AN ANALYSIS OF FACTORS AFFECTING THE GLOBAL LOCATION OF PORK PRODUCTION: A CROSS-COUNTRY ONE-WAY RANDOM EFFECTS MODEL

by

HONGSIN PARK

(Under the Direction of Dr. Lewell F. Gunter)

ABSTRACT

The pork sector of the agricultural industry is a valuable contributor to the global food supply. Competitiveness considerations and technological change have contributed to the transformation of production away from dispersed small-scale units toward concentrated, large-scale production facilities. In this study, we described major characteristics and trends in world and U.S. pork markets. We also analyzed the effects of environmental constraints on changes in pork production. The analysis is addressed through the development of a cross-country, time-series model relating changes in pork production to changes in demand and cross-country differences in land availability. The results indicate that pork production responds to changes in pork demand and simultaneously, the responsiveness to pork demand is impacted by land availability. Because these and similar factors have implications for the ability of the hog industry to expand, land availability may become a key determinant of the future scale of the pork industry.

INDEX WORDS: Pork, Pork production, Pork economics, Location model, Environmental constraints.

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HONGSIN PARK

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HONGSIN PARK

Major Professor: Lewell F. Gunter

Committee: Jack E. Houston
Jeff Mullen

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
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Dedicated to My Parents, My Sister, and Brother-in-law

For Their Love and Support

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TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION

1. Background Information

1.1. World Pork Production, Consumption, and Trade

The pork sector of the agricultural industry is a valuable contributor to the global food supply and the income of many farmers in the world. It is also an important customer for many productive resources. Developments in efficiency, breeding, and management techniques have resulted in scale economies and have yielded considerable increases in productivity, particularly for larger operations. This serves as a motive for increasing the scale of production (OECD, 2003).

World pork production increased at an average annual growth rate of 2.4 percent between 1980 and 2003 to 88 million metric tons. During the early 2000s, China supplied about 50 percent of the world's pork production (170 million metric tons over the years 2000-2003), followed by the EU, the U.S., Brazil, and Canada (USDA, PS&D). The volume of pork exports increased approximately 9.3 percent annually for this period of 1980-2003 to 4.3 million metric tons. The EU, the largest exporter during the early 2000s, accounted for 33.2 percent of global pork exports (5 million metric tons over the years 2000-2003) (USDA, PS&D).

World pork consumption increased more than 78 percent between 1980 and 2003, when it reached 87.5 million metric tons. Poultry consumption also significantly increased by 219 percent during this period and continues to show a higher rate of growth than pork, while beef consumption has been stagnant in general (USDA, PS&D). China, the EU, the U.S., and Japan accounted for three-quarters of the total world pork consumption during the early 2000s. China, as a leading pork consumption country, consumed 16.4 million metric tons annually (UN, FAOSTAT).

1.2. U.S. Pork Production, Consumption, and Trade

The competitiveness of the U.S. pork industry in global markets is strengthened by its inexpensive and high-quality products (Clemens, Hayes, and Johnson, 1996). Endowed with a favorable climate, state-of-art production technology, low feed costs, and advantageous market structure, the U.S. is a leading hog producer, third only to China and the EU (Amponsah and Qin, 2000). U.S. pork production increased about 20 percent between 1980 and 2003, reaching 9 million metric tons (USDA, PS&D).

By producing the highest quality pork, the U.S. pork industry has managed to serve an ever-increasing number of consumers with different tastes and preferences both at home and abroad (Amponsah and Qin, 2000). To increase pork consumption, the U.S. pork industry invested resources in producing better-flavored, juicier, and more tender pork and launched a strong marketing campaign to encourage the consumption of pork (Amponsah and Qin, 2000). U.S. pork consumption increased at an average annual growth rate of 1.2 percent between 1980 and 2003 to 8.8 million metric tons (USDA, PS&D). Per capita consumption of pork in the U.S. was, on average, 64.94 pounds for the period of 1995-2002 (USDA, Food Consumption Data System).

The U.S. is a relatively recent entrant to the international pork market, becoming a net exporter in 1995 for the first time ever. During the early 2000s, the U.S. accounted for 18.4

percent of global pork exports. The U.S. exported about 0.78 million metric tons of pork in 2003, representing the 13th consecutive year-over-year export quantity increase (USDA, PS&D). During the period of 1998-2003, the top three major foreign markets for U.S. pork products were Japan, Mexico, and Canada. Taken together, these three countries comprised 77 percent of U.S. pork exports for this period of time. Japan, the largest foreign market for U.S. pork products, imported 53.3 percent more U.S. pork products in 2003 than in 1998 (USDA, PS&D).

Although the U.S. has been a net exporter of pork since 1995, the U.S. is the third largest importer of pork products in the world, accounting for a little less than one-fifth of world pork imports during the early 2000s. Most of the increase in the U.S. imports was from Canada. Canadian pork exports to the U.S. accounted for over 87 percent of total U.S. pork imports during the period of 1998-2003, compared with only 50 percent in 1990 (USDA, PS&D).

1.3 Literature on the Economics of Pork Production, Consumption, and Trade

Recent literature on the economics of the pork sector includes discussion of changes in pork production technology, market structure, and environmental impacts of production. Competitiveness considerations and technological change have contributed to the transformation of production away from dispersed small-scale production units toward concentrated, very large-scale production facilities. The transformation to large-scale production has been accompanied by concerns about greater environmental impacts from concentrated production. Very large production units create local environmental problems, especially with regard to odors and manure storage and disposal.

The location of pork production facilities in the future will arguably be strongly influenced by the ability of producers to adopt the low-cost technology needed to compete in global markets while dealing with constraints on large-scale production facilities associated with environmental problems created by such facilities.

2. Objectives

The major objectives of this research are as follows:

1) To describe major characteristics and trends in world and U.S. pork production, consumption, and trade.

2) To review and describe recent economic literature on pork production, consumption, and trade.

3) To develop an empirical model to analyze the effects of environmentally-related constraints on production to changes in pork production.

The third objective is addressed through the development of a cross-country, time-series model relating changes in pork production to changes in demand and cross-country differences in population density and arable land.

3. Organization

The remainder of the thesis is divided into four chapters. Chapter 2 describes characteristics and trends in the international market for pork, and in U.S. pork markets. Chapter 3 reviews economic literature in the area of pork production, pork consumer demand, market structure, and pork trade and government policy. Chapter 4 presents the development of the econometric model briefly described under Objective 3 above. This chapter also includes the data description and the estimation results from the model. The final chapter, Chapter 5, summarizes this study, presents the conclusions, points out limitations of the study, and gives suggestions for future research.

CHAPTER 2

THE INTERNATIONAL MARKET FOR PORK

1. World Pork Production, Exports, and Consumption

International trade in pork has risen significantly in recent years as a result of bilateral and multilateral trade agreements, income growth, and technological innovations in transport and shelf-life extension. There is little doubt that as incomes continue to grow, markets continue to liberalize, and science finds new ways to extend the shelf-life of fresh meat over longer periods, international trade in pork will increase further (Amponsah and Qin, 2000).

1.1. World Pork Production and Exports

The pork sector of the agricultural industry is an important contributor to the global food supply and the income of many farmers in the world and is an important customer for many productive resources (OECD, 2003).

After a 16-week gestation period, 22-26 weeks are usually required to grow a pig to slaughter weight in case of a farrow-to-finish operation (USDA, Briefing Room: Hogs). Developments in production, breeding, and management techniques have resulted in scale economies and have enabled considerable increases in productivity, particularly for larger operations. This serves as a motive for increasing the scale of production. Improved farming techniques, improvements in management practices, and advances in genetics have resulted in significant productivity improvements in terms of increased weight, decreasing feed requirements, and the number of pigs farrowed per sow per year (OECD, 2003).

World pork production increased 56.2 percent (average annual growth rate of 2.4 percent) between 1980 and 2003 to 88 million metric tons. The volume of pork exports increased approximately 9.3 percent annually for this period of time and expanded to 4.3 million metric tons (see Figure 2.1 and Table A in Appendices). The only years world production decreased over the period 1980 to 2003 were 1996 and 2000. The decrease in 1996 was due to an outbreak of foot-and-mouth disease (FMD) in Taiwan, one of the largest pork producers and exporters at that time (Greene and Southard, 1998). Pork exports experienced relatively small decreases in 1989, 1991, and 1992, but increased every other year from 1980 to 2003.

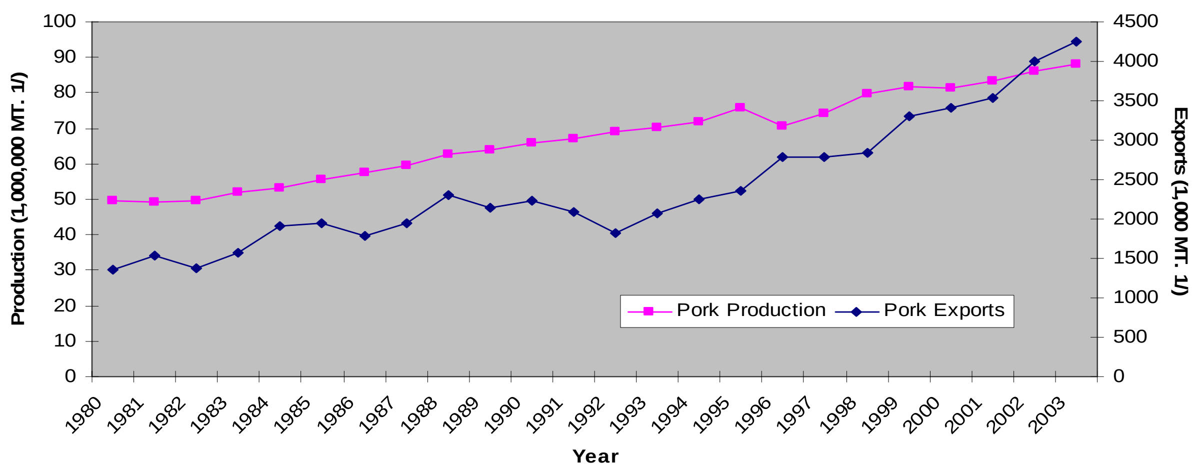

Figure 2.1. World Production and Exports of Pork (1980-2003)
1/ Carcass weight equivalent

Source: USDA, Foreign Agricultural Service (FAS). Production, Supply and Distribution Online. Webpage: http://www.fas.usda.gov/psd/Psdselection.asp (Accessed August, 2004).

