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WORLD PRODUCTION AND TRADE OF PISTACHIOS: THE ROLE OF THE U.S. AND FACTORS AFFECTING THE EXPORT DEMAND OF U.S. PISTACHIOS

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Thesis/Dissertation Errata Page Request

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Description of errata page: Richard Matoian from the American Pistachio Growers brought to my attention that the Administration Committee for Pistachios does not nor has ever recommended authority to operate a reserve pool. Hence, I made the following revisions to my thesis on this topic.

Number of errata page (up to 10): 1 Date: 2017-10-11

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I approve the attached errata page and the addition of it to the above-mentioned thesis/dissertation and the corresponding UKnowledge record of the thesis/dissertation.

Name: Sayed Saghaian Date: Oct. 11, 2017

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Assistant Dean of Graduate Academic Services, Graduate School, University of Kentucky

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Errata Page

Location (page and line numbers)	Original Text	Correction
Pg 12 Line 5 below chart	In order to stabilize the price, the marketing order held a reserve pool to compensate the shortages in supplies in the “off” years. "	Remove
Pg 15 Line 1	because of the reserve pool held by the marketing order to mitigate the price swings	Remove

ABSTRACT OF THESIS

WORLD PRODUCTION AND TRADE OF PISTACHIOS: THE ROLE OF THE U.S. AND FACTORS AFFECTING THE EXPORT DEMAND OF U.S. PISTACHIOS

The primary purpose of this study is to evaluate the role of the US in the worldwide production and trade of pistachios, identify and estimate the major factors affecting export demand for US pistachios in 21 major markets, accounting for 78 percent of total US pistachio exports. The study estimated the impacts of US pistachio own price, cross price, importing markets' GDP, real exchange rates and effect of food safety shocks. A panel data analysis was conducted using data from 1989 to 2009. A Houseman test indicated that the random effects estimator was the chosen estimator. Elasticity analysis indicated that US pistachio demand showed own price elastic, income elastic and real exchange rate elastic, while cross price and food safety shock inelastic. The paper also investigated effects of marketing orders in different industries to reinforce the findings by Alston et al. in 2005 on the Pistachio Order. The review concluded with a general positive effect. Consequently, to maintain international market share, US pistachio producers need to take advantage of their advanced technology and reputation for higher food safety standards, comply with regulations under the marketing order, focus on product diversification and find solutions to improve current food safety issues.

Key Words: Pistachios, Production, Export Demand, Marketing Order, Food Safety.

Zheng, Zijuan

Date

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Zheng, Zijuan

Director of Thesis

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2011

WORLD PRODUCTION AND TRADE OF PISTACHIOS: THE ROLE OF THE U.S. AND FACTORS AFFECTING THE EXPORT DEMAND OF U.S. PISTACHIOS

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Agricultural Economics in the
College of Agriculture
at the University of Kentucky

By
Zheng, Zijuan
Lexington, KY
Director: Sayed H. Saghaian, Professor of Agricultural Economics
2011

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I must also express my gratitude to my family for their love and support throughout this whole process. I am blessed with the love and support of my fiancée, mother, father, brother, and aunt. Each of you mean more to me than you will ever know.

Lastly, the environment of cooperation, discussion, and free exchange of ideas encouraged among the graduate students in the department of Agricultural Economics stimulated a sense of collaboration that mitigated obstacles to learning.

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CHAPTER 1. INTRODUCTION

1.1. Problem Statement

In September 1997, the European Union (EU) rejected a large pistachio shipment from Iran, then the world's largest producer and exporter of pistachios, due to high levels of aflatoxin contamination. Since this incident, European countries have shifted their original importing source from Iran to the United States (US), which had created a large market for US pistachio growers. This food safety event caused catastrophic and long-lasting effects in pistachio trading and caught the attention of researchers and policy makers, as one can see from figure 1.1. Iran's pistachio export market share was still affected after five years.

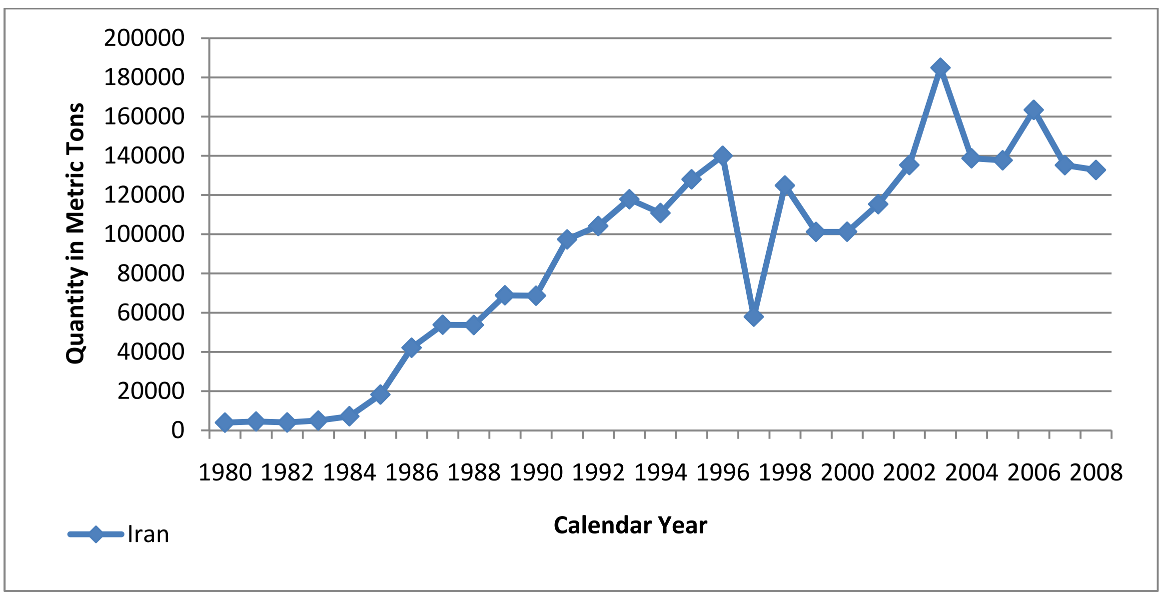

Figure 1.1: Pistachio Export in Iran, 1980-2009.

Data Source: FAO TradeSTAT

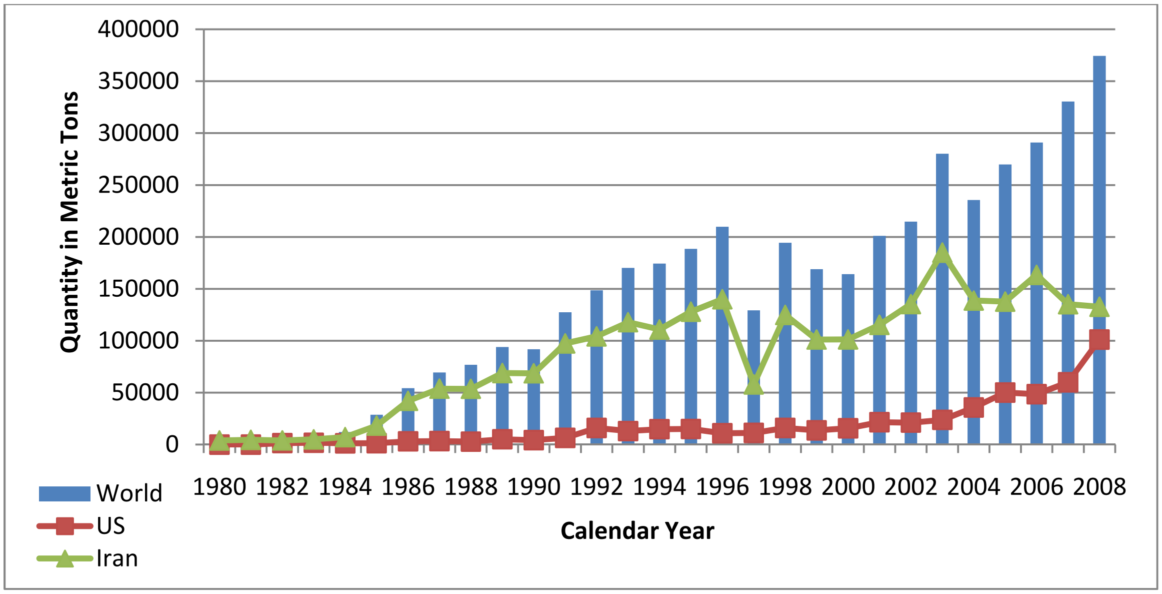

Figure 1.2: The US, Iran, and World Pistachio Exports in Quantity, 1980-2009.

Data Source: FAO TradeSTAT

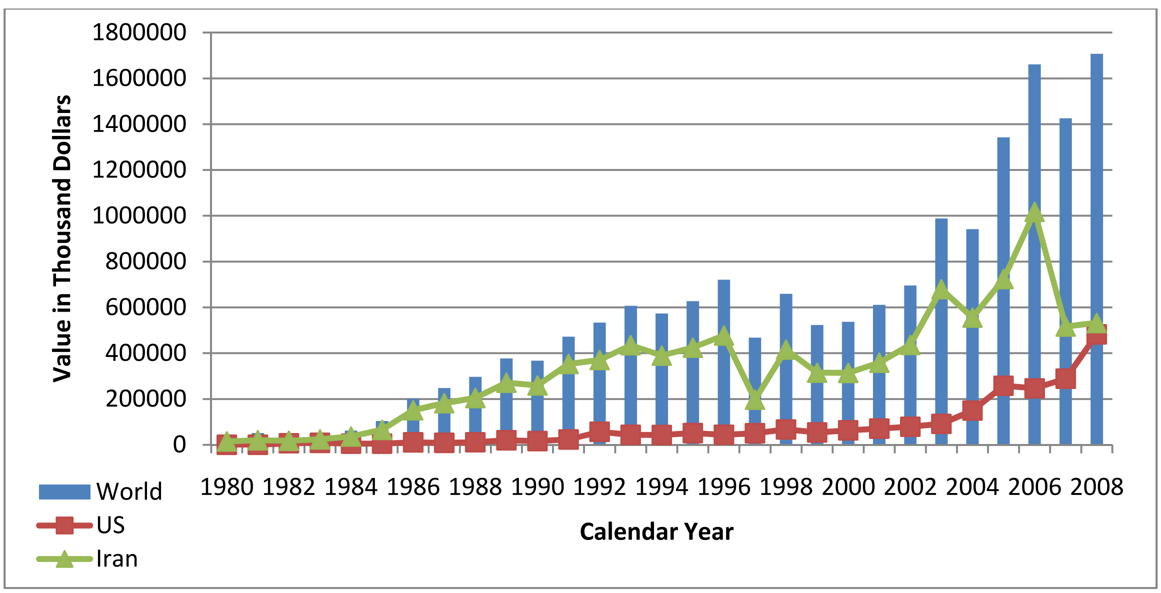

Figure 1.3: The US, Iran and World Pistachio Exports in Value, 1980-2008.

Data Source: FAO TradeSTAT

This incident highlights the significance of food safety in international trade. It changed the world pistachio export market situation. As shown in figures 1.2 and 1.3, the US has experienced much faster growth rate in pistachio exports (quantity and value) since the incident and has been catching up with Iran from 1998 to 2008. Yet there may be other factors that are important in this US export growth. This research will investigate the factors that have affected the US pistachio industry growth.

As Iran's major competitor in the world pistachio export market, it is important for the industry to understand the factors that cause the US to maintain or increase its global export share for pistachios. As a result, a comprehensive econometric model was established including variables such as US pistachio export prices, Iran's pistachio export price, foreign markets' GDP, the real exchange rates between foreign currencies and the US dollar, US export prices of substitutes such as almonds, walnuts, and pecans, and two indicator variables specifying the impact of food safety shocks. Data for the 21 major exporting destinations, which together account for 78 percent of the total US pistachio exports, were used.

1.2. Objectives

The first objective of this study is to evaluate the role of the US in the worldwide production and trade of pistachios, as well as to identify the most important factors affecting the variations of US exports. As stressed in the last section, food safety shocks can affect exports by threatening consumer confidence, so the second objective is to explore effects of food safety shocks on US pistachio exports by quantifying food safety shocks by two indicator variables, one for Iran and one for the US. Third, federal marketing orders provide orderly marketing environment as well as regulations on food safety and quality standards. Thus, in order to reinforce the findings by Alston et al. in 2005 on the Pistachio Marketing Order, a review of previous literature on effects of marketing orders in other industries was done. The last objective is to conclude useful agribusiness and policy making implications in the pistachio industry based on the estimation results and research done in the area for future reference.

1.3. Scope

In order to accomplish the above objectives, the scope was limited to a case study of 21 US pistachio exporting markets in the world. The 21 markets chosen can be divided into six regions in the world, North America, South America, Europe, Middle East, North Africa, and Asia. Data were available from 1989 to 2009, which account for 78 percent of total US pistachio exports.

Data limitations restricted the power of the food safety indicator variable. Data on food safety shocks were not completely available. For example, effects of each food safety incident can differ from case to case. Some incidents cause disastrous, long-lasting consequences and whoever suffers from them might take years to recover. Other incidents are discovered quickly and solved right away, causing little impact or harm on consumer confidence. However, no data were available on how many metric tons were recalled for each food safety incident from a certain country. This makes it impossible to specify the extent of the food safety variable. These data limitations reduced the power of the variable in estimating its effects on the dependent variable.

