, low-cholesterol diet to beef demand, is not statistically significant. This result is intuitive because most people are likely to have been exposed multiple times to the information on medical benefits of the low-fat, low-cholesterol diet through either continuous coverage in the media over an extended period of time or their medical and dietary advisors. Given that this information does not represent anything new to most

consumers, they may be willing to acknowledge the information but not to change their dietary habits, *i.e.*, to decrease beef consumption, because of that.

The causality between LC and BEEFINDEX is examined next. Bivariate causality is determined to exist. In other words, based on the test results we reject at 1 percent significance the hypothesis that LC does not Granger cause BEEFINDEX. This result confirms what many have suspected: more frequent writings in newspapers about low-carb diets led to an increase in beef consumption. The writings about the Atkins diet or similar low-carb diets are a typical case of herding behavior by media. Once the news on low-carb diets was picked up by media leaders, no newspaper could afford to ignore the information. This type of herding behavior may be classified as either information or reputation-based herding (*e.g.*, Bikhchandani and Sharma, 2000). Once the media overwhelmed the public with the information on low-carb diets, many people responded by entering one of the formal low-carb diet programs or by trying to adjust their diet on their own. Low-carb diets are unorthodox and have a great deal of appeal to many of the most affected segments of the population (very overweight and obese people): they can lose weight while not eating less overall and by eating even more of the foods such as meats and cheese. While medical researchers have some doubts about long-term viability, success, and health consequences of this diet, many among more than 150 million overweight and obese Americans are not willing to wait for the scientific research. Ultimately, the demand for meats, and beef in particular, soared to levels much higher than in recent years. That in turn did not go unnoticed by the media. Higher consumption and demand for beef and other high protein foods led to more newspapers articles and media reports about low-carb diets. This conclusion is

supported with rejecting at 1 percent significance the hypothesis that LC does not Granger cause BEEFINDEX.

Finally, bivariate causality is determined to exist, at 1 percent significance, between LC and LFLC. This result is an interesting by-product of our investigation. Newspaper reports on low-carb diets are often coupled with writings (often comparisons) about competing diets including low-fat, low-cholesterol diets. Thus this contemporaneous bivariate causality is a logical consequence of the newspapers writings.

### **Herd Behavior: An Explanation for Short-Run Causality Results**

The short run causality tests were used to determine if the separate diets affected the demand for beef, or if the demand for beef affected the dietary preferences of the population. The short run results show that the newspaper reports concerning the low-carb diet have an affect on the demand for beef. The Pairwise Granger Causality tests show that newspaper reports on the low-carb diet do cause change in the demand for beef, but the tests do not explain why these changes occur.

A plausible explanation as to the cause of such changes is the affect of herd behavior. Herd behavior is defined as decision making that is influenced by what others around us are doing. The decision maker has her own information about a situation, but under the influence of herd behavior will disregard that information and follow a previous decision maker's or makers' lead. This kind of behavior is observed in various social and economic situations including, among others, voters behavior being influenced by opinion polls to vote in the direction that the poll predicts will win (e.g., Cukierman, 1991), fertility decision making including decisions whether or not to use

contraception or how many children to have (Cotts Watkins, 1990), or investors behavior in financial markets (e.g., Bulow and Klemperer, 1994; Devenow and Welch, 1996; Jain and Gupta, 1987; Veldkamp, 2004).

A herd behavior model could be used in the case of low-carb diets to explain the affect of these newspaper articles on beef demand. The reason for using herd behavior in this case is due to the relatively short life span of the low carbohydrate diet.

However, similar monthly data would have to be used instead of quarterly data in order to have a significant number of observations. Monthly data from 1997-2004 (time of low-carb diet's popularity) would need to be collected. The model would estimate how people will make decisions based what they read in newspaper and magazine articles and not based on their own individual information. This will test if herd behavior exists in the decision making process of Americans wanting to lose weight.

The herd behavior model might also show more conclusive results with other sources of protein in low-carb diets. Broilers and eggs are two sources of protein linked to low-carb diets. Biological characteristics also make it easier for producers of broilers and eggs to adjust supply to meet demand. This makes it easier for the short-run model to track, more precisely, the behavior using the available monthly time series data.

## **CHAPTER 5**

### **SUMMARY AND CONCLUSIONS**

#### **Problem**

Obesity became one of the main health and social concerns in the United States during the last 15 years. One of the most commonly chosen ways to fight obesity is changing dietary habits. This change is sometimes guided by medical professionals based on knowledge in medical research accumulated over many decades. Sometimes, however, people who are most endangered, i.e., the most overweight and obese people, do not have the will and ability to follow medical advice and make a certain sacrifice. As an alternative to more exercising and less eating, there are many special diets that emphasize changing dietary preferences rather than decreasing the amount of food consumed. Two of the most popular and competing diets during the last 15 years have been, first, the low-fat, low-cholesterol diet, and, later, the low-carb diet. As a large number of Americans adopted these diets, the types of foods consumed were changed. In this research, we focused on beef and showed that it represents one of those foods where demand fluctuated as the perception about its weight-loss potential changed. In other words, we showed that many Americans are health conscious and have changed their diet from “healthy” low-fat, low-cholesterol (which implies low-beef consumption) to a perceived “weight loss” low-carb diet (which implies high-beef consumption).