The shares of the top five producing countries in the world market accounted for, on average, 86.4 percent of production during the period of 2000-2003. During this period, China supplied about 50.2 percent of global pork production, followed by the EU, the U.S., Brazil, and Canada, with market shares of 20.9 percent, 10.4 percent, 2.8 percent, and 2.1 percent, respectively (see Figure 2.2). For this period of time, China, the EU, the U.S., Brazil, and Canada produced 170 million metric tons, 70.6 million metric tons, 35.3 million metric tons, 9.4 million metric tons, and 7.1 million metric tons, respectively. Pork production in the U.S. increased about 2 percent per year and expanded to 9.1 million metric tons in 2003 (see Figure 2.3). According to OECD (2003), production in the EU as a whole grew at a slower annual rate of about 1 percent during the 1990s and early 2000s but there was variation between EU countries: production declined in Germany, the Netherlands, and the United Kingdom, but increased in Belgium, Denmark, and Spain.

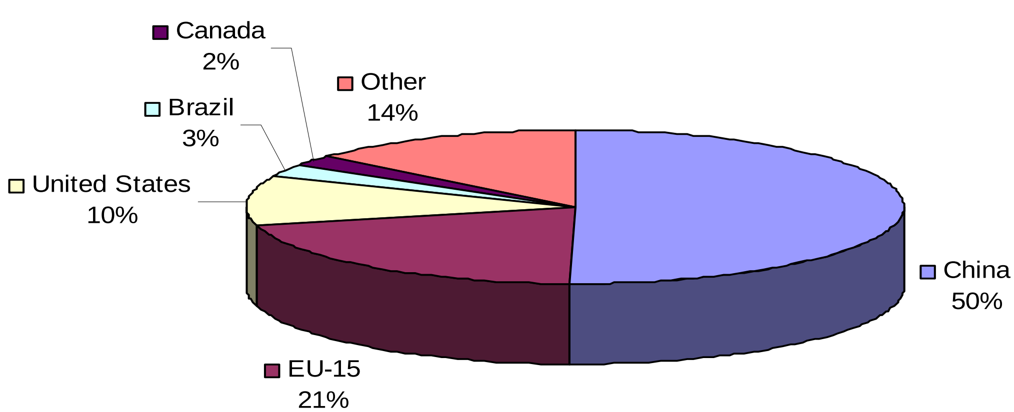

Figure 2.2. Country Shares of World Pork Production (2000-2003 on Average)

Source: USDA, Foreign Agricultural Service (FAS). Production, Supply and Distribution Online. Webpage: http://www.fas.usda.gov/psd/Psdselection.asp (Accessed August, 2004).

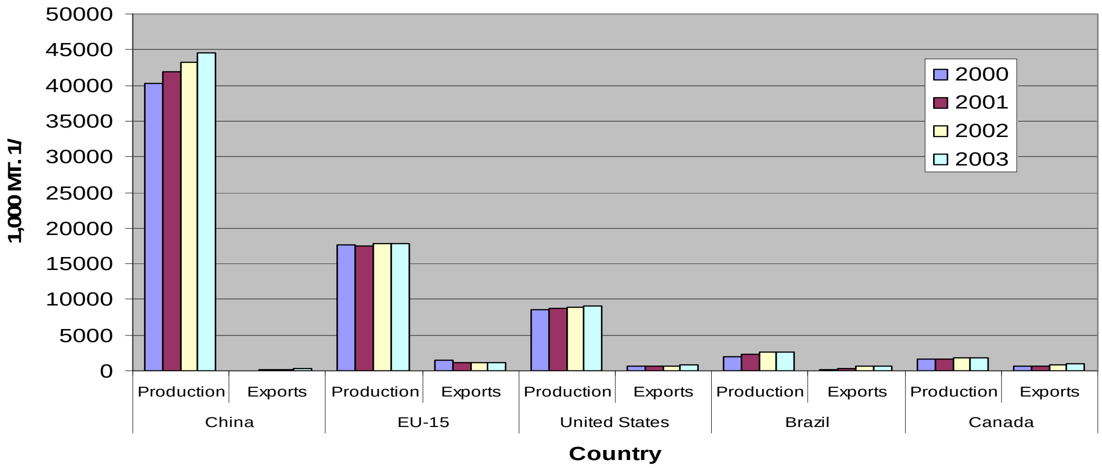

Figure 2.3. Major Countries of Pork Production and Exports (2000-2003)
1/ Carcass weight equivalent

Source: USDA, Foreign Agricultural Service (FAS). Production, Supply and Distribution Online. Webpage: http://www.fas.usda.gov/psd/Psdselection.asp (Accessed August, 2004).

From Figure 2.4, the market shares of the top five pork exporting countries accounted for, on average, 88.6 percent of the global export market during the period of 2000-2003. The EU is the largest exporter accounting for 33.2 percent of global pork exports in this period of time, followed by Canada, the U.S., Brazil, and China at 21.2 percent, 18.4 percent, 11.1 percent, and 4.7 percent, respectively. The EU's share in the global pork export market declined from 43 percent in 2000 to 27 percent in 2003, while Canada, Brazil, and China gradually and slightly increased from 19 percent, 5 percent, and 2 percent in 2000 to 23 percent, 15 percent, and 7 percent in 2003, respectively. The U.S. export share remained roughly stable for this period of time. For the period of 2000-2003, the EU exported 5 million metric tons, Canada exported 3.2 million metric tons, the U.S. exported 2.8 million metric tons, Brazil exported 1.7 million metric tons, and China exported 0.7 metric tons. China exported 0.4 percent of its production, while

Canada, Brazil, the U.S., and the EU exported 45.3 percent, 18.1 percent, 7.9 percent, and 7.2 percent, respectively (see Figure 2.3).

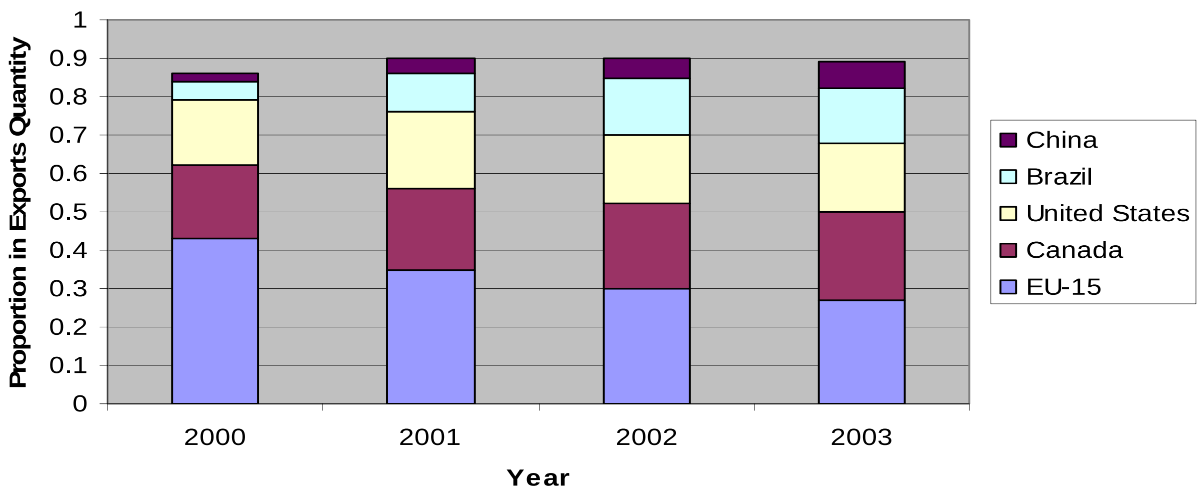

Figure 2.4. Market Share of Top Five Pork Exporting Countries (2000-2003)

Source: USDA, Foreign Agricultural Service (FAS). Production, Supply and Distribution Online. Webpage: http://www.fas.usda.gov/psd/Psdselection.asp (Accessed August, 2004).

1.2. World Pork Consumption

Pork accounted for the largest share of world meat consumption. Production has increased to meet increasing consumer demand. World pork consumption increased more that 78 percent between 1980 and 2003, when it reached 87.5 million metric tons (see Figure 2.5 and Table A in Appendices). Poultry consumption has also significantly increased by 219 percent during this period and continues to show a higher rate of growth than pork, while beef consumption has been stagnant in general. Note a drop in pork consumption between 1996 and 1997, with a quick recovery to the former consumption level. The Asian financial crisis hit in 1997 and reduced consumption growth in some major Asian markets for the global pork supply. For beef consumption, concerns about the discovery of BSE and E. coli in 1996 from a local slaughter house slowed global beef consumption for a while. The lingering effects of food safety concerns began to dissipate in 1997 and the outlook for beef consumption began to improve in the latter part of 1997 (Greene and Southard, 1998).

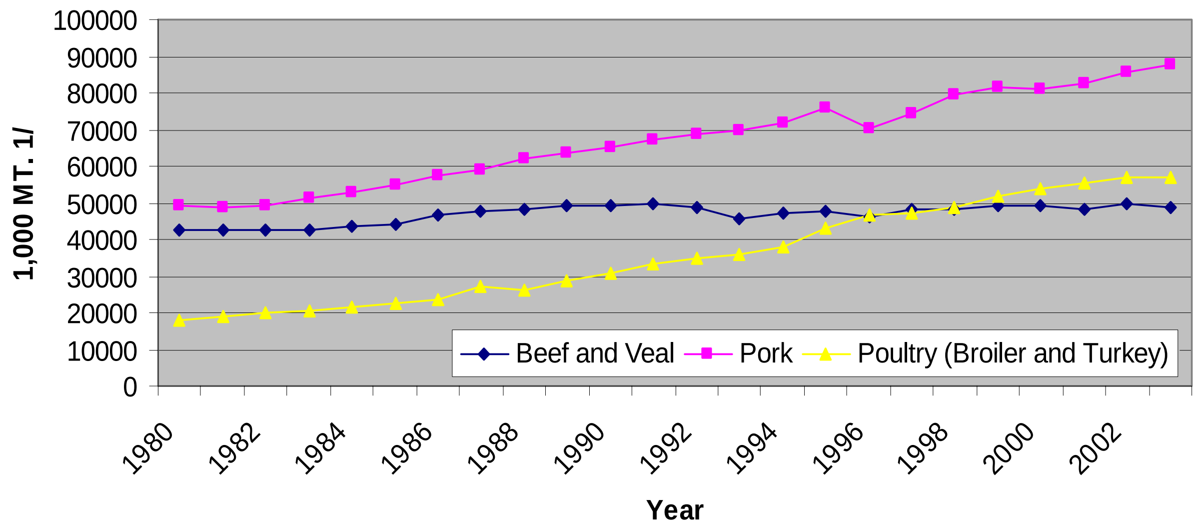

Figure 2.5. World Meat Consumption (1980-2003)
1/ Carcass weight equivalent

Source: USDA, Foreign Agricultural Service (FAS). Production, Supply and Distribution Online. Webpage: http://www.fas.usda.gov/psd/Psdselection.asp (Accessed October, 2004).