1.4. Organization

The current chapter presents the problem description, objectives and some of its limitations. The next chapter will present background information on the US pistachio industry, including production, export and food safety. Chapter 3 provides a discussion of current food safety issues and a description of each food safety incident that occurred in the studied period. Related literature review on export demand, marketing orders, and food safety concerns is incorporated into each associated section. Chapter 4 presents an analytical framework to estimate the effects of selected variables on US pistachio export. Chapter 5 includes the empirical results and elasticity analysis. Finally chapter 6 concludes with a summary, conclusions, agribusiness and marketing implications, limitations and suggestions for future studies.

CHAPTER 2. BACKGROUND

This chapter begins with an introduction to pistachios. A brief historical description and illustrations of US pistachio production based on available data reveals the underlying forces that led to the US success in today's market. Excess supplies in the US naturally lead to more exports (See the following section). Finally the highlighted food safety issue is briefly addressed in the last section.

2.1. Pistachios (Pistachio Profile)

Pistachio is one of the many popular tree nuts around the world. Pistachio trees are originally from dry lands and desert climate areas and are native to Syria, Iran, Turkey, Greece, Turkmenistan, Pakistan, and Afghanistan. The trees are often planted in orchards, and normally take seven to ten years to reach maturity. Pistachio is considered to be very important in both nutritional (100 grams of edible pistachio contains about 600 calories, in which 53% fat, 21% protein, 18% carbohydrates, 2.2% fiber and no cholesterol. Pistachio is also rich in vitamins such as B1, B2, C, and E.) and economic forms in Iran and is called the “green gold” by local people (Aghdaie, 2009). Like many tree nuts, pistachio trees suffer from alternate bearing, which means production goes up and down each year. The price of pistachios is often determined by the degree of shell splitting and the color of the kernel. Pistachios enclosed in shells are worth less than those that have opened for the extra cost incurred when opening the shells mechanically. Also, pistachios that have deeper kernel color are more valuable (See Figure 2.1).

Figure 2.1: Pistachio Kernel Colors

Source: Google Images

In 1954, pistachio trees were first introduced into the US but the commercial industry did not develop until 1976. From 1906 to 1976, the US mainly depended on importing pistachios from Iran, which was the biggest pistachio producer and exporter in the world. However, due to Iran's Islamic Revolution and the strained political relationship between the two countries, Iran stopped exporting goods to the US, which stimulated the growth of the US pistachio industry. For the following three decades, the US pistachio industry has grown briskly and in 1982, the US entered the world trade market, posing a strong rival against Iran.

2.2. Production

According to the United States Department of Agriculture (USDA), approximately 98 percent of US pistachios are produced in California. Other states producing pistachios include Arizona, Nevada, New Mexico and Texas. According to Food and Agricultural Organization (FAO) Production Indices, the top four pistachio producers in 2008 were Iran at 192,269 metric tons (mt) (35% of the world's production), the US at 126,100 mt (23%), Turkey at 120,113 mt (22%), and Syria at 52,600 mt (9.6%). Figure 2.2 presents the four countries' production share for the years from 1980 to 2009.

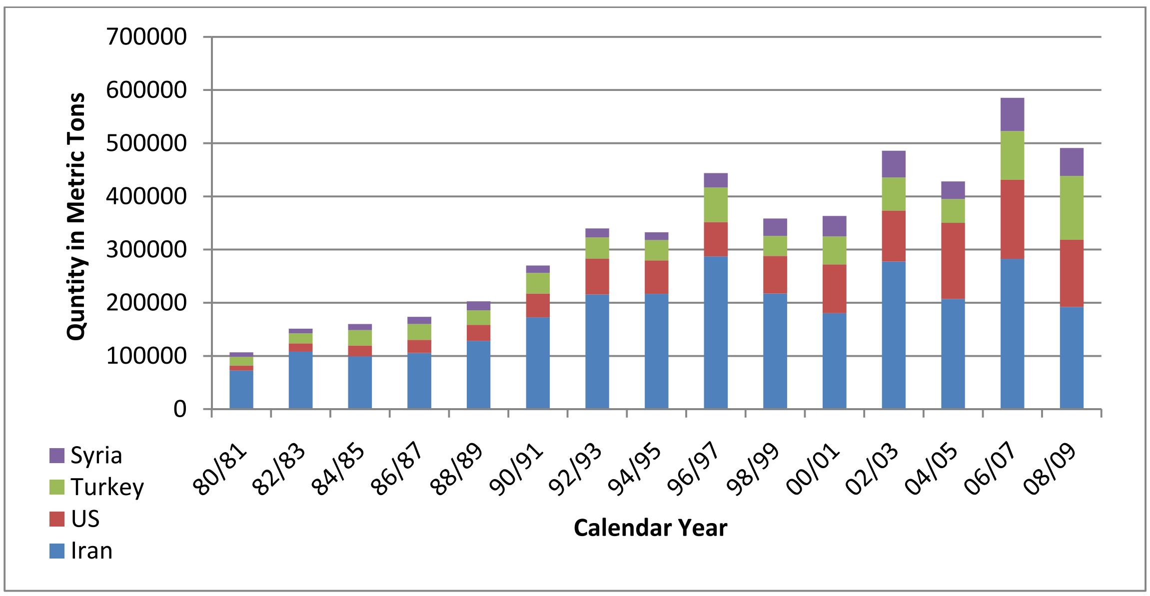

Figure 2.2: Pistachio Production in Iran, the US, Turkey, and Syria, 1980-2009.

Data Source: FAO Production Indices

Table 2.1 presents the four major pistachio producers mentioned above and their corresponding production in metric tons for the past thirty years. Each row is calculated by taking the average of production values in the corresponding two years in order to counter the effects of alternate bearing variations. The very right column is the US market share in percentage value, which has grown from 7.14 percent in 1980/1981 to 23 percent in 2008/2009.

Table 2.1: Major World Pistachio Producers' Production Quantity in Metric Tons, 1980-2009.

Year	Iran	US	Turkey	Syria	World	US % of World
80/81	72,569	9,435	16,250	8,502	132,132	7.14%
82/83	107,876	15,830	19,000	8,606	177,450	8.92%
84/85	99,248	20,455	29,000	11,414	186,523	10.97%
86/87	105,662	24,485	30,000	13,387	203,404	12.04%
88/89	128,317	30,145	27,500	16,750	232,016	12.99%
90/91	172,658	44,680	39,000	13,700	301,312	14.83%
92/93	215,482	67,815	39,500	16,950	372,518	18.20%
94/95	216,889	62,815	38,000	14,732	368,962	17.02%
96/97	287,043	64,765	65,000	26,876	489,883	13.22%
98/99	217,500	70,535	37,500	32,909	403,180	17.49%
00/01	180,500	91,625	52,500	38,680	404,166	22.67%
02/03	277,596	95,710	62,500	50,220	529,746	18.07%
04/05	207,278	142,882	45,000	32,921	479,196	29.82%
06/07	282,750	148,326	91,708	62,625	639,980	23.18%
08/09	192,269	126,100	120,113	52,600	548,377	23.00%

Data Source: FAO Production Indices

Figure 2.3 shows the dominant position of Iran and the US in world pistachio production. As shown, production growth rate had slowed down in Iran after 1997, while the US had experienced relatively faster growth rate thereafter. Amirtaimoori and Chizari (2007) investigated the reason behind this by looking at the area harvested and yield together with production for the years of 1982 to 2004. Here we can adopt the same approach for the period of 1980 to 2008. Figures 2.4 and 2.5 represent the area harvested and yield for the two countries.

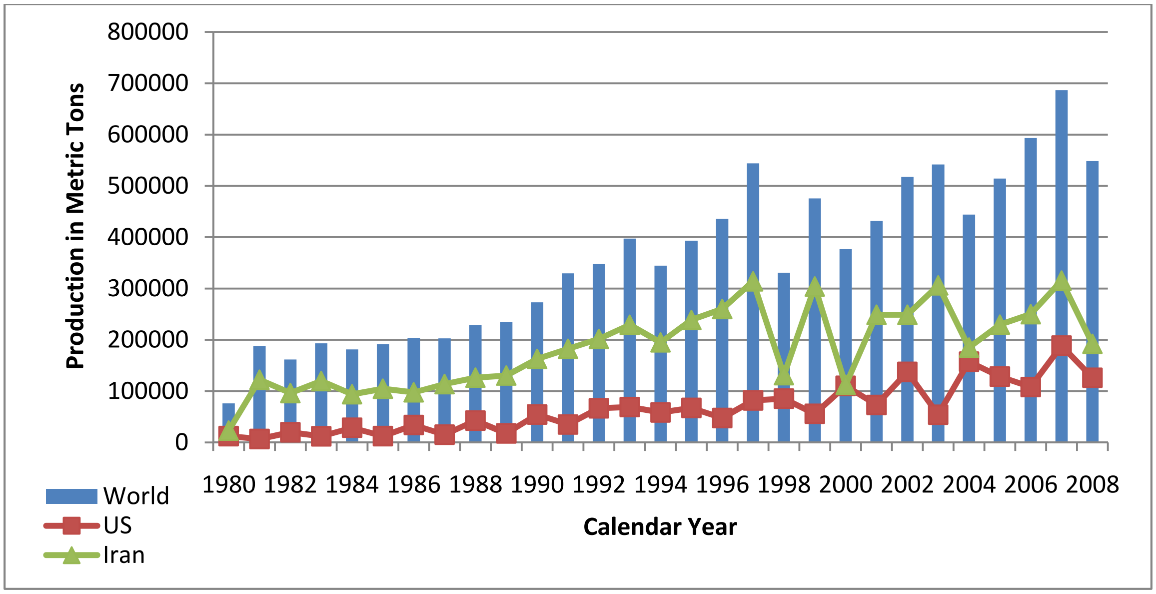

Figure 2.3: Iran, the US, and World Pistachio Production Situation, 1980-2008.

Data Source: FAO Production Indices

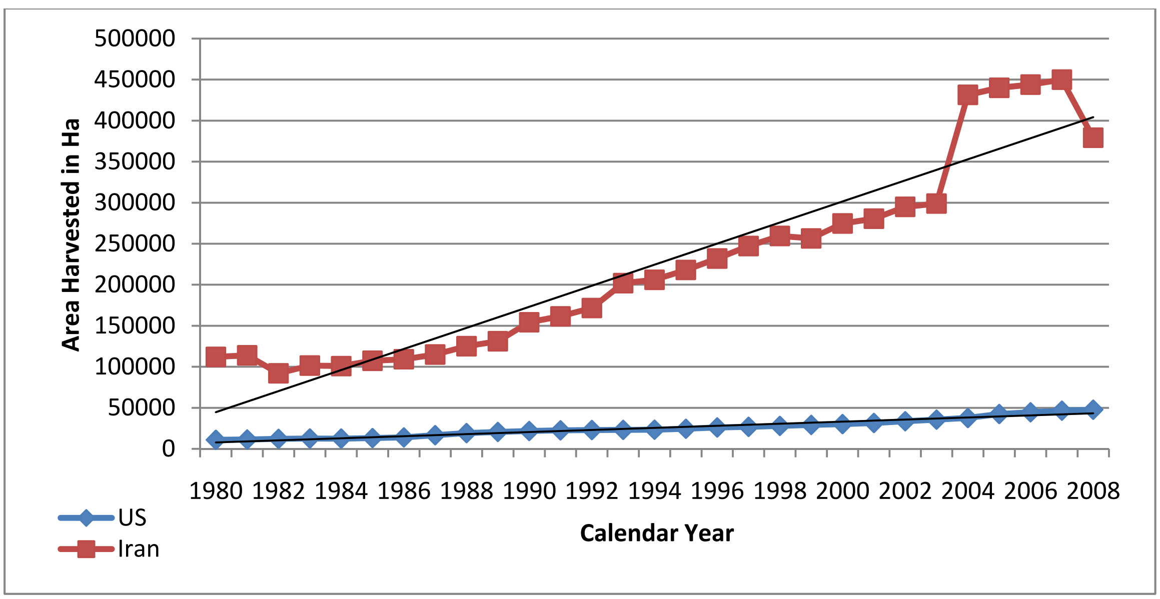

Figure 2.4: Pistachio Harvested Area in the US and Iran, 1980-2008.

Data Source: FAO Production Indices

From figure 2.4, one can see that Iran has a much larger pistachio harvested area than the US because of its desirable climate and long history of pistachio production. Pistachio harvested area in Iran has been trending up over the past 28 years. However, virtually all the commercially produced pistachios in the US are grown in California (USDA). So it is not surprising that the trend line for US harvested area is less steep than the Iranian trend line in Figure 2.4.