#### **Procedures and Data**

The procedures used in this study were a series of econometric tests. The data collected for the study included the beef demand index and newspaper articles during

the time span between 1990:I and 2004:IV. The Beef Demand Study Group economists developed an annual retail beef demand index with the series starting in 1980 (Genho, 1998). The index can be found published quarterly ([www.aaec.vt.edu/rilp/demandtop.html](http://www.aaec.vt.edu/rilp/demandtop.html)) by the Virginia Tech's Research Institute on Livestock Pricing (RILP). The source of data that will track the participation in the low fat, low cholesterol and low-carb diet is one quarterly number of newspaper articles published in the United States. The source for this data was an online newspaper library, NewsLibrary.com. This library is considered the world's largest newspaper archive.

There were three different tests used in this study. The first test was the Augmented Dickey Fuller test, used to determine if the time series' in question was stationarity. After the three data sets were 1<sup>st</sup> differenced I(1) to allow for the time series to be stationary the Johansen Cointegration test was performed. This test demonstrated that two time series sets are cointegrated. The next test was the Granger Causality test. This test was performed to determine if there was a short term link between media coverage of specific diets and beef demand. This test was performed using only two data sets at a time.

The focus of this study was to determine (a) whether media and health/obesity interests changes have impacted beef demand, and (b) if yes, how these changes impacted the beef demand. Pure time series methods including testing for unit roots, cointegration and impulse response analysis, Granger causality tests, and VEC analysis were employed in order to answer these questions. Some may be concerned because some important economic and socio-demographic determinants, that are usually a part

of the structural meat demand models (e.g., Marsh, 2003; Eales and Unneveher, 1988, 1993), are not present in this analysis. It is believed that this methodology is powerful and appropriate to answer the questions posed. Imposing a structure on a model provides qualitatively different answers. One main concern is then about appropriate model specification and its behavioral characteristics. The main concern was to establish the nature of the relationship between media and health changes and demand for beef over time, and time series analysis was selected the most appropriate method to answer questions.

## **Results**

Media reports over time, including newspaper articles and magazine features on low-carb diets, have been the trigger of change in consumers' dietary preferences. It was determined that media frenzy induces consumers to change their diet. This led to an increase in demand for beef when the low-carb diet became trendy. The cointegration tests help show that the three time series sets do not move independently of each other. These results show that when consumers change their dietary preferences this affects the demand for beef. The causality tests show the effect in a short-term situation. The results show that changes in media coverage of the low fat, low cholesterol diet do not cause a change in the demand for beef. However, changes in short-term media coverage on the low-carb diet do in fact cause a change in the demand for beef. These results are intuitive as more media coverage about low-carb diets which promote and increase in the consumption of food high protein will affect the demand for beef.

A plausible explanation for the short run behavior of Americans could be modeled around a herd behavior model. The herd behavior model could be tested to determine if Americans based their decisions regarding dietary preferences on what others are doing and not based on their own information. This model would help to explain the results of the causality tests.

### **Conclusions and Implications**

There are a few implications of these findings. First, health concerns are an important demand shifter for beef (and likely some other food products) in the long-term. Evidence was provided that the decrease and then increase in the demand for beef was influenced by the same reason, i.e., health concerns. Thus, maintaining currently existing positive image of beef as a healthy food may be very beneficial for the beef industry. It is even more critical for the beef industry to create this image if one knows the dependence of the beef industry on domestic markets: less than 8 percent of beef produced in the United States is exported (Miljkovic et al., 2003). Second, most overweight and obese people represent a group whose health is most eroded. These people are generally more vulnerable and likely to be influenced by various dietary or other programs that offer a quick fix for their problem. Media serves as a trigger that will swing people to become followers of a certain diet. Given the number of people in the United States affected with obesity, it is irrelevant if media reports about diets such as the low-carb diet in a positive, neutral, or moderately negative way (for as long as it is not very negative reporting). Many people are willing to try these diets and an increase in publicity will surely lead to the higher adoption rate of a potentially beneficial diet. Finally, the use of a herd behavior model could prove

valuable, not only to determine what was the cause of a change in beef demand, but also it is an important tool in determining what causes consumers to have a certain behavior. This knowledge of consumer behavior can be used by producers to adjust the allocation of check-off funds to support promotion of the health benefits of beef.

There have been reports that the low-carb diet is now becoming a fad diet of the past. The percentage of Americans on low-carb diets has been steadily decreasing since February of 2004 (Cattle Buyers Weekly, 2005). However, even though the participation in this diet is declining, the effect of the low-carb fad has been felt. Pork, broilers, and beef demand has all increased along with the popularity of the low-carb diet (CME). With that in mind, it is important to realize that producers need to understand the drivers of consumer behavior and how that behavior will affect them.

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