Table 2.1 shows that China, the EU, the U.S., and Japan account for three-quarters of the total world pork consumption during the early 2000s. During the late 1990s and early 2000s, per capita pork consumption was led by Poland, with 47 kg, followed by the EU (43 kg), China (31 kg), the U.S. (29 kg), and Canada (29 kg). In terms of annual growth rate between 1990 and 2003, Korea ranked first at 5.4 percent followed by China (4.3 percent) and Mexico (2.4 percent).

Table 2.1. Pork Consumption by Countries

Country	Average Per Capita Consumption (Kg)				Annual Average Consumption (1000 MT)	Average Annual Growth Rate (%)	
	1980-84	1985-89	1990-94	1997-2003	2000-2003	1980-89	1990-2003
Australia	15	17	19	19	374	2.2	0.4
Canada	32	31	29	29	1051	-1.9	0.6
China	13	18	23	31	42607	5.4	4.3
EU	38	40	40	43	16445	0.9	0.8
Japan	13	15	15	17	2311	1.8	1.5
Korea	8	9	15	20	1177	4.1	5.4
Mexico	19	13	11	11	1331	-6.8	2.4
Poland	39	43	49	47	1575	0.5	0.2
Russia	NA	NA	18	15	2224	NA	-3.4
U.S.	30	29	30	29	8586	-1.2	0.4
World	12	13	13	14	103998	1.2	1.0

NA: not available

Source: USDA, Foreign Agricultural Service (FAS). Production, Supply and Distribution Online. Webpage: http://www.fas.usda.gov/psd/Psdselection.asp (Accessed October, 2004).
United Nations (UN), Food and Agriculture Organization (FAO). FAOSTAT (database). Webpage: http://faostat.fao.org/?language=EN (Accessed October, 2004).

2. U.S. Pork Production, Consumption, and Trade

2.1. U.S. Pork Production

The competitiveness of the U.S. pork industry in global markets is strengthened by its inexpensive and high-quality products. The basic advantage in the U.S. is low-cost feed grains. The cost of production is the key in explaining the flow of pork from a low production-cost region (Clemens, Hayes, and Johnson, 1996). Endowed with a favorable climate, state-of-art production technology, low feed costs, and advantageous market structure, the U.S. is a leading hog producer, third only to China and the EU. Feed is the major production input in the pork industry, accounting for more than 65 percent of total production costs. Since the U.S. is one of the largest feed grain producers in the world, its comparative advantage in pork production is due, to a large extent, to the abundance of low-cost feed grains (Amponsah and Qin, 2000).

Being a net exporter is one result of significant structural changes affecting the U.S. pork industry in recent years. Since the mid-1980s, the industry has gradually adopted production practices based on fewer, larger operations and a reliance on contracting and vertical coordination to reduce producer/processor risk and to optimize year-round slaughter capacity utilization (Amponsah and Qin, 2000). The 1980s and 1990s have witnessed major technological breakthroughs in the pork industry. Advances in both genetic research and innovative swine management techniques have contributed to the high efficiency of the U.S. pork industry. Producers have maintained lower costs in pork production by using genetic improvements to attain higher reproductive efficiency. Since the early 1990s, these productivity gains have allowed the industry to export a higher percentage of U.S. commercial pork production (Amponsah and Qin, 2000). During the years of 1996-1997, however, reduced demand in Asian markets, especially Japan and Korea, led to significantly reduced U.S. pork production (Greene and Southard, 1998). Strong increases in pork production for the period of 1998-1999 led to depressed prices. Deteriorating hog prices devastated producers' returns, prompting producers to reduce pork production in 2000 (USDA, 1998, 1999a, and 2000a). U.S. production was 8.6 million metric tons, 8.69 million metric tons, 8.93 million metric tons, and 9.07 million metric tons, in 2000, 2001, 2002, and 2003, respectively, representing four years of consecutive increases (see Figure 2.6 and Table B in Appendices).

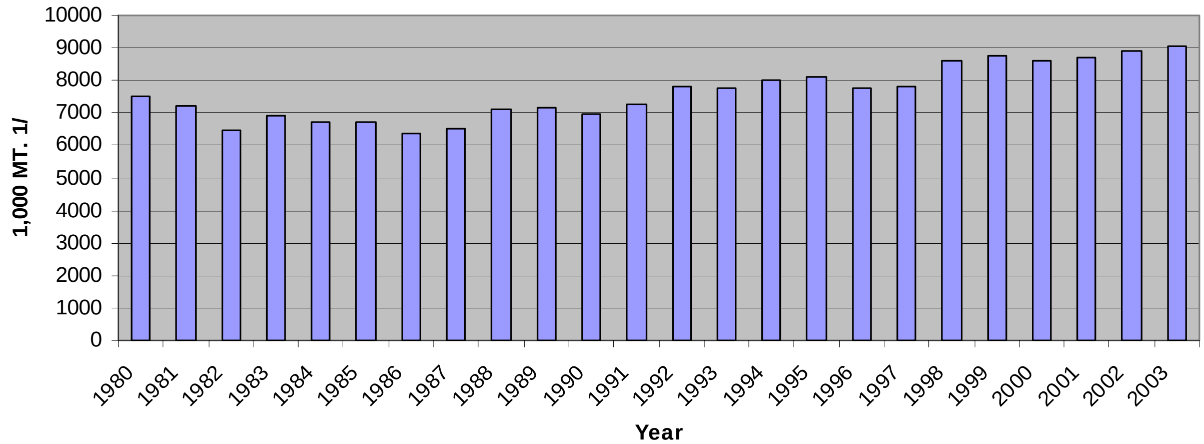

Figure 2.6. U.S. Total Pork Production (1980-2003)
1/ Carcass weight equivalent

Source: USDA, Foreign Agricultural Service (FAS). Production, Supply and Distribution Online. Webpage: http://www.fas.usda.gov/psd/Psdselection.asp (Accessed August, 2004).

The corn-belt extends through Indiana, Iowa, Missouri, southern Minnesota, southern Michigan, southern Wisconsin, and into eastern Kansas and eastern Nebraska. Rich, fertile soil, abundant rainfall, and more open plains resulted in the extensive development of this farmland. Along with the corn-belt line, pork production is concentrated in a group of states stretching from Minnesota, along Lake Michigan to Indiana and in North Carolina. For many years, the states of Iowa, Illinois, Minnesota, Nebraska, Indiana, and Missouri were leading pork producers, until the fast technological development in the pork industry in the 1980s and 1990s saw the rise of North Carolina as an important pork-producing state. By 1995, North Carolina had passed Illinois and is now second in number of pigs produced (McGlone and Pond, 2003). As shown in Figure 2.7, Iowa has the largest inventory. In 2002, Iowa's total number of hogs and pigs was 15.5 million head, with 10.3 million head, 6 million head, 4.9 million head, and 4.1 million head for North Carolina, Minnesota, Illinois, and Indiana, respectively. In 2002, these states accounted for approximately 65 percent of the U.S. total inventory.

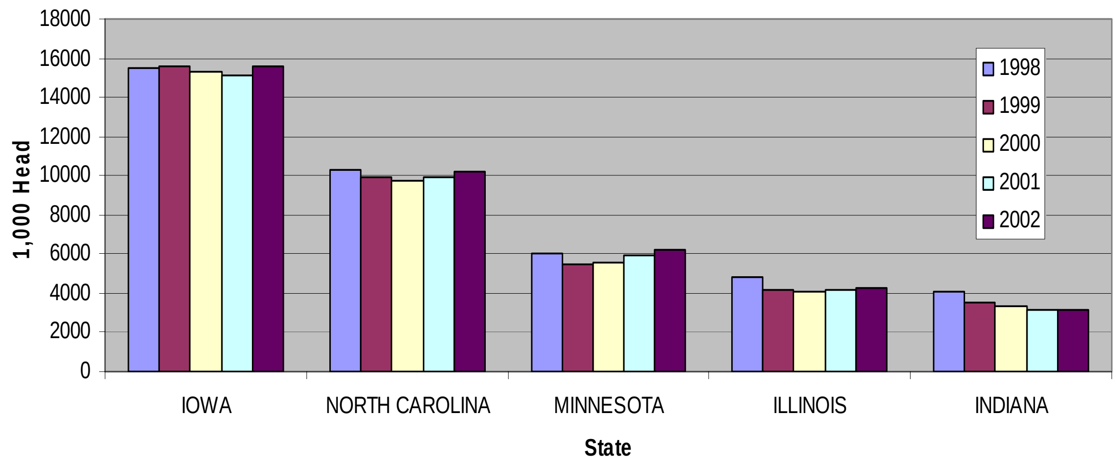

Figure 2.7. U.S. Total Inventory Number of Hogs and Pigs by States (1998-2002)

Source: USDA, National Agricultural Statistics Service (NASS), Agricultural Statistics Database.
Webpage: http://www.nass.usda.gov/QuickStats/ (Accessed September, 2004).

2.2. U.S. Pork Consumption

A combination of demographic and economic factors has influenced the changing demand for U.S. pork and pork products. These factors include demographic shifts, changes in consumer preferences, fluctuations in incomes and relative prices, and the development of new technology and marketing techniques (Amponsah and Qin, 2000).

The entire U.S. pork industry – from farmer to processor to store or restaurant – has undergone a transformation, in part because consumers want high-quality products at reasonable prices. Technological advances in production (including innovations in genetics, housing, and handling equipment) provide opportunities for pork producers to expand operations and have more control over the quality of pork produced (Martinez, 1997). One reason for increasing demand for pork is population growth. On the other hand, Americans have become wealthier and better educated and as a result, are more health- and nutrition-conscious than their predecessors

(OECD, 2003). To increase pork consumption, the U.S. pork industry invested resources in producing better-flavored, juicier, and more tender pork and launched a strong marketing campaign to encourage the substitution of pork for "the other white meat". The industry also developed other marketing techniques to promote pork and pork products (Amponsah and Qin, 2000). Table B in Appendices includes data on U.S. pork consumption. Table 2.2 illustrates per capita consumption data for beef, veal, pork, chicken, and turkey.