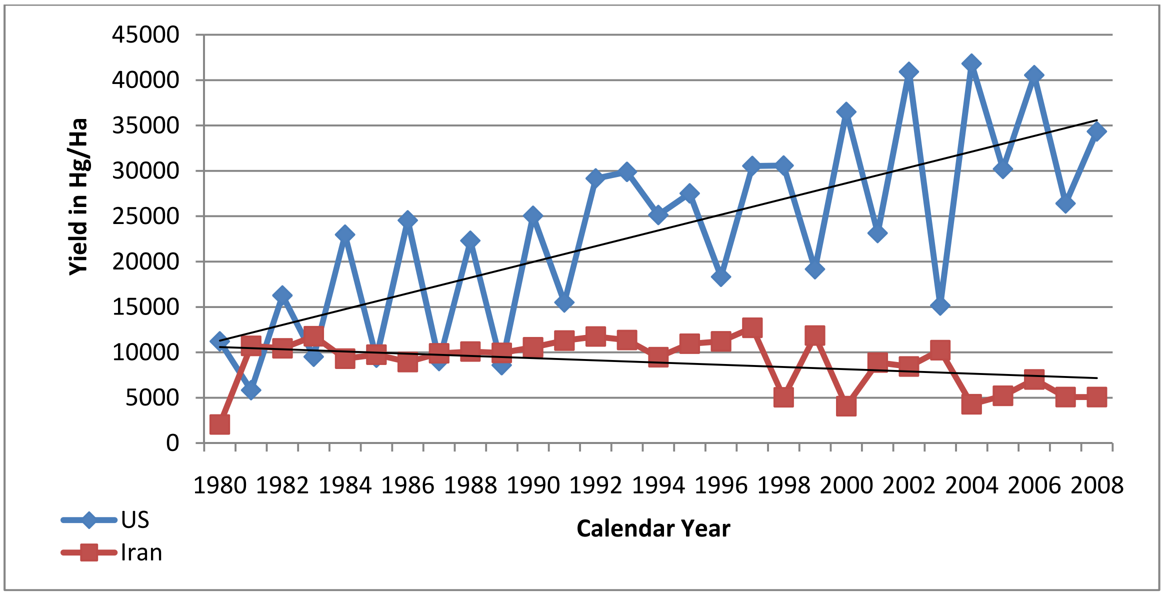

Figure 2.5: Pistachio Yield in the US and Iran, 1980-2008.

Data Source: FAO Production Indices

According to figure 2.5, although having great advantages in harvested area, Iran has a declining yield rate over time, whereas yield in the US has been increasing. This means that the US has been making much better use of its existing harvested area by adopting advanced technology and experienced labor. Therefore, it's not difficult to see why in figure 2.3, the production growth rate in the US is catching up with Iran, especially in recent years. Moreover, data indicate that average pistachio yield in Iran was low in 2001 mainly because of the serious drought.

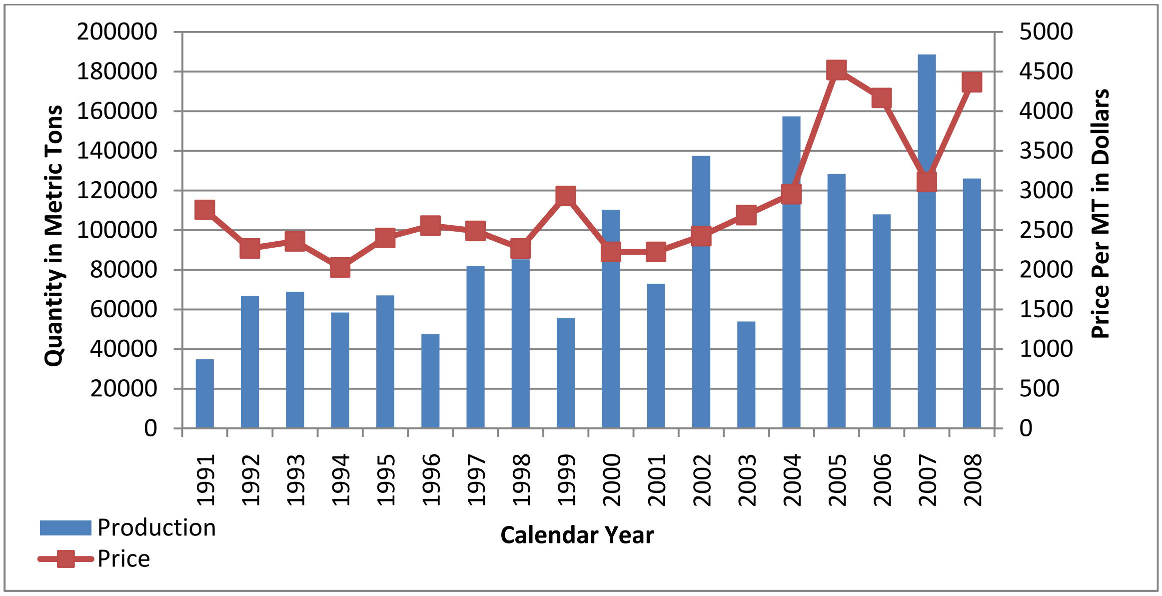

Figure 2.6: US Pistachio Production and Price

Data Source: FAO Production Indices

Figure 2.6 presents US pistachio production and price variation from 1991 to 2008. As one can see, there is an inverse correlation between price and production quantity. Like many tree nuts, there is an "on" and "off" year cycle in pistachio production, which means in one year there would be a larger amount of pistachios produced, but in the following year a relatively smaller amount. In order to stabilize the price, the marketing order held a reserve pool to compensate the shortages in supplies in the "off" years. Jolly and Norris (1992) have modeled this by simulating US pistachio prices using a simple linear regression model to estimate the relationship between production and bearing acres. Results showed the high significance of both bearing acreage and the alternate bearing variables. This implies the importance of proactive management such as pistachio carryover stocks in "on" years in order to counter off the "off" years' effects on price variations.

2.3. Export

As transportation infrastructure and marketing networks develop, as well as per capita income and consumer demand increase, international food trade is expanding along with the pace of globalization (Buzby et al., 2008). Figure 2.7 presents the world pistachio export market share in 2008, in which Iran and the US are playing the leading roles with 35% and 27% of the world total, respectively, followed by Hong Kong (HK) with 8%, Germany with 5%, Netherlands with 4%, and Australia with 4%. According to Global Trade Atlas Navigator, in calendar year 2003, 99 percent of HK's $151 million pistachio imports were from Iran and over 95 % of HK's $18 million of pistachio exports were re-exported to China.

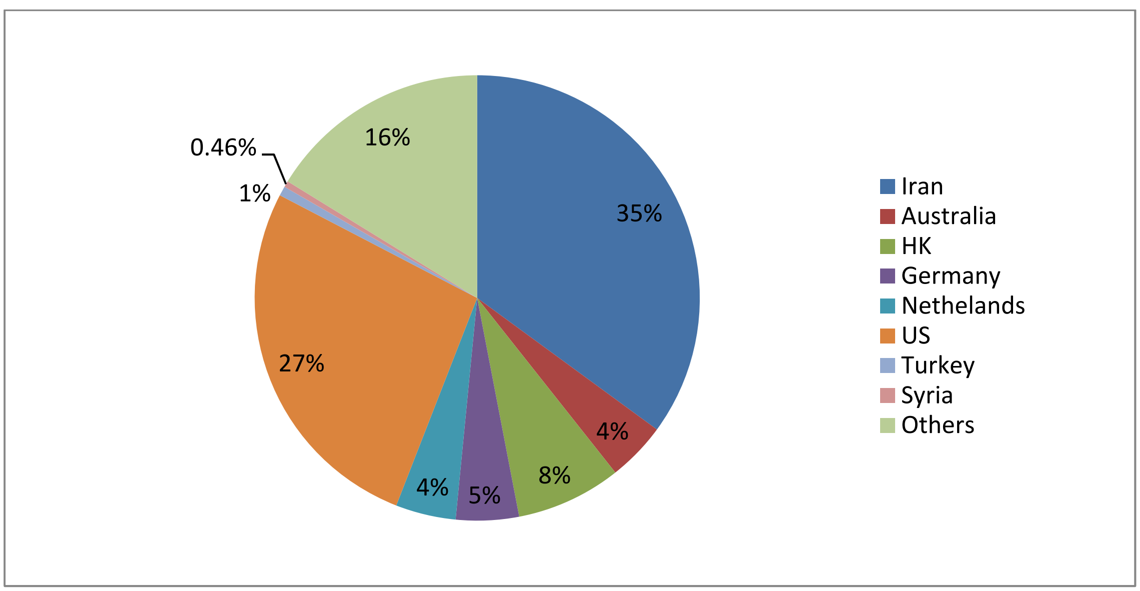

Figure 2.7: World Pistachio Export Shares, 2008.

Data Source: USDA ERS GATS

2.3.1. Duopoly: US-Iran

The characteristics of duopoly market structure are specified as: two countries account for a significant portion of total market share; goods can be homogeneous or partially differentiated; at least some degree of barriers to entry; may be incomplete information on prices, technology, and quality. Figures 1.2 and 1.3 show that the US and Iran form a duopoly situation in pistachio exports quantity and value for the years from 1980 to 2008. As one can see, in the 1980s, Iran dominated world pistachio exports, while export growth in the US was progressive and slow. However, the market situation experienced a dramatic change in the 1990s, when the export growth rate in the US started to catch up with Iran, especially in 1998, a year after the discovery of the aflatoxin contaminated pistachio shipment from Iran. Most of EU countries shifted their primary importing origin from Iran to the US, which as a result created a large export market regulated by stricter aflatoxin standards. The maximum allowable concentration of aflatoxin set by FDA is 20 parts per billion (ppb), foreign markets usually reject shipments with concentrations of 4 to 15 ppb according to the European community regulation on aflatoxin levels. This shift explains the main reason for the change in US and Iran's market share in pistachio trade.

2.3.2. US Pistachio Export Markets

Due to the success in pistachio production, excess supplies have led the US into the world market. Figure 2.8 shows US pistachio market status including production, export and consumption from 1989 to 2008. As shown, there are significant variations in production every other year due to its alternate bearing nature. But at the same time, exports have been growing steadily and do not seem to be significantly affected by these production dips because of the reserve pool held by the marketing order to mitigate the price swings. Consumption in the US used to be relatively low but has been growing progressively over time as production and per capita income goes up. According to the Economic and Research Service (ERS), per person consumption of pistachios had reached 0.23 pounds in 2007. However, nutritional research has helped increase the consumption of tree nuts lately as people are pursuing healthier diets. Karim and Vardan (2003) documented a long term study consisting of 26,000 healthy people, in which 7,000 were given nuts to eat at least five times a week. It was shown that the group given nuts in their regular diet reduced their risk of heart disease.

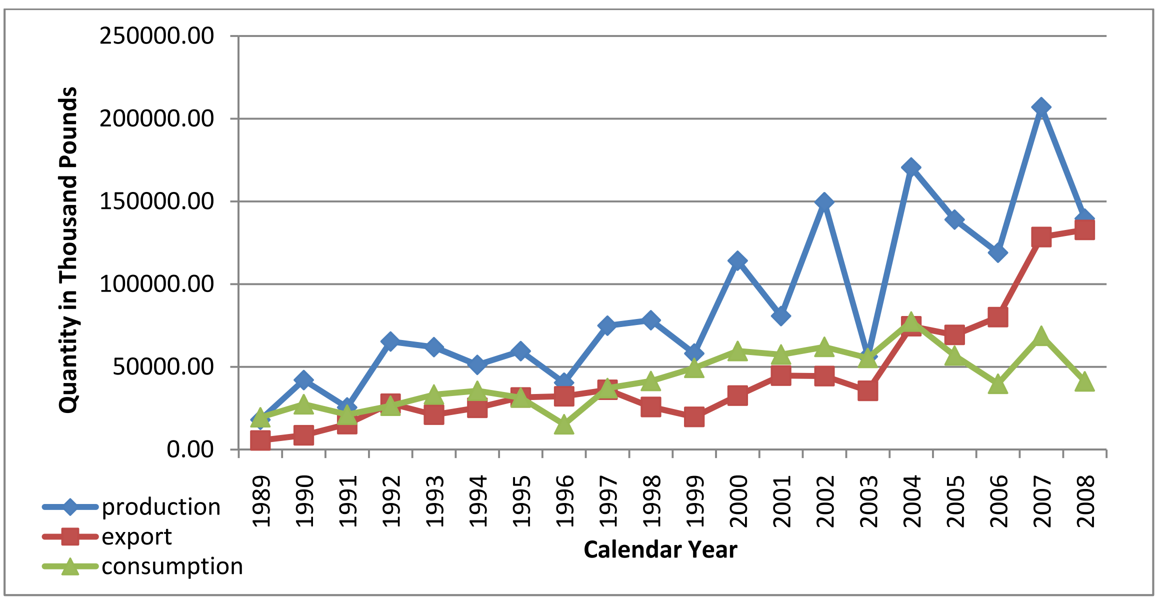

Figure 2.8: US Pistachio Market Status: Production, Export, and Consumption, 1980-2008.

Data Source: USDA

Table 2.2 shows US pistachio supplies and utilization in thousand pounds for the studied period. It starts with beginning stock from the previous year, followed by production and imports. The total supply is the sum of the first three columns. Demand is consist of domestic consumption and exports to foreign countries. Ending stock is the result of subtracting the total demand from the total supplies. Finally the ending stock of the previous year becomes the beginning stock in the following year.