Table 2.2. U.S. Per Capita Consumption[1] of Red Meat and Poultry (1995-2002)

Year	U.S. Population (millions)	Red Meat (carcass)[2]			Poultry (ready-to-cook)[3]	
		Beef	Veal	Pork	Chicken	Turkey
		------------------------ pounds ------------------------				
1995	266.557	95.5	1.2	66.3	79.3	17.6
1996	269.667	95.7	1.4	62.0	80.6	18.1
1997	272.912	93.6	1.2	61.4	83.1	17.2
1998	276.115	95.0	1.0	66.1	83.8	17.6
1999	279.295	96.2	0.8	67.7	89.0	17.5
2000	282.388	96.5	0.8	65.5	90.1	17.3
2001	285.321	94.3	0.7	64.4	89.7	17.5
2002	288.205	96.4	0.7	66.1	94.3	17.7

1. Includes processed meats and poultry on a fresh basis. 2. Beef carcass weight is the weight of the chilled hanging carcass, which includes the kidney and attached internal fat (kidney, pelvic, and heart fat), but not the head, feet, and unattached internal organs. Definitions of carcass weight for other red meats differ slightly. 3. Ready-to-cook poultry weight is the entire dressed bird, which includes bones, skin, fat, liver, gizzard, and neck.

Source: USDA, Economic Research Service. Food Consumption (per capita) Data System. Webpage: http://www.ers.usda.gov/Data/foodconsumption/datasystem.asp (Accessed September, 2004).

Table 2.3 shows pork values at retail, wholesale, and farm level in the U.S. for the period of 1980-2003. Retail values are generally trending up. Farm values, however, show a gradual downward trend since the mid 1980s. The combination of these prices results in a farm share of around 50 percent during the 1980s. The farm share has fallen to the 20s and 30s since 1997 (see also Figure 2.8). Large U.S. production increases in 1998-1999 led to a significant drop in pork values during these years. The production decrease in 2000 is a lagged response to the reduced producers' returns for the period of 1998-1999 (USDA, 1998, 1999a, and 2000a).

Table 2.3. Pork Values at Retail, Wholesale, and Farm Level in U.S. (1980-2003)

Year	Retail Value[1]	Whole-sale Value[2]	Gross Farm Value[3]	Byproduct Allowance[4]	Net Farm Value[5]	Total Farm-Retail Spread	Wholesale-Retail Spread	Farm-Wholesale Spread	Farmers' Share[6]	51-52% Lean Hog Price, Live Eqv.[7]
	Cents per lb.								%	$/cwt
1980	147.5	103.0	79.4	5.1	74.3	73.2	44.5	28.7	50	42.49
1981	161.2	112.1	88.0	5.3	82.6	78.6	49.1	29.5	51	47.08
1982	185.6	128.0	109.9	6.4	103.4	82.1	57.5	24.6	56	58.78
1983	179.7	114.5	94.9	5.1	89.8	89.9	65.2	24.7	50	50.78
1984	171.4	115.7	97.0	6.1	91.0	80.5	55.8	24.7	53	51.91
1985	170.8	106.5	88.7	4.9	83.9	87.0	64.4	22.6	49	47.82
1986	188.8	116.6	101.8	5.1	96.7	92.1	72.2	19.9	51	54.46
1987	199.4	118.8	102.4	5.3	97.1	102.2	80.6	21.7	49	54.81
1988	194.0	106.2	86.1	4.6	81.5	112.5	87.9	24.7	42	46.07
1989	193.5	104.3	87.4	4.7	82.7	110.8	89.2	21.6	43	46.75
1990	224.9	124.3	107.9	5.6	102.3	122.6	100.6	22.0	45	57.75
1991	224.2	114.4	96.8	4.8	92.0	132.2	109.7	22.5	41	51.79
1992	209.5	104.0	83.9	4.3	79.5	130.0	105.5	24.5	38	44.87
1993	209.1	108.1	90.0	4.9	85.1	124.0	101.0	23.0	41	48.17
1994	209.5	104.0	78.5	4.6	73.9	135.7	105.6	30.1	35	42.00
1995	206.1	103.8	83.4	5.1	78.3	127.8	102.3	25.5	38	44.62
1996	233.7	123.2	105.7	6.3	99.4	134.3	110.5	23.8	43	56.53
1997	245.0	123.1	101.5	6.2	95.3	149.6	121.9	27.7	39	54.30
1998	242.7	97.3	64.9	3.7	61.2	181.5	145.4	36.1	25	34.72
1999	241.5	99.0	63.6	3.2	60.4	181.0	142.5	38.5	25	34.02
2000	258.2	114.5	83.5	4.1	79.4	178.8	143.7	35.0	31	44.66
2001	269.4	117.8	85.8	4.5	81.3	188.1	151.6	36.5	30	45.88
2002	265.7	100.7	65.2	3.4	61.9	203.9	165.0	38.9	23	34.87
2003	265.8	107.4	73.8	4.2	69.6	196.3	158.4	37.9	26	39.50

1. Estimated weighted average of BLS prices of retail cuts from pork carcass. 2. Value of wholesale quantity equivalent to 1 lb. of retail cuts. 3. Market value to producer for 1.869 lb. of live animal, equivalent to 1 lb. of retail cuts. 4. Portion of gross farm value attributed to edible and inedible by-products. 5. Portion of gross farm value minus farm by-product allowance. 6. Percent net farm value is of retail price. 7. Previously, 5/6/7 market hog price. Live equivalent is equal to 51-52% lean carcass price multiplied by .74.

Source: USDA, Economic Research Service (ERS), Briefing Room: "Food Marketing and Price Spreads". Webpage: http://www.ers.usda.gov/briefing/foodpricespreads/meatpricespreads/historicalspreaddata.xls (Accessed September, 2004).

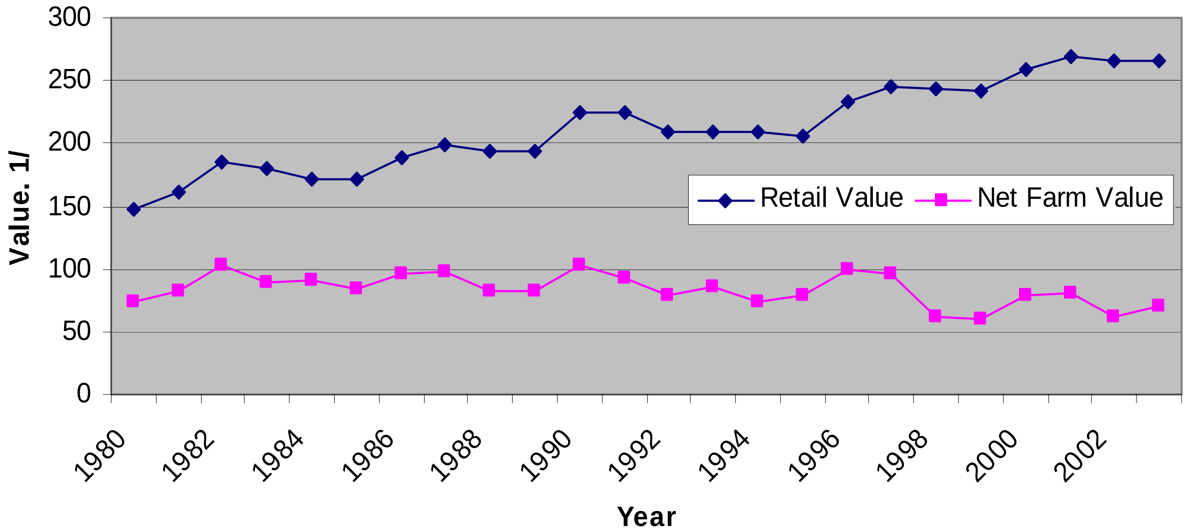

Figure 2.8. Retail and Net Farm Values in U.S. Pork Market (1980-2003)
1/ Cents per lb.

Source: USDA, Economic Research Service (ERS), Briefing Room: "Food Marketing and Price Spreads". Webpage: http://www.ers.usda.gov/briefing/foodpricespreads/meatpricespreads/historicalspreaddata.xls (Accessed September, 2004).

2.3. U.S. Pork Trade

During the early 2000s, the U.S. was the third largest pork exporter in the world, shipping about 0.7 million metric tons (carcass weight equivalent, or cwe) of fresh and frozen pork cuts to foreign markets. The U.S. is a relatively recent entrant to the international pork market, becoming a net exporter in 1995 for the first time ever (see Figure 2.9 and Table B in Appendices).

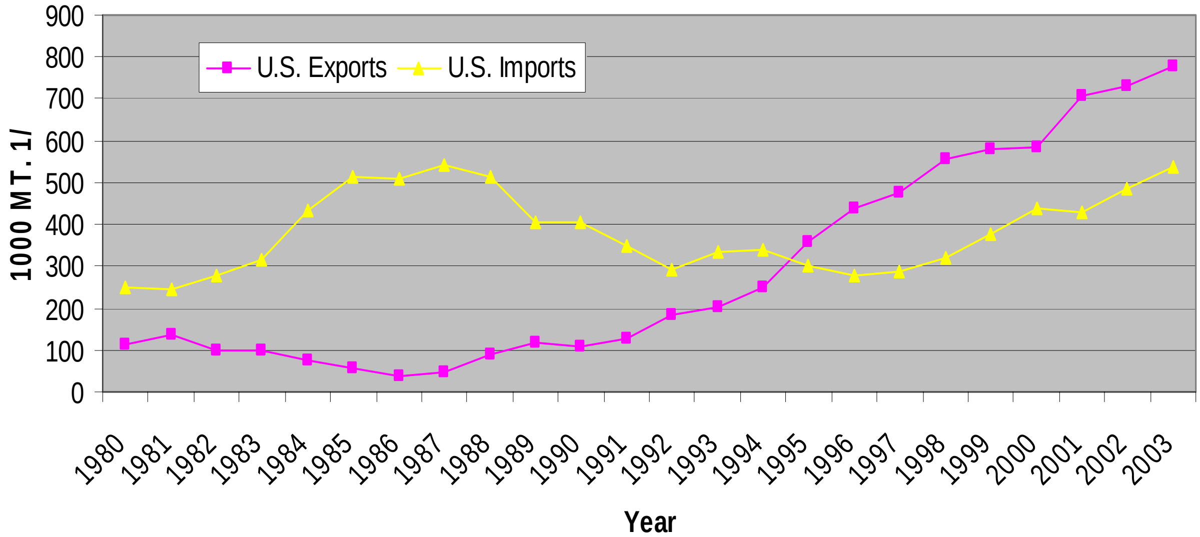

Figure 2.9. U.S. Pork Exports and Imports (1980-2003)
1/ Carcass weight equivalent

Source: USDA, Foreign Agricultural Service (FAS). Production, Supply and Distribution Online. Webpage: http://www.fas.usda.gov/psd/Psdselection.asp (Accessed August, 2004).

2.3.1. U.S. Pork Exports

The primary competitors of the U.S. in foreign markets are the EU, Canada, and Brazil. During the period of 2000-2003, the U.S. accounted for, on average, 18.4 percent of global pork exports (see Figure 2.4). The U.S. exported about 0.78 million metric tons of pork in 2003, an increase of 6.6 percent over the previous year, representing the 13th consecutive year-over-year export quantity increase. U.S. pork exports in 2003 were valued at 1.25 billion dollars, an increase of 4.48 percent over 2002 and a decrease of 3.74 percent over 2001. Exports in 2003 accounted for 8.6 percent of 2003 U.S. pork production in quantity (see Figure 2.10 and Table B in Appendices).

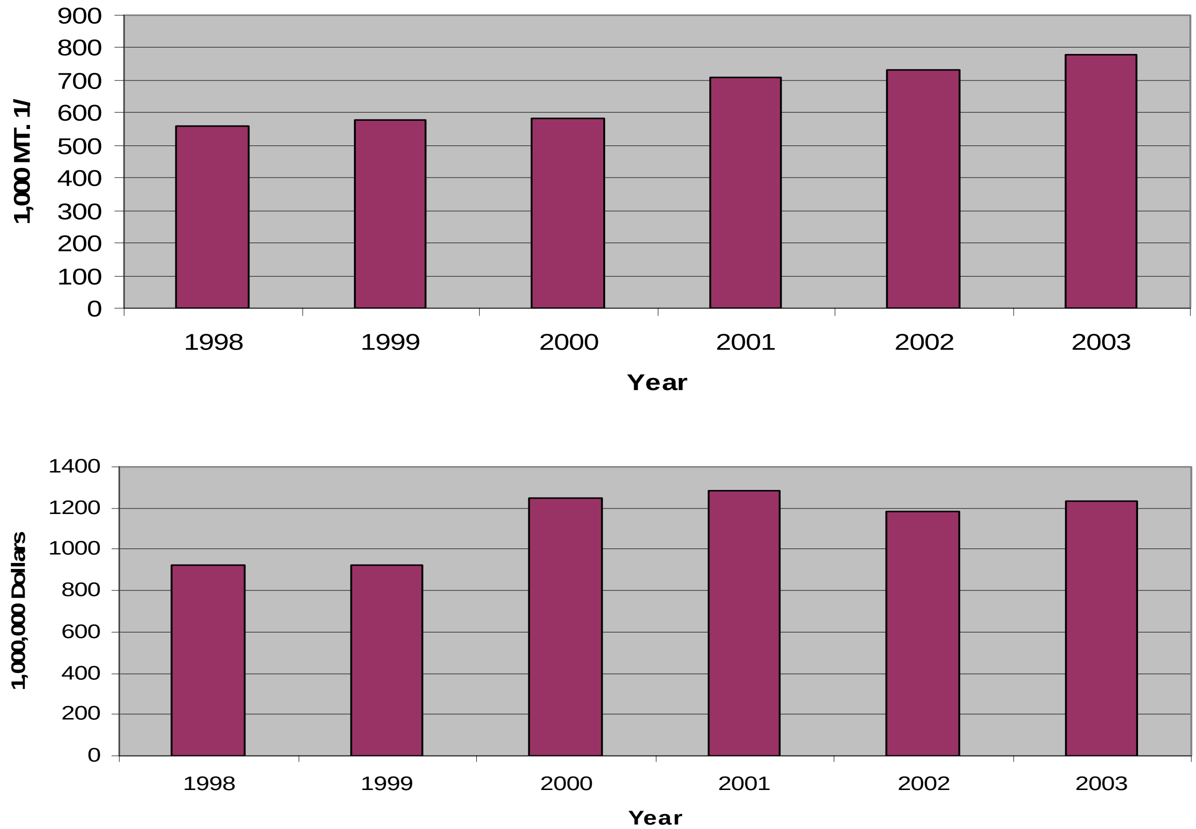

Figure 2.10. U.S. Pork Exports by Value and Quantity (1998-2003)
1/ Carcass weight equivalent

Source: USITC. Interactive Tariff and Trade Dataweb.
Webpage: http://dataweb.usitc.gov/ (Accessed September, 2004).
USDA, Foreign Agricultural Service (FAS). Production, Supply and Distribution Online.
Webpage: http://www.fas.usda.gov/psd/Psdselection.asp (Accessed August, 2004).

During the period of 1998-2003, the top three major foreign markets for U.S. pork products were Japan, Mexico, and Canada with 49.9 percent, 18.0 percent, and 9.1 percent, respectively. Taken together, these three countries comprised 77 percent of U.S. pork exports for this period of time (see Figure 2.11).

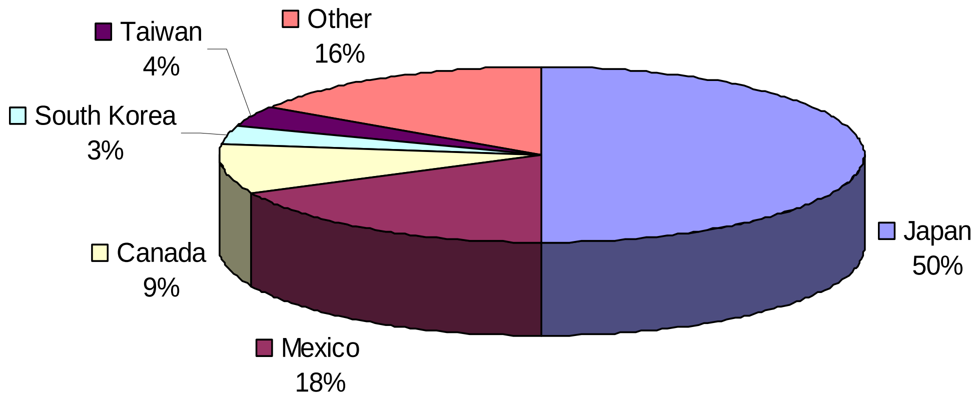

Figure 2.11. Country Shares of U.S. Pork Exports in Quantity (1998-2003 on Average)

Source: USDA, Foreign Agricultural Service (FAS). Production, Supply and Distribution Online. Webpage: http://www.fas.usda.gov/psd/Psdselection.asp (Accessed August, 2004).

Japan imported 0.8 percent more U.S. pork products in 2003 than in 2002, and 2.8 percent more than in 2001 (see Figure 2.12). Japanese demand for U.S. pork products slightly increased despite lackluster economic growth and higher minimum import price imposed by Japan's Safeguard. Japanese domestic pork production was lower, however, suggesting that imported products contributed to maintaining established consumption levels (USDA, 2004). Further data about Japanese pork import is provided at Table C in Appendices.

Mexico was the second most important export market for the U.S. during the early 2000s. Although there was 22.2 percent more pork imported from the U.S. in 2003 than in 2002, this represented a small decline compared with the pork imports in 2001 (see Figure 2.12). Mexican demand for U.S. pork appears to be sensitive to changes in Mexican national income. The decline in U.S. exports to Mexico was accompanied by the Mexican Peso Crisis in 1995, followed by the slight recovery of the Mexican economy and demand for U.S. pork products.

However, during the early 2000s, the economic recession of Mexico brought about a slowdown, rather than a decline (USDA, 2003).

Canadian pork imports from the U.S. were 48,000 metric tons in 2001, almost the same amount in 2002, and slightly decreased to 47,000 metric tons in 2003 (see Figure 2.12). Stable Canadian pork imports from the U.S. for the recent three consecutive years was accompanied by tremendous expansion in the Canadian pork industry in recent years. Stable inflow of U.S. pork products to Canada, despite increased Canadian production, can be attributed to two main factors. First, Canadian exporters sell Canadian pork cuts into profitable foreign markets, thereby resulting in "shorting" in the domestic market. Competitively priced U.S. pork cuts thus flow north to meet Canadian consumption demands. Second, economic forces are pushing U.S. pork industries and Canadian food industries closer together (USDA, Briefing Room: Canada).

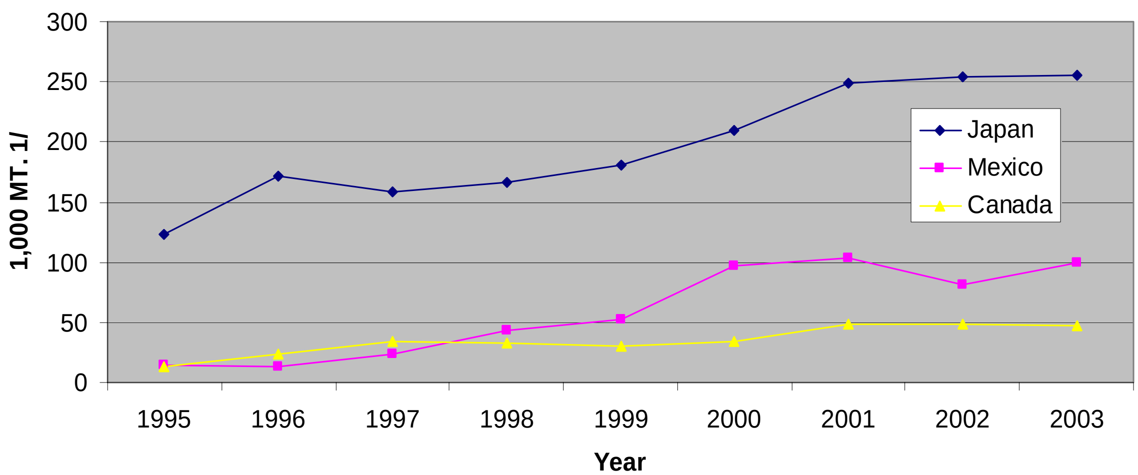

Figure 2.12. Top Three Foreign Markets for U.S. Pork (1995-2003)
1/ Carcass weight equivalent

Source: USITC. Interactive Tariff and Trade Dataweb.
Webpage: http://dataweb.usitc.gov/ (Accessed September, 2004).