Table 2.2: US Pistachio Supplies and Utilization (in Thousand Pounds)

Year	Beginning Stock	Production	Import	Total Supply	Export	Consumption	Ending Stock
1989	14,897	18,029	2,124	35,051	5,519	19,487	10,045
1990	10,045	42,047	853	52,945	8,682	27,399	16,864
1991	16,864	25,476	250	42,590	15,413	21,104	6,072
1992	6,072	65,362	396	71,830	27,763	26,471	17,595
1993	17,595	61,911	494	80,000	21,066	33,262	25,672
1994	25,672	51,250	732	77,654	25,275	35,554	16,825
1995	16,825	59,504	422	76,751	31,540	31,417	13,795
1996	13,795	40,425	944	55,163	32,202	15,266	7,696
1997	7,696	74,930	417	83,043	36,150	37,150	9,742
1998	9,742	78,208	549	88,499	25,793	41,443	21,264
1999	21,264	58,083	297	79,644	19,803	49,378	10,462
2000	10,462	114,164	920	125,547	32,641	59,577	33,329
2001	33,329	80,733	532	114,594	44,744	57,426	12,425
2002	12,425	149,513	764	162,702	44,449	62,073	56,180
2003	56,180	56,217	1,459	113,857	35,551	55,365	22,941
2004	22,941	170,515	798	194,254	74,550	77,387	42,317
2005	42,317	139,003	912	182,233	69,332	56,834	56,066
2006	56,066	119,000	1,388	176,454	80,061	39,764	56,629
2007	56,629	206,998	943	264,569	128,494	68,771	67,304
2008	67,304	139,591	985	207,881	132,778	41,222	33,881

Data Source: USDA

Figure 2.9 represents the 21 major US pistachio exporting markets in quantity and value in 2009. As one can see, European countries including Belgium & Luxembourg, Netherlands, Germany, France, Spain, Italy, United Kingdom, account for a large proportion of the total US exports.

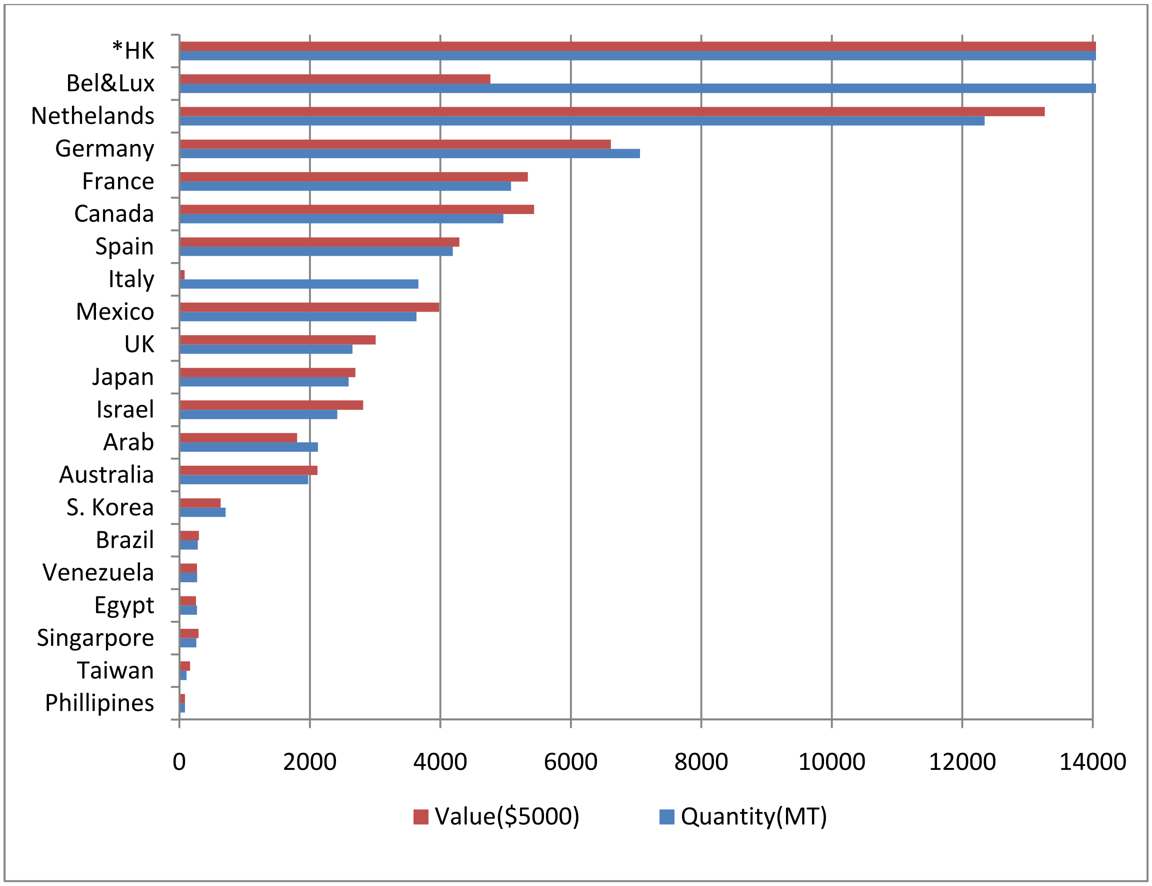

Figure 2.9: Top 21 US Pistachio Export Destinations in Quantity and Value, 2009.

*Some are re-exported to China.

Data Source: USDA ERS GATS

2.3.3. Food Safety Issues and Loss/Gain of Markets

Food safety has received more and more attention by industries, consumers, and policy makers nowadays, especially in developed countries. Buzby et al. (2008) mention that food safety concerns may have far-reaching implications such as reduced demands, altered international trading patterns, and limited access to foreign markets for the rejected US products. They also point out that globalization of the food supply chain can spread food safety risks to a much wider geographic area.

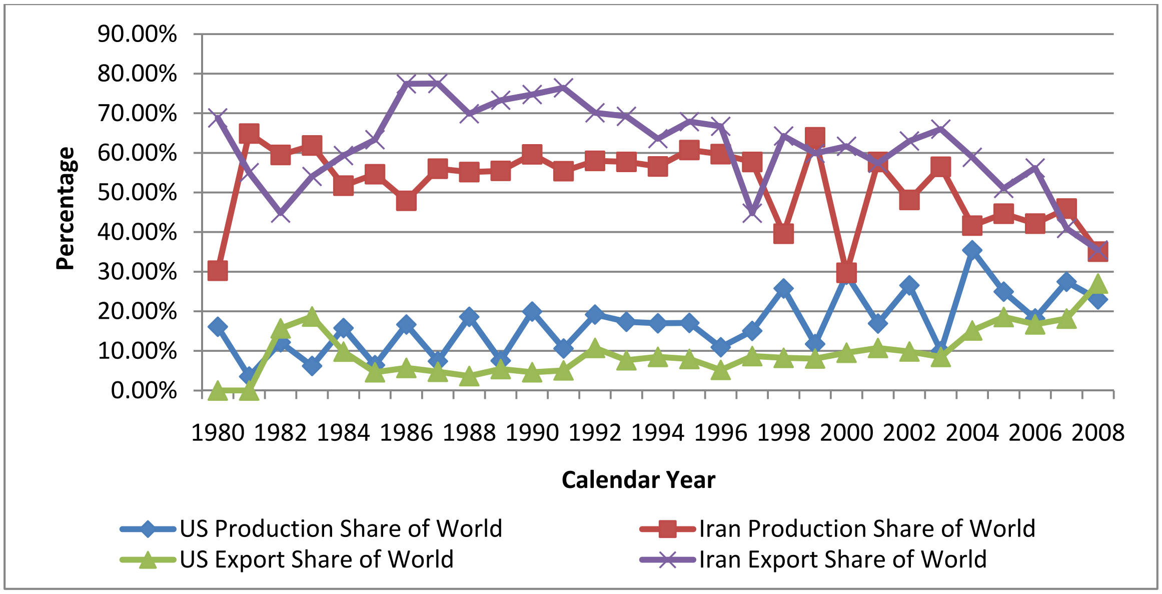

Figure 2.10: Loss/Gain of Markets for Iran and the US, 1980-2009.

Data Source: FAO Production Indices & TradeSTAT

Table 2.3: Production and Export Share of the World for the US and Iran, 1980-2009.

Country	Production Share in 80s	Production Share in 90s	Production Share after 2000	Export Share in 80s	Export Share in 90s	Export Share after 2000
Iran	53.74%	56.89%	44.61%	64.34%	65.76%	54.50%
US	11.04%	16.46%	23.53%	6.83%	7.47%	14.91%

Data Source: FAO Production Indices & TradeSTAT

The most far-reaching food safety concern for pistachio consumption originated from the 1997 Iran aflatoxin contamination. Figure 2.10 and table 2.3 illustrate the change in both production and export market shares in the last three decades. As the US successfully entered the world market, Iran's production share fell from 53.74% in the 1980s to 44.61% after 2000; their export share fell from 64.34% in the 1980s to 54.50% since 2000. In contrast, the US experienced a steady growth in production share from 11.04% in the 1980s to 23.53% after 2000; US export share increased from 6.83% in the 1980s to 14.91% after 2000. The change was not apparent until 1997, when the food safety shock in Iran caused significant market share gains for the US. Figure 2.11 shows the dramatic increases in US exports to EU countries in ten year intervals, especially in the last ten years, indicating the gain in European market share for the US over time.

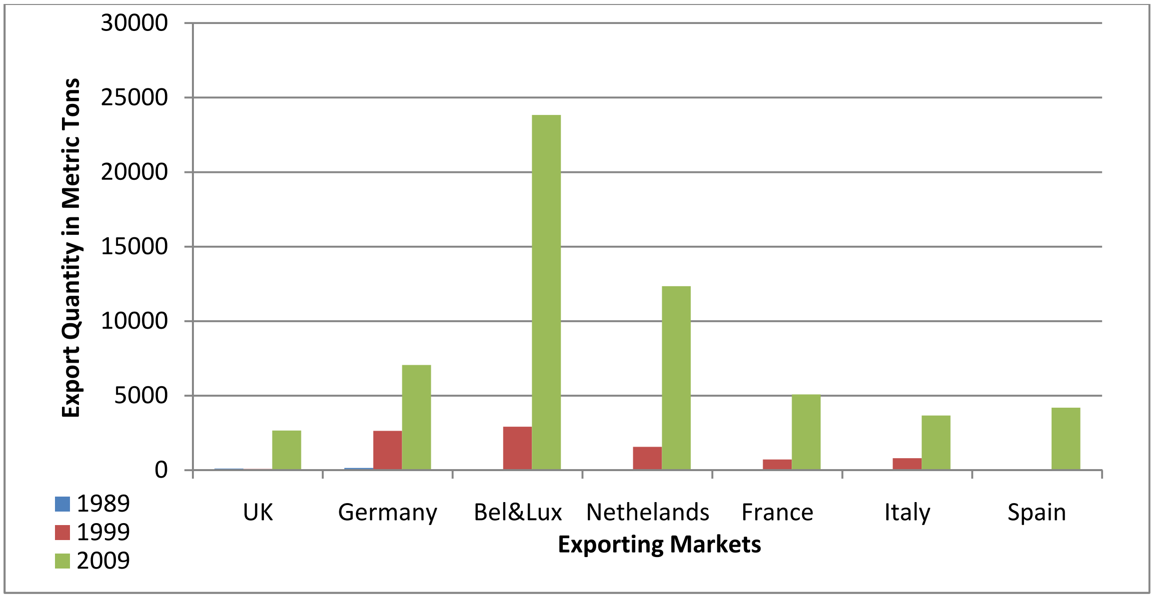

Figure 2.11: Percentage Growth of Export Share in European Markets, 1989, 1999, and 2009.

Data Source: USDA ERS GATS

Aflatoxin contamination in pistachios can happen when they are in the field, during harvest season, in storage and during processing procedures whenever the surrounding environment is moist enough for the dry core of pistachios to absorb moisture and distend. The humid core provides a perfect condition for fungus to grow and reproduce to create aflatoxin (Aghdaie, 2009). The poisoning can pose a severe threat to consumers' health and therefore reduce their confidence in purchasing pistachios (Pistachio Profile).

According to the FDA food-related refusal reports, for the period of 1998 to 2004, there were 241 violations for aflatoxin, in which 32.4% were for nuts and edible seeds and

42.7% were for the non-chocolate candy group. Many of the non-chocolate candy products contained nuts and seeds susceptible to aflatoxin contamination. Other crops frequently affected by aflatoxin include, but are not limited to, corn, rice, cottonseed, wheat, peanut, soybean, sunflower, spices, almond, walnut, coconut, and Brazil nuts.

Funded by assessments on California pistachio producers, a pistachio federal marketing order went into effect on August 1, 2005 and is designed to establish maximum tolerance levels and mandate testing for aflatoxin in order to increase consumer confidence and demand for pistachios.

Food safety concerns and how such concerns affect export demand and effects of marketing orders are addressed in more detail in the next chapter.

CHAPTER 3. FOOD SAFETY ISSUES

This chapter starts with the broader food safety concept and narrows down to aflatoxin contamination in tree nuts because of its relevance to pistachios. First, an introduction to the favorable conditions for aflatoxin development in pistachios is described. This is followed by the aflatoxin contamination incidents that occurred between 1989 and 2009. Then the prevailing collective actions to prevent aflatoxin contamination as well as previous literature on the effects of collective actions in different industries are introduced in order to reinforce the findings by Alston et al. in 2005 on the Pistachio Marketing Order.

3.1. Food Safety

Food safety outbreaks have increasingly caught the attention of policy makers and companies in the food industry. Buzby et al. (2008) examined the FDA data for the years from 1998 to 2004 on refusals of import to the US. They found that the three industries with the most food safety violations are fruits, fishery/seafood (with sanitary issues) and vegetables (with pesticide residues issues).