2.3.2. U.S. Pork Imports

Although the U.S. has been a net exporter of pork since 1995, it remains an important importer of pork products as well. The U.S. is the third largest importer of pork products in the world, accounting for a little less than one-fifth of world pork imports during the early 2000s, with Japan and Russian Federation ranked first and second, respectively (USDA, PS&D). In 2003, the U.S. imported approximately 0.54 million metric tons of pork products at about 9.3 percent increase over 2002. The imported value in 2003 increased 13.9 percent to 0.82 billion dollars, compared with 2002 (see Figure 2.13 and Table B in Appendices).

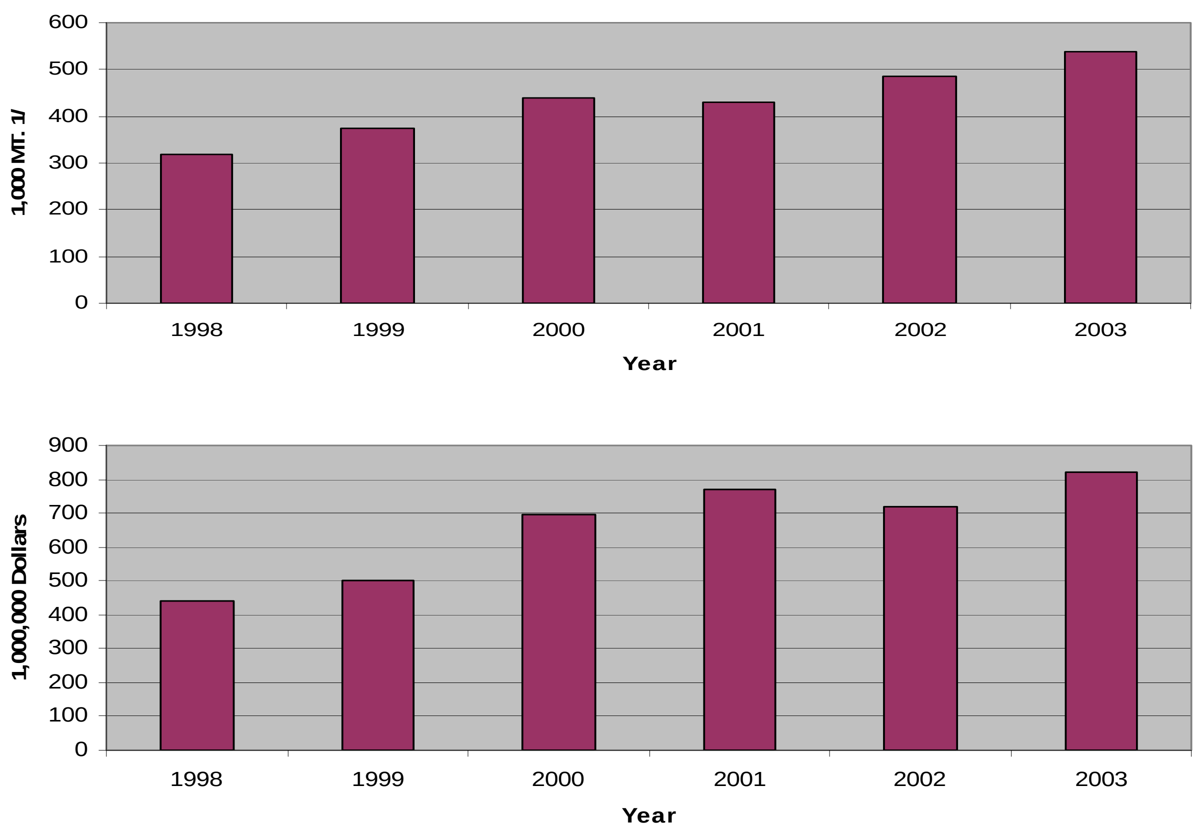

Figure 2.13. U.S. Pork Imports by Value and Quantity (1998-2003)
1/ Carcass weight equivalent

Source: USDA, Foreign Agricultural Service (FAS). Production, Supply and Distribution Online. Webpage: http://www.fas.usda.gov/psd/Psdselection.asp (Accessed August, 2004).

Most of the increase in the U.S. imports was from Canada, whose exports to U.S. accounted for over 87 percent of total U.S. pork imports during the period of 1998-2003, compared with only 50 percent in 1990 (USDA, PS&D. Also see Figure 2.14). The significant expansion of the Canadian pork industry in the last decade has enabled it to export pork to help to fill the increase in the U.S. pork demand. On the other hand, the North American Free Trade Agreement (NAFTA), cross-border investments, and low transportation costs have together accelerated the rate of integration in the pork and food industries of North America. Importing agents in the U.S., whose objective is to secure pork products for sale and distribution in North American retail and foodservice outlets, are willing to source products wherever North America pork product costs are minimized (USDA, 2003).

As the second largest supplier to U.S., Denmark's exports to the U.S. fluctuated between 35,000 metric tons and 45, 000 metric tons for the period of 1998-2003 (USDA, PS&D). Most of the increase in Canada's U.S. market share has come at Denmark's expense. Proximity to the American market allowed Canada to be competitive over Denmark, especially in fresh products. Traders from North America have exploited the relatively free-trade environment that exists between the U.S. and Canada to integrate American and Canadian pork supply chains (Mattson et al., 2001).

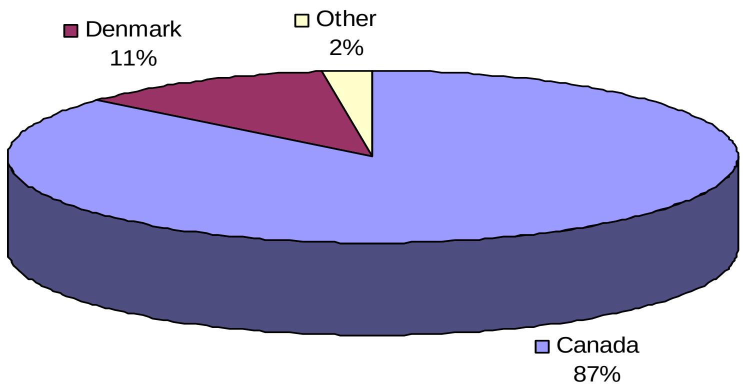

Figure 2.14. Country Shares of U.S. Pork Imports in Quantity (1998-2003 on Average)

Source: USDA, Foreign Agricultural Service (FAS). Production, Supply and Distribution Online. Webpage: http://www.fas.usda.gov/psd/Psdselection.asp (Accessed August, 2004).

2.3.3. U.S. Pork Trade by Categories

According to the Harmonized Tariff Schedule (HTS) code system, pork meat (HTS code: 0203) can be divided into six categories: fresh/chilled carcass (HTS code: 020311), fresh/chilled hams (HTS code: 020312), fresh/chilled other (HTS code: 020319), frozen carcass (HTS code: 020321), frozen hams (HTS code: 020322), and frozen other (HTS code: 020329). For readers who want even more exact knowledge about the HTS code system of pork meat, Table D is attached in Appendices.

2.3.3.1 U.S. Pork Exports by Categories

Figure 2.15 depicts the total value of U.S. pork exports by parts from 1998 to 2003. For this period of time, fresh and chilled other accounted for 39.97 percent of the U.S. total exports in value, with frozen other, fresh and chilled hams, frozen hams, fresh and chilled carcass, and frozen carcass, at 31.01 percent, 11 percent, 7.94 percent, and 7.83 percent, and 2.25 percent, respectively. For the period of 1998-2003, fresh and chilled other and frozen other, as two dominating pork parts, were valued at 2.7 billion dollars and 2.1 billion dollars, respectively. The composition of "other" pork parts is not clearly defined in the data documentation.

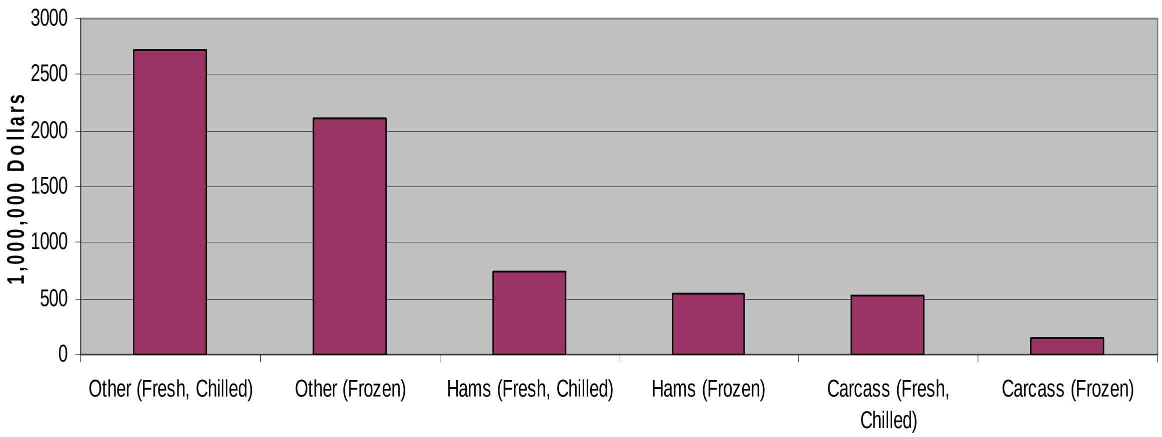

Figure 2.15. Total Value of U.S. Pork Exports by Parts (1998-2003 Total)

Source: USITC. Interactive Tariff and Trade Dataweb.
Webpage: http://dataweb.usitc.gov/ (Accessed September, 2004).

Figure 2.16 shows the major pork importing countries from the U.S. by parts from 1998 to 2003. As mentioned earlier, Japan accounted for about 50 percent of U.S. pork exports, dominating the pork market for all categories listed in the graph, especially for fresh/chilled other (HTS 020319) and frozen other (HTS 020329). From 1998 to 2003, Japan's imports were valued at \$ 4.4 billion of which 49.6 percent was fresh and chilled other and 27.4 percent was frozen other, followed by Mexico, and Canada at \$ 0.8 billion, and \$ 0.5 billion, respectively. These three markets accounted for 96.5 percent of the world imports of U.S. fresh and chilled other and 72.9 percent of U.S. frozen other. Further data of major pork importing countries from the U.S. can be referred at Table E in Appendices.

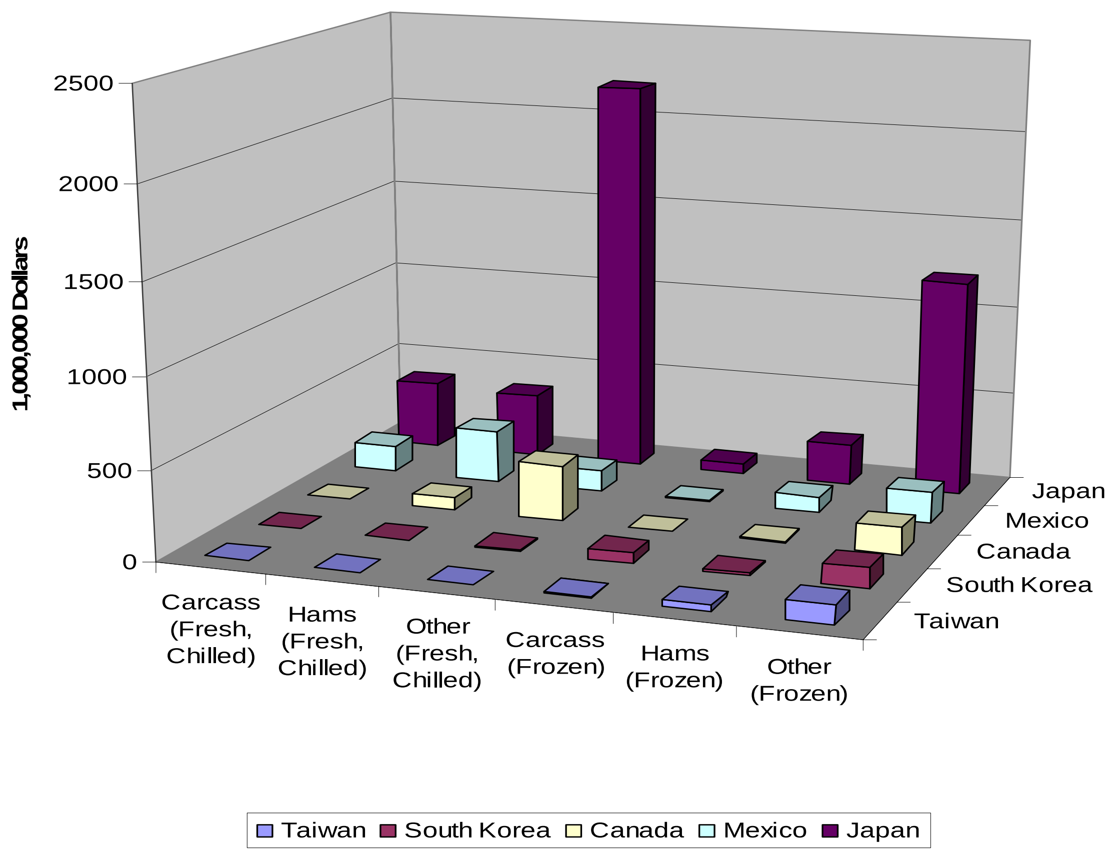

Figure 2.16. Major Pork Importing Countries from U.S. by Parts (1998-2003 Total)

Source: USITC. Interactive Tariff and Trade Dataweb.
Webpage: http://dataweb.usitc.gov/ (Accessed September, 2004).

When taking a closer look at Japan's consumption pattern of U.S. pork, Japanese trade maintained strong imports of U.S. fresh and chilled pork, which accounted for about 66.2 percent of Japan's total pork imports for the 1998-2003 (see Figure 2.16). In the chilled pork market, the U.S. is now the largest supplier to Japan following the departure of Taiwan in 1997 and Korea in 2000 due to FMD outbreaks. U.S. pork has already achieved success in the Japanese market. For example, the Japanese *Tonkatsu* chain (fried pork cutlet) uses American chilled pork (loins and tender loins) purchased through a special contact with a U.S. supplier. Interestingly, the restaurant chain markets their pork cutlets as exclusively U.S. pork, an unusual strategy given that most Japanese consumers assume that *Tonkatsu* is generally made with domestic pork. The company's advertising emphasizes that the U.S. pork is specially produced for quality and taste (USDA, 2002). Value items in retail fairs and the HRI (Hotel, Restaurant, and Institutional) / HMR (Home Meal Replacement) sector has favored U.S. chilled pork as it reportedly tastes better than frozen pork (USDA, 2001). Frozen pork, which accounted for the remaining 33.8 percent of total pork imports, is mostly utilized for manufacturing processed pork products and in the food service industry. Imported frozen loins, heavily used to make loin roll hams, is utilized in the ham and sausage manufacturing sector, of which one of the most popular items is a gift ham. Furthermore, a large supply of surplus frozen stocks was channeled to the price-sensitive HRI/HMR sector, particularly for take-out, convenience lunch box, and frozen foods. Japan ham and sausage manufacturers are the largest end user of imported frozen pork (USDA, 1999b and 2000b).

As a leading importing country from the U.S., Japan imported fresh and chilled other parts with 392 million dollars, and frozen other parts with 248 million dollars in 2003, a slight increase over the previous year for both parts (see Figure 2.17). However, when compared with 2001, fresh and chilled other parts decreased 8.8 percent while frozen other parts decreased 14.2 percent. Note that Japan's imports are not of much variety, and in general, Japan's imports are mostly fresh and chilled "other" and frozen "other".

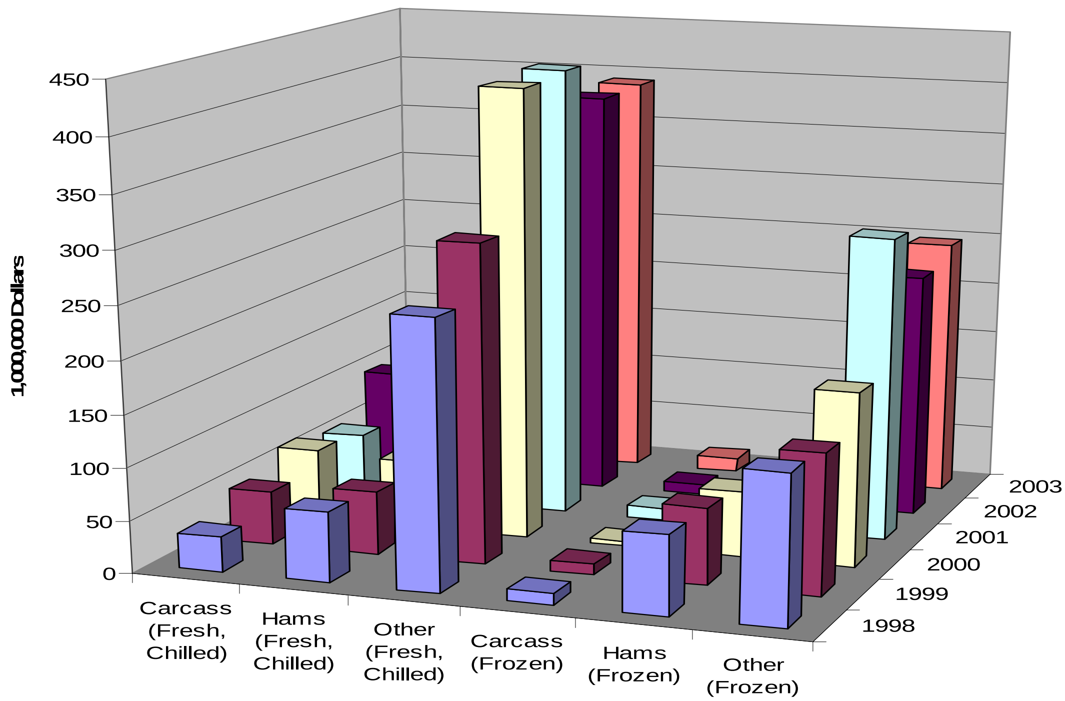

Figure 2.17. Japan Pork Imports from U.S. by Parts (1998-2003)

Source: USITC. Interactive Tariff and Trade Dataweb.
Webpage: http://dataweb.usitc.gov/ (Accessed September, 2004).

2.3.3.2 U.S. Pork Imports by Categories

Figure 2.18 shows the total value of U.S. pork imports by parts from 1998 to 2003. U.S. imported fresh and chilled other (HTS 020319), frozen other (HTS 020329) and fresh and chilled hams (HTS 020312), as dominating parts, with values of 1.9 billion dollars, 1.3 billion dollars, and 0.6 billion dollars, respectively. For this period of time, these three major parts accounted for about 96 percent of U.S. total imports in value. Again, the word of "other" pork parts is not clearly defined in the data documentation.

Figure 2.18. Total Value of U.S. Pork Imports by Parts (1998-2003 Total)

Source: USITC. Interactive Tariff and Trade Dataweb.
Webpage: http://dataweb.usitc.gov/ (Accessed September, 2004).

Figure 2.19 shows the major pork exporting countries to the U.S. by parts from 1998 to 2003. As shown earlier, Canada accounted for the majority of U.S. pork imports and dominated the pork market for most categories listed in the graph, especially for fresh/chilled other (HTS 020319) and fresh/chilled hams (HTS 020312), with frozen other (HTS 020329) second only to Denmark. From 1998 to 2003, Canadian exports to the U.S. were valued at 3.1 billion dollars of which 61.1 percent was fresh and chilled other, 19.6 percent was frozen hams, and 15.4 percent was frozen other. Canada was followed by Denmark, the United Kingdom, and Ireland at 783 million dollars, 42 million dollars, and 41 million dollars, respectively. Canada accounted for almost 100 percent of the world exports to the U.S. in fresh and chilled other, fresh and chilled hams, and 35.6 percent in frozen other. Further data of major pork exporting countries to the U.S. can be referred at Table F in Appendices.