For US tree nut production, the total loss in sales to aflatoxin contamination goes up to $50 million per year and is much higher in years with greater insect damage (Cardwell et al., 2001). Major importers of US pistachios have set total aflatoxin action threshold levels at 4 parts per billion (ppb), which is far below the 20 ppb level recommended by the FDA for domestic foods. According to Campbell et al. (2003), “The low thresholds for aflatoxin contamination have significantly increased the probability for rejection of tree nut shipments by the major importing nations of the EU and Japan.”

3.2. Aflatoxin in Pistachios (Prevention of aflatoxin in pistachios – FAO)

Most of the time, pistachio shells split naturally prior to harvest with the hull covering the intact nuts, protecting the kernel from invasion by molds and insects (Figure 3.1). For nuts with poor hull protection in the orchard, it is much easier to be exposed to contamination. However, “early split” can happen whenever the hull is attached to the shell, resulting in the splitting of both the hull and the shell. According to a US study, approximately one to five percent of the nuts are early splits. Sommer, Buchanan and Fortlage (1986) and Doster and Michailides (1995) examined the effects of early splits and found that about 20 percent of early splits were contaminated with aflatoxin, while the rate was zero percent in nuts with intact hulls. Aflatoxin and insect contamination caused by early splitting have posed a great danger to consumer health and it is very difficult to detect when nuts have become contaminated by early splits. Because of this fact, it is necessary to time application of either chemical or biological control treatments.

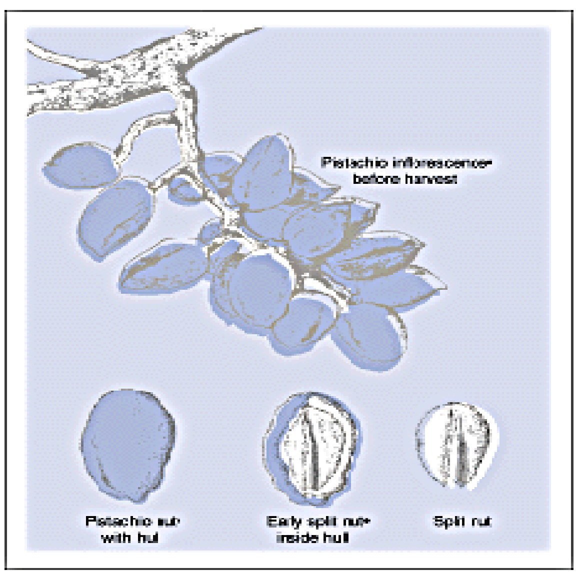

Figure 3.1: Pistachio Nut and Shell within the Hull

Source: FAO

Furthermore, early split nuts that are not infected in the orchard could still become contaminated during processing, transportation, and storage if the environment is humid and warm unless they are dried and refrigerated. Late harvesting, bird damage and cracking may also cause hull rupture in pistachios. The navel orange worm (NOW) sometimes damages the hulls of nuts and can cause aflatoxin contamination. Fortunately, NOW problems are easy to prevent and eliminate by hand sorting.

To conclude, the timing of splitting is of great importance in pistachio production. On one hand, early splits increase the risk of aflatoxin contamination. Late splitting on the other hand leads to market discounts because of the extra cost incurred when opening the shells mechanically. This indicates the importance of timing the shell splitting in order to minimize the loss to aflatoxin contamination and to maximize the market value of the nuts.

3.3. Food Safety Incidents in Pistachios

Table 3.1: Pistachio Food Safety Incidents

Year	# of Incidents	Country	Severity	Source of Pistachios
1997	2	Iran/S. Korea	High/High	Iran/US
1999	1	Germany	Low	US
2000	3	Australia/Japan/France	Low/Low/Low	US/US/US
2007	1	China	None	US
2008	1	US	None	US
2009	1	US	None	US

Data Source: Google News Timeline

Table 3.1 provides an overview of the food safety incidents associated with pistachios in the studied period. The third column describes the location that the incident took place.

The fourth column describes the severity of each event in terms of the effects on export quantity and price. The right column states the source of pistachios that are contaminated.

In September 1997, the EU placed its first ban on pistachio imports from Iran due to high levels of aflatoxin. The embargo was lifted again in December when Tehran assured that it would improve food safety inspections and product quality. However, EU import demand for Iranian pistachios was affected for a much longer period. According to FAO TradeSTAT, exports to EU countries dropped from 102,698 mt in 1997 to 59,619 mt in 1998 (See Figure 1.1).

According to a local South Korean newspaper, Thrifty Payless Ice Cream was discovered to have potentially dangerous bacteria contamination in November 1997. The six contaminated flavors include Pistachio Nut, Medieval Madness, Chocolate Chip, Cookies and Cream, Strawberry, and Strawberry Cheese. Figure 3.2 shows that the imports of US pistachios plunged from 541 mt in 1997 to 84 mt in 1999 and bounced back to 341 mt in 2000. However, from 2001 to 2005, the export quantities stayed under 200 mt. The export prices to South Korea were affected the following years as well. Prices went down from $4,938 per mt in 1997 to $3,687 per mt in 2001, indicating a severe negative impact. Yet there may be other reasons causing this negative impact, this short term effect is negligible.

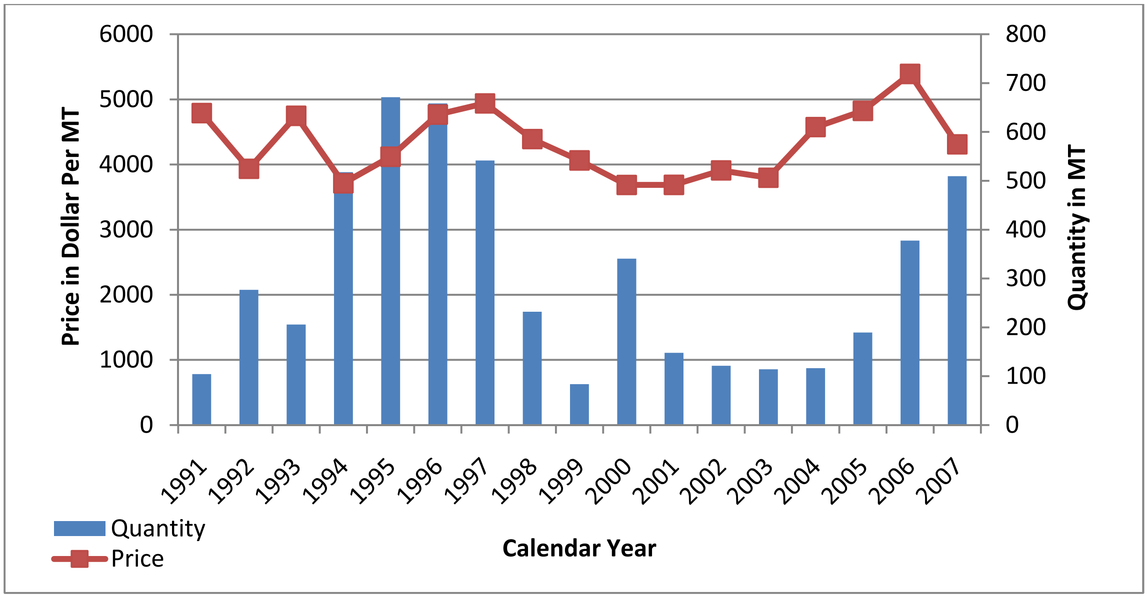

Figure 3.2: US Pistachio Export Price and Quantity Variations to S. Korea, 1991-2007. Data Source: USDA ERS GATS

In 1999, a German inspection group reported that eight out of eleven sampled pistachios from supermarkets contained higher than allowable aflatoxin levels and that the highest levels were found in California pistachios. In 2000, several articles were published in Germany's *Der Spiegel* and *Sueddeutsche Zeitung* as well as regional newspapers reporting discoveries of high aflatoxin levels in pistachio ice creams. Surveys indicated the continued reoccurrence of high levels of aflatoxins worldwide. For example, pistachios were recalled in Australia, Japan and France due to high levels of aflatoxin later that year.

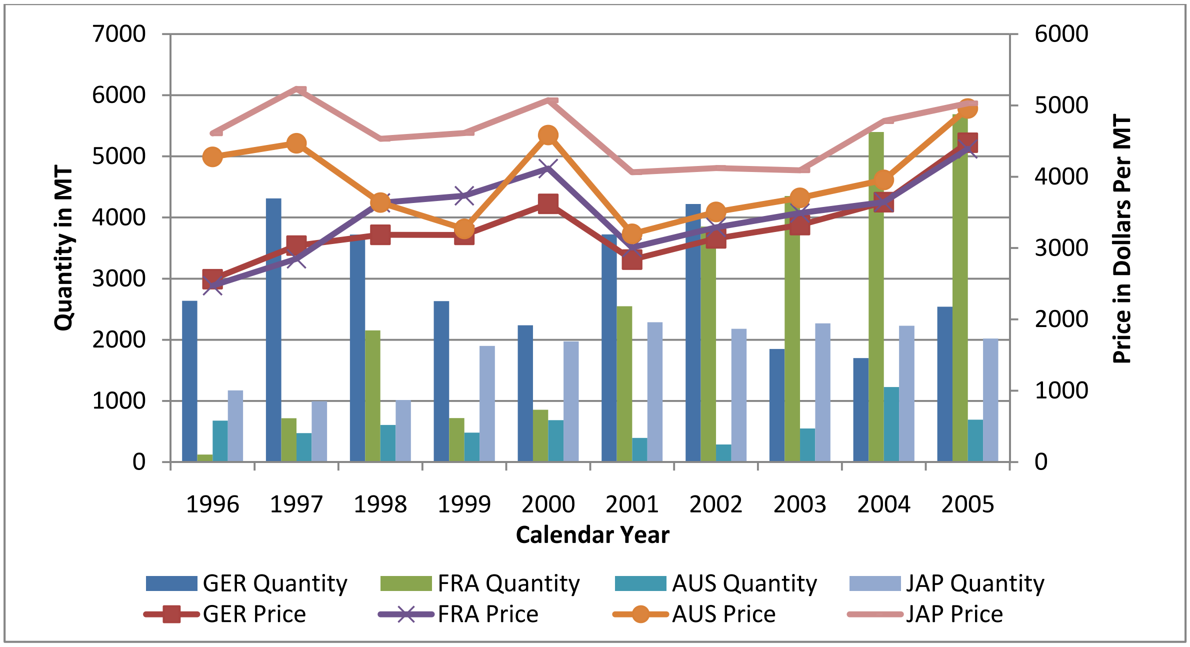

Figure 3.3: US Pistachio Export Quantity and Price Variations to Germany, France, Australia, and Japan, 1996-2005.

Data Source: USDA ERS GATS

Figure 3.3 shows the export demand of US pistachios to the affected four countries in 1999 and 2000, in both quantity and price. The amount exported to Germany decreased from 2,633 mt in 1999 to 2,237 mt in 2000; exports to Australia fell from 686 mt in 2000 to 287 mt in 2002; exports to France and Japan went up after 2000. However, one can see the short term effects more clearly from price variations. In 2001, the export prices of US pistachios to Australia, France, and Japan all went down significantly since the food safety incidents in 2000.

In September 2007, a shipment of pistachios from the US was rejected by China because it contained ants. Figure 3.4 shows US pistachio export quantity and price to China from 2005 to 2010, but the overall trend line seems unaffected by the 2007 incident.

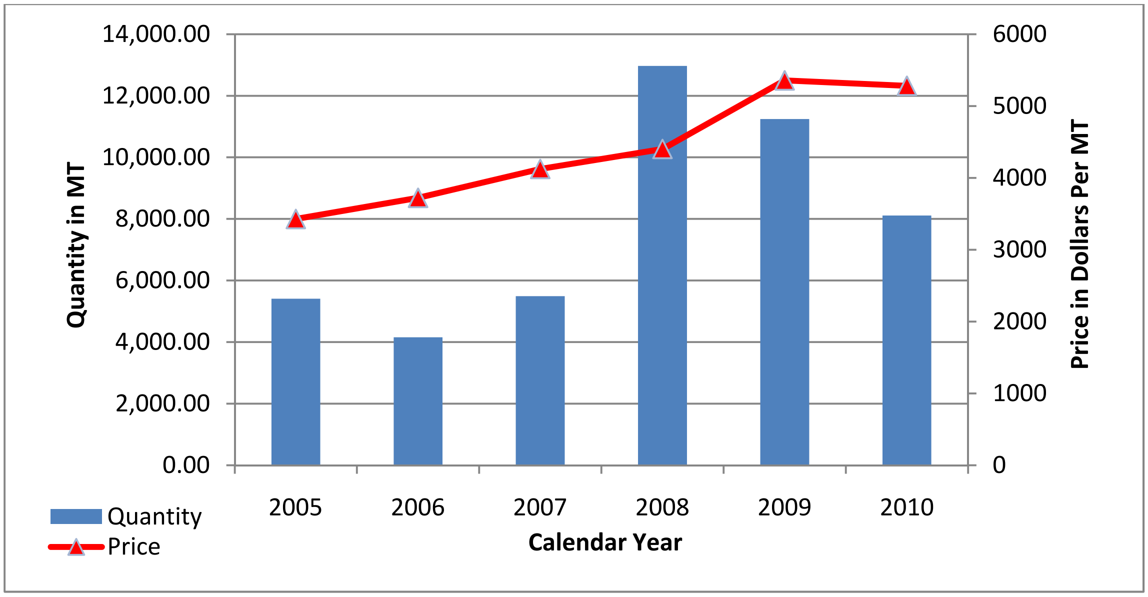

Figure 3.4: US Pistachio Export Quantity and Price Variations to China, 2005-2010.

Data Source: USDA ERS GATS

On August 12, 2008, a US newspaper reported that "popcorn, pistachios, Tic Tacs, and Skittles are the latest threat to local children". On March 26, 2009, Kraft Foods recalled its Nature Nantucket Blend trail mix, which contains pistachios that might be tainted with salmonella. These events occurred during years of 2008 and 2009 in the US and did not significantly affect consumer confidence in the world, since there are no big swings in pistachio export quantity and price as shown in figure 3.5.

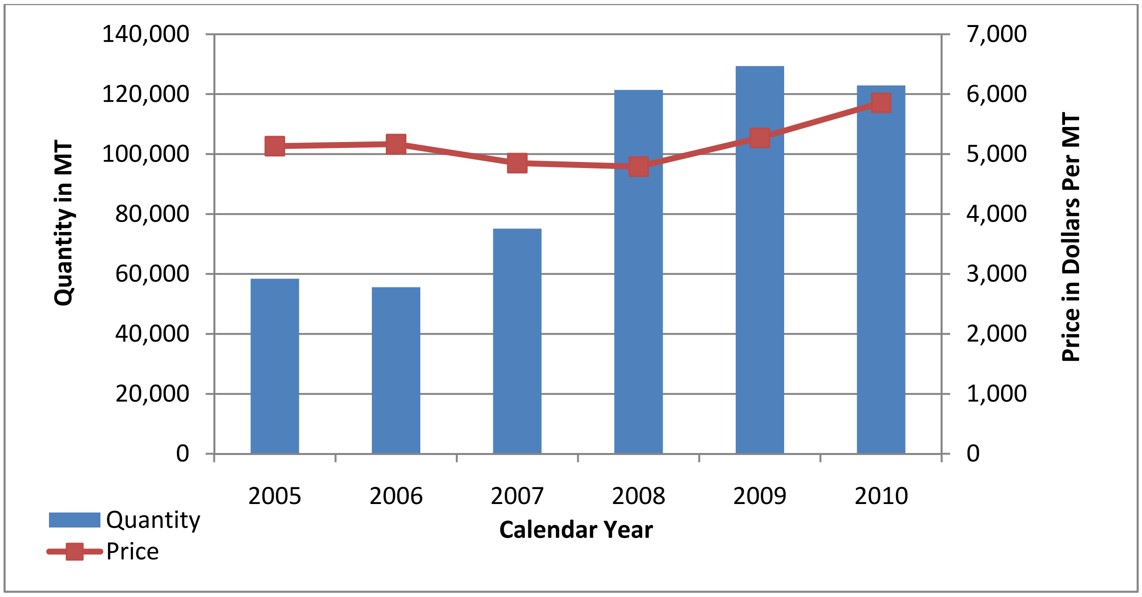

Figure 3.5: US Pistachio Export Price Variations to the World, 2005-2010.

Data Source: USDA ERS GATS

As mentioned earlier, effects of each food safety incidents differ from case to case. The 1997 aflatoxin event in Iran and South Korea led to disastrous and long-lasting consequences; while the other incidents that were discovered quickly and solved right away did not spread out the concerns among consumers. Although it is difficult to see direct correlation between food safety incidents and pistachio exports from the above figures because there could be a lot of factors affecting the exporting quantity and price, it is of obvious importance to regulate food safety standards in order to prevent such disastrous food safety incidents from happening in the future.

3.4. Collective Actions

The efforts made by pistachio producers and the federal government to control aflatoxin levels in pistachios are described in this section. The prevailing collective actions for the pistachio industry are the California Pistachio Commission and the Federal Marketing

Order. Aflatoxin is one of the main issues behind this. Previous literature reviews on the effects of collective actions in other industries are also discussed in this section in order to explore the feasibility of such actions and facilitate future policy making.

3.4.1. The California Pistachio Commission

In 1981, California pistachio producers formed the California Pistachio Commission (CPC) to provide support through public relations, government relations, marketing, and research funding (with $0.035 per pound collected from pistachios produced in California). According to Alston, et al. (2005),

> CPC has sponsored research on a wide variety of cultural challenges such as disease and insect control, methods of increasing production yields, and cultivar improvement. CPC receives funding under the Market Access Program (MAP) to promote pistachio exports to Japan, Korea, China, Malaysia, Philippines, Thailand, Canada, and the United Kingdom.

MAP funds to the pistachio industry averaged about one million dollars per year during the four years ending in 2009 (USDA FAS). This funding has been important to US pistachio promotional efforts.

3.4.2. The Federal Marketing Order for California Pistachios

A federal marketing order is a collective action taken by an industry, with support of the federal government to increase consumer demand, consumer confidence and producer returns by controlling quality standards through quality inspection and packing regulations, and investing in market promotion and research and development. Marketing orders allow industries to regulate the product quantity available in the market through volume controls, which include production limitations, diversions of some products to reserve pools, and market allocation restrictions (Berke and Perloff, 1985). The pistachio marketing order was established in August 2005 to enhance better product quality by setting a maximum aflatoxin tolerance level as well as inspections for defects and size.

In the same year (2005), Alston et al. developed a stochastic simulation model of supply and demand to assess the impact of the proposed federal marketing order for California pistachios. For the 50 years ahead, they measured the effects of the marketing order by comparing the two simulations of outcomes generated from economic indicators in the industry with and without the marketing order in estimated from 250 random draws considered in the study. The cost-benefit analysis showed that the measured benefits from marketing orders will greatly exceed the costs for producers' compliance to the regulations.

3.4.3. Effects of Collective Actions in Other Industries

The effects of marketing orders in US agriculture have been extensively studied and people hold diverse viewpoints on their effects in different industries. On one hand, people against them believe that the resulting "destruction of edible product or its diversion into lower-valued uses" will transfer the costs incurred to consumers (Chalfant and Sexton, 2002). On the other hand, people who support them argue that marketing orders will induce "orderly marketing", which is beneficial to both producers and consumers over the long term (Jesse, 1979).

3.4.3.1. Studies Showed Positive Effects of Marketing Orders

Chalfant and Sexton (2002) examined the grading errors scheme on marketing orders in the California prune industry and their results showed that grading errors can increase industry profits because it could potentially enforce a price discrimination scheme, in which demand for high quality products is generally inelastic compared to demand for low quality products.

Freebairn (1973) evaluated the effects of a uniform meat grading scheme on market performance and reached the conclusion that under the condition of uncertainty, increased product information available in the market will increase both consumer and producer welfare by reducing costs incurred by the ex post decision errors.

Berck and Perloff (1985) used a dynamic model to show how profit-maximizing farmers would vote on marketing order rules based on rational expectations. They concluded that the dynamic model in the study had reached the same equilibrium as the static model and that all farmers will vote for the same rules which are market allocation and crop destruction. The only difference between the dynamic and static models is that early entrants may have greater profits in the short run, yet the higher profits will encourage more new and less efficient firms into the industry. In the long run, the excess supplies will drive down prices, and consumer welfare will increase while producer welfare will decrease. Thus, the marginal profits diminish over time and finally will reach equilibrium.

Dobson and Salathe (1979) performed a study analyzing the effects of federal milk orders on the economic performance of US milk markets by examining what the markets might be without the order. According to their analysis, if federal milk orders were suspended, the market will suffer from "lower Class I differentials, greater price variability, and smaller Grade A milk surpluses might emerge in the future." (Dobson and Salathe, 1979)

French and Nuckton (1991) used a dynamic econometric model to examine the effects of volume control by comparing prices, production, profits, and related measures under the scenarios with and without the volume control. The comparison leads to the conclusion that the volume control has benefited consumers and producers or at least with no welfare loss over the 22 year period in the study.

3.4.3.2. Studies Showed Negative Effects of Marketing Orders

Chambers and Pick (1994) applied the Walter and Baldwin Criteria to examine the effects of minimum quality standards and found that they are nontariff barriers because although one country will gain, it is impossible for both partners to gain from these standards.

Thompson and Lyon (1989) performed a case study of the California-Arizona navel orange marketing order examining how the farm and retail price spreads were affected by the suspension of the volume control in 1985. Results indicate that "the 1985 suspension had decreased FOB retail price spreads in Atlanta and San Francisco by about 1.3 cents per pound." (Thompson and Lyon, 1989)

3.4.3.3. Summary

In summary, after weighting evidence of previous studies, it appears that marketing orders generally have positive effects. For one thing, five out of seven studies showed positive effects of marketing orders, or at least they don't leave producers and consumers worse off. For the other, the second study by Thompson and Lyon (1989) where the effect was negative, its influence was not strong and it was short term (18 weeks).

The results seem to be different across studies. The potential reasons for this could be that different types of quantity controls, such as producer allotments, market allocations, grading scheme and reserve pools, may affect price and quantity variations in different ways. Furthermore, even for the same type of quantity control, it may affect price and quantity differently in different industries due to the nature of each food industry. Many plausible scenarios could be generated and the effects of marketing orders would differ.

CHAPTER 4. ANALYTICAL FRAMEWORK

This chapter presents the analytical framework of the study. It starts with an introduction to previous literature on export demand functions, which leads to the finalized model of the thesis. All the variables are introduced and data sources are specified. A Hausman test is performed and the justification for the estimation procedure is presented at the end of this chapter.

4.1. Model Design

One should review the literature in order to get insights into setting up a good fitting model and explaining variations in the variables of interest. There are many studies on export demand functions, but not for pistachios. The following three papers are examples of export demand functions in general.

Senhadji and Montenegro (1999) used time series techniques to estimate the aggregate export demand elasticities for 53 developing and industrial countries and found a significant effect of the trading country's income and relative prices on export demand, especially in the long run. The results also showed that trade is an important engine driving the growth of economy in all developing countries.

Bahmani-Oskooee and Domac (1995) performed a cointegration analysis with annual data from 1923 to 1990 to investigate the export-led growth hypothesis for Turkey. They concluded that there is a long term equilibrium, and "bi-directional Granger causality" between export growth and output growth. This means that not only export growth causes output growth, but also output growth causes export growth.

Cosar (2002) studied the price and income elasticities of Turkish aggregate export demand using cross sectional data and concluded that Turkish export demand is elastic with respect to foreign income but inelastic with respect to the real exchange rate in both the short run and the long run.

The vast majority of the previous literature focused on how the importing countries' income and exchange rate affect export demand. However, there is a lack of more comprehensive empirical research exploring effects of more factors on export demand variations, particularly, for pistachios. This paper offers new evidence in explaining the variations of export demand for US pistachios, by expanding the export demand function to integrate a standard export demand function with effect of food safety shocks.

The export demand function of this thesis takes the form of a simple, linear regression relating US pistachio export demand quantity to several independent variables, including pistachio export price, Iran's export price (a substitute's price), the average US export price of almonds, walnuts and pecans, importing countries' GDP, and the real exchange rate between the country's currency and the US dollar. As previously stressed, food safety shocks can also affect export demand by threatening consumer confidence; as a result, two indicator variables, one for Iran and the other for the US, are created to investigate the effect of such concerns. Therefore, a comprehensive model that incorporates all the important variables mentioned in previous literature, the effects of substitutes or complements, and food safety shocks, will be estimated covering a much wider and more up to date time span from 1989 to 2009. This is also a major contribution of this research.

The critical economic indicators affecting export demand are hypothesized to be own price, cross prices, GDP's, the real exchange rates, and food safety shocks. Equation 4.1 specifies the export demand function for US pistachios.

$$\ln(Q_{i,t}) = \beta_0 + \beta_1 * \ln(EP_{i,t}) + \beta_2 * \ln(CEP_t) + \beta_3 * \ln(PNUTS_{i,t}) + \beta_4 * \ln(GDP_{i,t}) + \beta_5 * \ln(RER_{i,t}) + \beta_6 * FS1_t + \beta_7 * FS2_t + \varepsilon \quad (4.1)$$

the formula for the average price of other tree nuts $PNUTS = \frac{PA_{i,t}+PW_{i,t}+PP_{i,t}}{3}$ (4.2)

the formula for the real exchange rate is $RER = \frac{P_d}{e*P_f}$ (4.3)

where, $e = \frac{F_c}{\$}$ (4. 4)

The model utilizes a logarithmic function that makes values on different scales more comparable to each other, evening out the successively larger distances between the values, and also makes the functional form more flexible and much easier to interpret the coefficients, since they are in elasticity form. For example, β_1 is the own price elasticity for the response variable, which can be used to measure the percentage change in quantity demanded caused by a 1% change in its own price. β_2, and β_3 are the cross price elasticities of demand measuring the percentage change in the export demand for US pistachios caused by a 1% change in the price of complements or substitutes. β_4 is the GDP (income) elasticity of demand, which measures the percentage change in export demand caused by a 1% change in GDP in the importing countries. And finally β_5 is the real exchange rate elasticity of export demand measuring the percentage change in the response variable caused by a 1% change in the real exchange rate between foreign currencies and the US dollar.

4.2. Variables

In equation 4.1,

$Q_{i,t}$ - US export quantities of pistachios to country i in time t;

$EP_{i,t}$ - US pistachio export prices to country i in time t;

CEP_t - competitor's (Iran's) pistachio export price in time t;

$PNUTS_{i,t}$ - the US average export price of other tree nuts to country i in time t.

In equation 4.2,

$PA_{i,t}$ - US almond export price to country i in time t;

$PW_{i,t}$ - US walnut export price to country in time t;

$PP_{i,t}$ - US pecan export price to country in time t;

$GDP_{i,t}$ - GDP of country i in time t;

$RER_{i,t}$ - the real exchange rate between country i's currency and the US dollar in time t.

In equation 4.3,

P_d - domestic price level in the importing countries;

P_f - price level in foreign countries, which is the US price level;

e - the nominal exchange rate, which is defined as the number of units of the domestic currency (Fc) that can purchase a unit of a given foreign currency ($) (See equation 4.4);

$FS1_t$- food safety shock from Iran in time t, in which “0” denotes a situation with “no food safety incidents”, whereas “1” denotes “occurrence of a food safety incident”.

$FS2_t$- food safety shock from the US in time t, in which “0” denotes a situation with “no food safety incidents”, whereas “1” denotes “occurrence of a food safety incident”.

The subscript i denote cross sectional changes for the 21 exporting destinations, and the subscript t represents the time changes from 1989 to 2009 by calendar year. Among all the variables, competitor’s export prices and food safety shocks are time variant but cross sectional invariant. All other variables are both time variant and cross sectional variant, which is the panel data.

The effect of the own price of pistachios on quantity demanded is expected to be negative according to economic theory. To account for complementary and substitutional relationships for the response variable, the average export price of US walnuts, almonds and pecans, and export price of pistachios in the competing country (Iran) were included in the model. They may impact positively on the response variable if the consumption relationships among these tree nuts are substitutional, and negatively if complementary. The Iranian export price (CEP) was used as a proxy for all the US competitors because of the importance of Iran as a competitive pistachio producer and exporter in the world. Thus an increase in CEP might encourage the importers to purchase more from the US. Therefore, the expected sign of the coefficient of CEP is positive.

According to the literature, a positive relationship is expected between importing regions’ GDP and the demand for US pistachios. For one thing, trade and GDP growth are positively correlated with each other. For the other, pistachios are more expensive than most tree nuts (See table 4.1); the increased consumption of pistachios is associated with higher income levels.

Table 4.1: Tree Nut Retail Prices (in Dollars per MT)

Tree Nut	Price
Almond	3,086
Groundnut	507
Hazelnut	1,786
Pistachio	4,365
Walnut	1,334

Data Source: FAO PriceSTAT

In equation 4.3, the real exchange rate (RER) in this paper is defined as the ratio of domestic (in the importing countries) price level over the price level in the foreign countries multiplied the nominal exchange rate (e). In equation 4.4, e is defined as the foreign currency over the US dollar. The reason for choosing RER over e is that in practice, a change in RER, rather than its absolute level, is more important because in contrast to e, RER will change as the price level changes. An increase in RER is termed as appreciation, while a decrease is depreciation. As the US dollar appreciates, we would expect a decrease in e and less export, holding everything else constant, we would therefore expect an increase in RER. Thus, the expected correlation between RER and the response variable is negative.

Last but not least, the sign for FS1 can be either positive or negative depending on the nature of each event as mentioned in the last chapter. The sign for FS2 is expected to be negative on the US exports.

4.3. Data

Twenty-one major importing markets are selected as the studied sample: Canada, Mexico, Brazil, Venezuela, United Kingdom, Germany, Belgium & Lux, Netherlands, France, Italy, Spain, Australia, Taiwan, Hong Kong, South Korea, Japan, Philippines, Singapore, the United Arab Emirates, Israel, and Egypt. Annual data for the studied variables are available for the years from 1989 to 2009.

Data for Iranian pistachio export values and quantities were collected from Food and Agriculture Organization (FAO) TradeSTAT. Data for the real exchange rates and GDP's were acquired from USDA and are in real US dollars with 2005 as the base year. Data for export quantities and values for pistachios, almonds, and walnuts to each country were from USDA General Agreement on Trade and Services (GATS) statistics. Total price and quantity values are the sum of all types of nuts, which are fresh/dry/shell, fresh/dry/noshell, and preserved. Export prices are the average values calculated by dividing the total export values by the total export quantities. Data for food safety shocks were collected using Google News Timeline.

In the model, all the variables were formatted as indexed values: all variables were divided by their corresponding values in the base year 2000. Using the indexed form not only helps to make each time series equivalent in magnitude, but also helps to incorporate in a parsimonious way and thus helps to minimize specification errors.

As mentioned earlier, the data for 21 exporting destinations ranged from 1989 to 2009 and formed a panel data set. There are various benefits for using panel data estimation. First, the panel data estimation measures variations over both the cross sectional and time series dimensions jointly, which provides more information and better coefficient estimates than pure cross sectional or pure time series data. It allows for correction of heterogeneity and increased the power of the tests. Second, panel data adjusts dynamic variations in the data by exploring information from the dynamic reactions of each of the individuals, but not from the lengthy time series (Kennedy, 2003).

4.4. Model Validation-Hausman Test (Hausman, 2003)

There are two types of models for panel data analysis: the fixed effects model and the random effects model. In order to determine the best fit model with unbiased, consistent, and hopefully efficient estimator in estimating the dependent variable, a Hausman test is performed.

The Hausman test determines whether there is a significant difference between the fixed and random effects estimators by testing the null hypothesis that the difference between an efficient estimator and an inefficient estimator is zero.

As we know, a random effects estimator is more efficient than fixed effects estimator by saving degrees of freedom and correcting the composite errors. Moreover, the random effects estimator allows estimation of coefficients on time-invariant variables as well, so their effects are not eliminated. Although the random effects model has the above advantages, we can only use it when the Hausman test supports it to avoid overestimating the common slopes. Therefore, if the Hausman test does not support it, we will use the fixed effects estimator.

Consider the linear model in 4.5

$$y = \beta_0 + \beta_1 x + \varepsilon \tag{4.5}$$

where y is invariant and x is vector of regressors, β is a vector of coefficients and ε is the error term. Now we have two estimators for β: $\widehat{\beta_{FE}}$ and $\widehat{\beta_{RE}}$. Under the null hypothesis, both of these estimators are consistent, but $\widehat{\beta_{RE}}$ is efficient, which means that it has the smallest asymptotic variance. Under the alternative hypothesis, $\widehat{\beta_{FE}}$ is consistent, whereas $\widehat{\beta_{RE}}$ is not. Then the Hausman test statistic is:

$$H = (\hat{\beta}_{RE} - \hat{\beta}_{FE})'[V(\hat{\beta}_{RE}) - V(\hat{\beta}_{FE})](\hat{\beta}_{RE} - \hat{\beta}_{FE}) \quad (4.6)$$

In the model of 4.1, the Hauseman test is chi-square distributed with 6 degrees of freedom, which is the number of time-varying regressors. Here, the test result generated by Data Analysis and Statistical Software (STATA) is chi2 (7) = 3.09 with p-value = 0.8769, indicating no evidence to reject the null hypothesis. Therefore, the random effects estimator is chosen.

CHAPTER 5. EMPIRICAL RESULTS

The export demand function of US pistachios was estimated using a double log linear regression model relating the response variable to several independent variables as mentioned in Chapter 4. This chapter presents the results using the chosen estimator, which is the random effects model. After that, elasticity analysis is performed.

5.1. Data Summary

Table 5.1 summarizes the data set. The first row id (identification) varies from 1 to 21, indicating the 21 different exporting markets. T (time) varies from 1989 to 2009, which is the studied period of 21 years. The number of total observations is 21 by 21 is 441. The between variations of lncep (competitor's export price) and fs1, fs2 (food safety shock) are 0 because they are cross-sectional invariant. Lnq (US pistachio export demand quantity), lnep (US pistachio export price), and lngdp (foreign markets' GDP) have picked up more variations within each market than between the 21 markets because they tend to vary more by time than across regions. Table 5.1 also shows that the scale of the data variations are small due to the chosen double log function and the use of indexed values calculated by dividing all the data, with exception of the food safety indicator variable, by their corresponding value in the base year 2000. The manipulations mentioned above make variables scaled differently more comparable to each other and reduce specification error by randomizing the residual error variance.

Table 5.1: Data Summary

Variable		Mean	St. Dev.	Min.	Max.	Observations
	overall	11	6.062178	1	21	N=441
id	between		6.204837	1	21	n=21
	within		0	11	11	T=21
	overall	1999	6.062178	1989	2009	N=441
t	between		0	1999	1999	n=21
	within		6.062178	1989	2009	T=21
	overall	-0.076301	1.573559	-5.808143	5.318779	N=424
lnq	between		0.7956132	-1.438917	2.396793	n=21
	within		1.37208	-5.290908	4.683569	T-bar=20.1905
	overall	-0.010328	0.227067	-1.164296	0.6771204	N=424
lnep	between		0.1179521	-0.2148037	0.1898922	n=21
	within		0.1949104	-0.9809089	0.6331943	T-bar=20.1905
	overall	0.1867136	0.1715177	0	0.6965274	N=441
lncep	between		0	0.1867136	0.1867136	n=21
	within		0.1715177	0	0.6965274	T=21
	overall	-0.055953	0.2191882	-0.8213057	0.5868347	N=441
lngdp	between		0.0399635	-0.1452881	0.036094	n=21
	within		0.2156826	-0.7319709	0.5542674	T=21
	overall	-0.097538	0.2228181	-0.7627607	0.6509151	N=441
lnrer	between		0.1567546	-0.29609	0.2697277	n=21
	within		0.1618419	-0.9261218	0.5033568	T=21
	overall	0.0664777	0.5573818	-6.873888	1.277713	N=441
lnpnuts	between		0.3952056	-1.337599	0.8517869	n=21
	within		0.4019782	-5.469811	1.404077	T=21
	overall	0.047619	0.2132007	0	1	N=441
fs1	between		0	0.047619	0.047619	n=21
	within		0.2132007	0	1	T=21
	overall	0.2857143	0.452267	0	1	N=441
fs2	between		0	0.2857143	0.2857143	n=21
	within		0.452267	0	1	T=21

Generated by STATA

5.2. Parameter Estimates

The parameter estimates are reported in table 5.2, with all coefficients except one, which is price of other tree nuts, statistically significant at the one percent level of significance.

Table 5.2: Parameter Estimates for the Overall Export Demand Function

Variable	Parameter	Expected Signs	Estimate	95%LB	95%UB
US Pistachio Export Prices	β_1	-	-1.786 ***	-2.469	-1.102
Iran's Pistachio Export Prices	β_2	+	1. 353***	0.440	2.267
GDP's in importing countries	β_3	+	1.111***	0.359	1.863
Real Exchange Rate	β_4	-	-1.592**	-2.323	-0.862
Other Tree Nuts Export Prices	β_5	+/-	0.221	-0.089	0.531
Food Safety Shocks in Iran	β_6	+/-	-1.079***	-1.716	-0.443
Food Safety Shocks in the US	β_7	-	0.789***	0.474	1.104
Constant	β_0	n.a.	-0.651 ***	-1.082	-0.220

***: statistically significant at the one percent level. Within R^2: 26.94%; Between R^2: 1.33%; Overall R^2: 17.67%; χ^2_6: 143.63, $p < .0001$

The within R^2 of the model is 26.94%, meaning that 26.94% of the variation in US pistachio exports within each market is explained by the model. The between R^2 specifies the percentage of variations between the 21 markets that is explained by the model, which is 1.33%. And the overall goodness of fit of the model to the data is 17.67%. The p-value of the Wald statistic is very small, indicating a rejection of the null hypothesis that no variables is explaining the variations in the data, which means at least one variable in the model is explaining the variations of the predicting variable.

As one can see, the between R^2 is 1.33%. This may lead us to the question: What is an acceptable R^2? The answer to this question depends on where the random noise comes from in the data. In one model, a smaller R^2 may contain much more information than, in another model when the R^2 is near one. For example, the R^2 in a model using time trend to explain GDP growth will be extremely high, compared to the R^2 in another model using unemployment rates, quality of life, and education investments. But the second model actually contains much more information than the first one. Panel data is a combination of cross sectional and time series data, so we would expect the reported explanatory power of panel data to lie in between that of time series and cross sectional data. In this case, the model is explaining 17.67% of the overall variation, which is a good fit in general. Although we may not be able to explain cross region variations very accurately, we may very accurately be able to measure the effects of the right-hand side variables within each market.

In this case, it makes perfect sense that the within R^2 is larger than the between R^2. We would expect different factors affecting the import demand for a product in different markets. Senhadji and Montenegro (1999) found in their study that in developing countries, income levels and relative prices on export demand are affecting trade significantly, and trade is very important in driving the growth of all developing countries. In developed countries, there are various economic growth engines other than trade. Thus we would expect the random noise, which reflects factors that are not captured by the model, to be greater in developed countries than that in developing countries.

In table 5.2, US pistachio export price and the real exchange rate have a statistically significant negative impact at the one percent level, as expected, whereas the average export price of other tree nuts and the importing regions' GDP's have statistically significant positive impact at the one percent level, also as expected.

The food safety shock in Iran variable is negative and statistically significant at the one percent level, meaning that food safety incidents in Iran will affect consumer confidence in consuming pistachios even from the US. This negative effect is not surprising. As we know, consumers associate food safety problems from Iran to the world. Since Iran is the largest pistachio producer and exporter, it is likely for consumers to assume most of the pistachio products are not safe after the 1997 incident. The food safety shock in the US variable has the surprisingly unexpected positive sign.

Of all the parameter estimates, only the price of other tree nuts is not significant. This indicates no apparent correlation between US pistachio exports and the export price of other tree nuts. In other words, the increase in pistachio export price will not encourage countries to import more almond, pecans, or peanuts, or the other way around.

Regarding the negative correlation between the real exchange rate and export demand quantity, in equation 4.4, holding foreign currencies constant, a depreciation of the US dollar will lead to a higher nominal exchange rate. Then in equation 4.3, holding price in domestic market and foreign countries constant, as the nominal exchange rate goes up, the real exchange rate will go down and therefore lead to increased export quantities of US pistachios to foreign markets.

5.3. Elasticity Analysis

As mentioned earlier, the model of equation 4.1 is a double log function, in which the coefficient estimates can be interpreted as elasticities. β_1 can be interpreted as for every 1% of own price increase in pistachios, the export quantity demanded on average will go down by 1.79%, after adjusting the effects of all the other variables. β_2 can be interpreted as for every 1% of competitor's price increase in pistachios, the export quantity demanded on average will go up by 1.35 %, after adjusting the effects of all the other variables. For every 1% increase in foreign markets' GDP, the export quantity demanded on average will increase by 1.11%, after adjusting the effects of all the other variables. Again, for every 1% increase in the real exchange rate, the export quantity demanded will decrease by 1.59 % on average, after adjusting the effects of all the other variables. The elasticities for $\beta_1, \beta_2, \beta_3, \beta_4$ are greater than one, which indicates that US pistachio export demand is own-price elastic, cross-price elastic, income elastic, and real exchange rate elastic.

The determinants of price elasticity of demand include, but are not limited to, availability of substitutes, percentage of consumer's income that the product's price represents, necessity of the product in daily life, and brand loyalty. The more and closer the substitutes available in the market, the more price elastic is demand; the higher the percentage of consumer's income that the product's price represents, the more elastic demand tends to be; the less necessary the product is, the more elastic is demand; the lower brand loyalty, the more elastic is demand.

Pistachios are own-price, cross-price, income and real exchange rate elastic as expected and the elasticities are estimated as -1.79, 1.35, 1.11 and-1.59, respectively, which is plausible for the following reasons. First, there are plenty of substitutes available in the market such as almonds, pecans, cashews, peanuts, ect. Consumers have plenty of choices and can live without pistachios. However, the substitutes are not close enough to replace pistachios, restricting the price elasticity from being too high. Second, pistachios are more expensive than most tree nuts (See Table 4.1) and thus representing a higher percentage of consumer's income, indicating the elasticity of GDP (income) on demand for the product. Third, pistachio is not a necessity in daily diet, meaning the demand for pistachio is elastic on price. Fourth, there is little brand identification with pistachios (Brunke et al., 2004), we would therefore expect the demand to be elastic.

CHAPTER 6. CONCLUSIONS AND IMPLICATIONS

This chapter starts with a summary of the study, followed by a discussion of the general conclusions from the estimation results presented in Chapter 5. The general conclusions lead to the implications, including economic and agribusiness implications. In agribusiness implications, issues regarding pistachio production, marketing strategies, and food safety prevention are addressed. Last, suggested future research areas are listed as extensions or modifications to enhance limitations of the current study.

6.1. Summary

During the last thirty years, the pistachio world trade pattern has experienced a dramatic change. The US went from a pure importer to a major exporter that can compete with Iran, which formed a duopoly situation. This study explores the underlying factors behind this fact.

The US pistachio industry started growing in 1976 and the US became an exporter in 1982. Iran was the absolute dominant producer and exporter until 1997, when the food safety incident of an aflatoxin contaminated shipment of pistachios to the EU countries greatly changed the trade flow. The EU countries switched their primary importing origin from Iran to the US, which caused significant market share gains in the European markets for the US.

This thesis aimed to achieve the following objectives. The first objective was to establish an export demand function and explain the variations of US pistachio export demand quantity in the studied period. Second, it attempted to quantify the food safety shock variable and examine its effect on US pistachio exported. Third, it explores effects of marketing orders in general to facilitate future policy making. The last objective was to draw reliable conclusions and implications based on the model for future economic use, marketing strategies, policy making, and agribusiness applications.

Given the above objectives, the evolution of the US pistachio industry was reviewed, in contrast with Iran and several other important producers. Then, the export market situation was discussed including illustrations of loss and gain of market share for Iran and the US based on available data.

Data for the studied sample consisting of 21 major exporting destinations was collected for the years from 1989 to 2009, which formed a panel data set. The theoretical framework was translated into a comprehensive double log econometric model including several important components discussed in the literature and new prospects by the author. A Hauseman test indicated that the random effects model is the preferred estimator. Estimation results were statistically significant, plausible, and consistent with theoretical analysis.

6.2. Conclusions

Estimation results in table 5.2 show that pistachio's own-price and the real exchange rate between foreign currencies and the US dollar have a negative effect on amount demanded by international markets, and the elasticities are estimated as -1.79 and -1.59, respectively. While foreign regions' GDP's and cross-price of Iran's price are affecting the quantity demanded positively, and their elasticities are estimated as 1.11 and 1.35, respectively. These results answer the first objective.

Regarding objective 2, although the food safety in Iran variable is showing negative effect, indicating the spillover effect of the 1997 food safety incident from Iran to the US. As mentioned, since Iran is the largest pistachio producer and exporter, it is likely for consumers to assume most of the pistachio products are not safe after the 1997 incident. The food safety shock in the US variable has the surprisingly unexpected positive sign.

Regarding objective 3, the review of previous literature on effects of marketing orders in different industries has generally suggested a positive effect on increased producer profits and more stabilized price variations in the orderly marketing environment.

The last objective regarding useful implications on economic and agribusiness use are presented in the next section.

6.3. Implications

This section describes the implications of the thesis based on the conclusions drawn from the model and the research done. It is divided into two parts, which are economic and agribusiness. It tells the readers how these results may be used in future policy making and agribusiness applications.

6.3.1. Economic Implications

As shown in table 7, US pistachio export demand is own-price, income (GDP's in foreign markets), and real exchange rate elastic; while demand is cross-prices and food safety shock inelastic. This indicates that a one percent change in its own price, income, and the real exchange rate will cause the export demand quantity to change for more than one percent. This gives economists a base to predict future pistachio demand and to make policies regarding the real exchange rates to stimulate demands based on both domestic and international markets if necessary. To researchers, the general results can be applicable to other tree nut industries and time periods under the same assumptions. It provides a base for future studies in related areas.

Pistachios are more expensive than most tree nuts (See Table 4.1). This is why we see the positive correlation between its demand and income (GDP's in foreign markets). The fact that EU countries consume more pistachios exists in part due to their higher income levels (Karim and Vardan, 2003). So as GDP grows, we would expect more pistachio consumption. In return, the growth of the pistachio industry will contribute to GDP and income growth. The increased consumption of pistachios will drive growth in other tree nut consumption and lead to healthier diets. As the industry expands, on one hand, more and more labor will be employed, creating research and job opportunities and reducing the unemployment rate. On the other hand, the research to increase tree nut production would benefit the society as a whole. For producers, they will benefit by producing more and better nuts; for consumers, they will benefit by consuming cheaper and safer nuts.

6.3.2. Agribusiness Implications

The research is beneficial not only for economists and researchers, but also for producers in that they can adjust their production accordingly through the marketing order in order to maximize their profit level using the above results. Furthermore, other than the estimation results, there are more implications, which are discussed in this section.

6.3.2.1. Timing, Insect Control and Sorting

As mentioned, it is important to time pistachio splitting to prevent them from being contaminated or discounted in market value. On one hand, pistachio shells opened too early are at risk of aflatoxin contamination. Late splitting on the other hand would lead to market discounts because of the extra cost incurred to open the shells mechanically. This indicates the importance of timing. However, regarding how to control the perfect timing of pistachio shell splitting requires future research by biologists and agricultural engineers.

Before harvest, as mentioned, "early splits" caused by insect damage is an important factor leading to Aflatoxin contamination. As a result, developing better techniques in controlling insects in pistachio orchards has become more and more important because of the increased resistance to pesticides (Varela et al., 1993).

After harvest, sorting will greatly reduce the aflatoxin counts in pistachios. Campbell et al. (2003) documented the major sorting steps, in order, are:

> trash removal, water flotation to segregate empty-shell and immature nuts, hull removal, drying to 5-6% water content, sorting to remove closed-shell (again somewhat immature) nuts, electronic color sorting to segregate and remove stained shell nuts and, if required, hand sorting to complete the electronic process and also remove nuts with visible insect damage. Finally, nuts are size sorted.

6.3.2.2. Marketing and Food Safety

The US has been taking advantage of its modern technology in both production and packaging, higher than average expertise in product marketing and advertising, and higher standards for food safety. These are the underlying factors that led to the US ultimate success. However, compared to its biggest competitor Iran with 45% of world production and 55% of world export, both US production and export share is far behind

(See Table 2.3). Moreover, the variety of pistachio products in the US market is limited. The most commonly seen are salted/unsalted or shelled/unshelled. In contrast, there is a much wider variety of products in Iran, for example, different shapes, flavors, colors, and packages (See Figure 6.1).

Figure 6.1: Iranian Pistachio Colors and Packages

Source: Google Images

For roasting flavors in Iran, there are pistachios roasted with lemon juice and sprinkled with salt, pistachios in smoked, garlic onion, chili lemon and saffron flavors, ect. The color varies from the natural color to red, orange, green and purple for decoration purpose. The added flavors and colors to the shells make the nuts much more fun to consume. The packages of Iranian pistachios are fancy and beautiful as well and they have become an art in the Iranian culture.

For product shapes, there are round, long, and jumbo. Fandoghi (round) is the most widely available, and accounts for 40% of all pistachio orchards in Iran. Kalleh Ghouchi (Jumbo) pistachio accounts for 20% and has become popular among farmers because of its good yield. Akbari (long) accounts for 15% and is the longest type of pistachio and the most easy to open among the four. Ahmad Aghaei (long) accounts for 12% with high yield rates and shorter period of time to reach maturity, and has the whitest shell among the four. Ahmad Aghaei pistachio resembles the "Kerman" US pistachios. The last two are the newer varieties and each one has its special flavor and characteristic (Iranian Pistachio Varieties).

Therefore, in order to remain competitive in the international market, California growers should focus on market segmentation and product diversification for the next step. It may be difficult to develop different product shapes in a short period of time, but improving roasting techniques and expanding flavors, colors, and packaging choices are much easier, and there is great potential in the US market. Market segmentation and product diversification help to satisfy different consumer demands and increase both the consumer surplus and producer surplus.

To improve the current food safety situation, first is proper product packaging. As mentioned, pistachios not packaged properly can be at risk of being contaminated during processing, transportation or in humid storage environments. Therefore, developing safer packaging techniques and marketing management from farm to warehouse will reduce the loss to unsafe products.

Second, on one hand, according to the literature review in Chapter 3, marketing orders have positive effects on producer profits enforced by the potential price discrimination scheme and the "orderly marketing" environment. Furthermore, Alston et al. (2005) showed that the federal marketing order for California pistachios had a positive effect in their study. As a result, producer's compliance to the associated regulations such as minimum quality standards and maximum Aflatoxin thresholds will greatly reduce the loss to unsafe products. On the other hand, according to the duopoly economic theory, if the California pistachio growers act together as a whole through the federal marketing order, they will have the power to affect the price in the world.

Last but not least, in case of a food safety incident, better tracking records would improve the liability clarification. Pouliot and Summer (2008) showed that traceability improvement is a way to clarify liability by modeling a marketing chain in which the traceability system not only motivates suppliers to improve food safety, but also for the reduced liability that they are responsible for, which is the "free rider" problem. Hobbs (2004) also mentioned that the traceability system "provide ex post information" that helps consumers and suppliers to specify allocation of liability and stimulates companies' compliance on food safety regulations.

Thus it is necessary and beneficial for policy makers to impose mandatory traceability to benefit the consumers, marketers and farmers. It is beneficial for firms and marketers because the system allow them to avoid being responsible for other companies' liability and stimulate firms to implement stricter food safety rules. It is beneficial for consumers because they can consume safer food in the market, and even if in case of a food safety event, they will have much better chances on getting compensated, resulting in higher consumer confidence regarding food safety incident. Moreover, this is also something that the marketers should take advantage of in marketing the products.

6.4. Limitations and Future Research

Additional research in this area will be helpful in quantifying the current and predicting the future potential factors that affect the export demand of US pistachios. Three extensions or modifications to enhance the current study are to capture packaging and technology effects, the integration of food safety shocks in a more specific quantified model, and the willingness to pay for safer tree nut products.

For a thorough investigation of US pistachio export demand, the effects of packaging and modern technology should be incorporated in order to minimize systematic errors caused by missing components. Quantifying packaging, transportation costs, and technology would provide insights into marketing strategies and consumer preferences.

Second, the scope of food safety effect was limited to one indicator variable across 21 exporting markets. Quantifying the variable by specifying in metric tons in each destination would help increase the power of the t-test and provide more reliable results for policy making.

Moreover, the willingness to pay for traceability and safer food among consumers should be studied to give farmers and marketers a statistical and economical idea of the benefits by providing safer products.

Additional research will be of benefit in understanding other impacts on US pistachio demand in the world. Pistachio is a representative in the tree nut industry; understanding the factors affecting its demand is just the first step in discovering the factors affecting the demand for other tree nuts.

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Research Assistant Aug. 2009 - Present, Lexington, KY
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