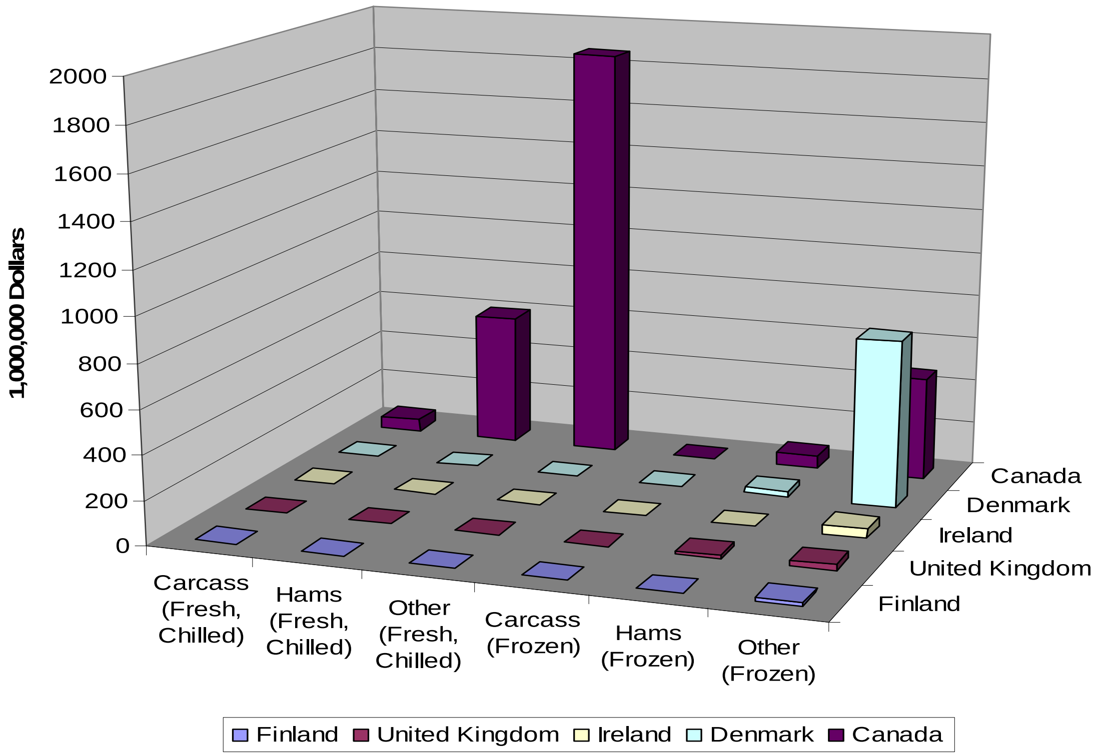

Figure 2.19. Major Pork Exporting Countries to U.S. by Parts (1998-2003 Total)

Source: USITC. Interactive Tariff and Trade Dataweb.
Webpage: http://dataweb.usitc.gov/ (Accessed September, 2004).

From Figure 2.20, we can take a closer look at Canada's exports to the U.S. by years. As a leading exporting country to the U.S., Canada exported fresh and chilled other parts valued at 419 million dollars in 2003 with continuous annual increases over 1998-2003, fresh and chilled hams valued at 114 million dollars, and frozen other parts valued at 84 million dollars.

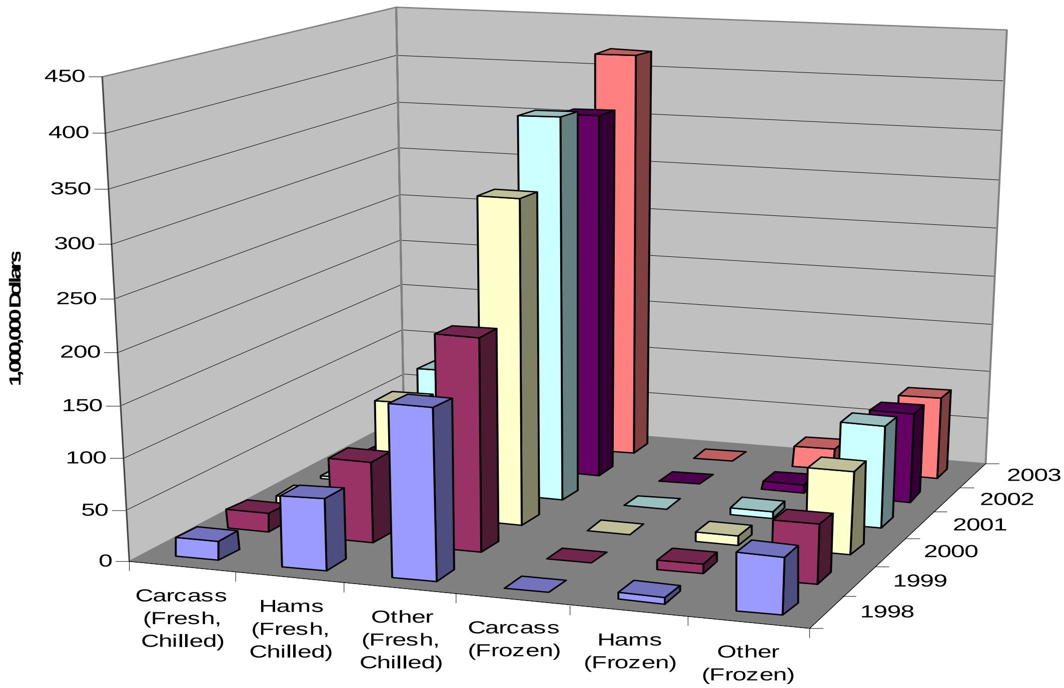

Figure 2.20. Canada Pork Exports to U.S. by Parts (1998-2003)

Source: USITC. Interactive Tariff and Trade Dataweb.
Webpage: http://dataweb.usitc.gov/ (Accessed September, 2004).

CHAPTER 3

RELATED LITERATURE

1. Pork Production Issues

The U.S. became a net exporter of pork for the first time in over 40 years in 1995, exporting over 100 million pounds (carcass-weight basis). Net exporter status represents a culmination of structural changes in the U.S. pork industry since the 1970s. The structuring effectively places the U.S. in the company of the other largest pork exporting countries (Haley and Jones, 1996).

Traditionally, the United States has under-exploited its comparative advantage in hog production. Despite its low feed costs, heterogeneous genetic stock and small-scale production handicapped U.S. competitiveness. Recently, however, the industry achieved new scale economies in production and has taken advantage of information coordination and reduced transformation costs, and has systematically produced attributes valuable in the export market (Beghin and Metcalfe, 2000).

As for the competitiveness of U.S. pork on international markets, Harley and Jones (1996) stated that over the last several years, new and significant infusion of financial capital, timely improvement in genetics and management practices, available farm labor, and a plentiful land base combined to create an industry characterized by fewer and significantly larger production units. Large hog operations achieve economies of size through better feed conversion, and by lowering labor costs. Harley and Jones (1996) emphasized that improved genetics of breeding stock has also been an important source of lower production costs for the hog production industry. The availability of land for production expansion and waste disposal is a critical determinant in the industry's drive to achieve economies of size and realize declining costs. The pork processing industry is also a major determinant of industry competitiveness in export markets. As on the production side, recent restructuring has given the pork processing industry the ability to produce large quantities of uniformly high-quality pork products at competitive world prices.

Key and McBride (2003) measured the impact of contracting on partial and total factor productivity and the production technology of U.S. hog operations. In the article, they focused on identifying and measuring the farm level productivity gains, if any, that can be attributed to contracting. In order to measure the impact of participating in a production contract on farm productivity, they used a treatment effects sample selection model. The model assumes a joint normal distribution between errors of the selection equation (contract/no contract) and the treatment equation (the measure of productivity). Through a sample selection model that accounts for the fact that unobservable variables may be correlated with both the operators' decision to contract and farm productivity, Key and McBride (2003) concluded that contract operations are substantially more productive than independent operations. In addition, contracting appears to represent a technological improvement over independent production resulting in about 20% more output for an average farm, holding inputs constant. The magnitudes of the productivity gains which can be attributed to contracting are striking, and are consistently large under various model specifications. Results also identify determinants of farmers' decisions to contract and other factors influencing farm productivity.

Environmental regulations, and the added costs generally associated with compliance, are considerations often factored into the choice of a business location. It has been hypothesized that geographic variation in environmental regulations and enforcement can induce a migration of industries across state or country boundaries to "pollution havens" where compliance costs associated with environmental regulation are lower (Sullivan, Vasavada, and Smith, 2000). Sullivan, Vasavada, and Smith (2000) added that producers might respond to existing or impending costs of regulation by exiting the industry or by changing the scale and/or location of production. Moving to a different state or country might mitigate or bypass the costs of local or domestic environmental regulations altogether, but adding new capacity at the same site might enable economies of scale that offset additional costs of compliance.

Mathews, Buzby, and Tollefson (2001) studied use versus nonuse of livestock antimicrobial drugs to promote growth. They stated that use of antimicrobial drugs (antibiotics and others) in livestock production has been surrounded by controversy since the practice began in the 1940s. At high levels, the drugs are used to cure or contain livestock diseases. At low levels, they are used to enhance feed efficiency and promote growth, fight infections not easily detectable without clinical examination, and prevent diseases. It is primarily the low-level use of these drugs - particularly for promotion of growth - that raises concerns about their role in the emergence of drug-resistant bacteria.

Studies are inconclusive - some find reduced resistance in pathogens in livestock when drugs are withdrawn, while others find no change or increased resistance. Studies from Europe since the ban on antimicrobial growth promoters have demonstrated lower percentages of resistant bacteria from livestock where use of antimicrobial drugs for growth promotion was stopped (Mathews, Buzby, and Tollefson, 2001).

Haley, Jones, and Southard addressed the question of future pork production in their 1998 study. Will the exporting countries that currently dominate international pork markets still dominate in the future? Which countries are likely to be the leading pork exporters in the future? What factors can be assigned to identify countries that might become or remain leading pork exporters?

The extent to which the leading pork exporting countries will be able to meet forecast export growth will be determined largely by the ability of their pork industry to produce more hogs. Expansion of a country's hog production capacity is limited by its resource base. Of the three key hog production resources – land, labor, and capital - land is most likely to constrain future growth in pork production. Land is the key resource in pork production because of its multiple functions: land is, of course, necessary to house the animals. Hog feed supplies are frequently drawn from the domestic land base, as in the U.S. and Canada. However, the land requirement for animal housing facilities is relatively minimal, and the absence of a land base adequate to supply feed can be mitigated by importing feed, as is done by Denmark. Where land is a non-substitutable input into the hog production process is in manure utilization. An adequate land base for spreading manure residues is essential, simply because no other economically viable means of manure utilization currently exits (Haley, Jones, and Southard, 1998).

2. Pork Consumer Demand Issues

Using a trade model, Wang et al. (1998) studied Chinese consumer preference for major animal products and assessed the potential impacts of a reduction in China's import tariff on its pork and poultry demand and net imports. They reported that liberalization of China's pork and poultry markets will cause a relatively large change in world trade levels without causing any serious price disruptions. The U.S. is in a good position to capture much of the benefits of liberalization, because it already dominates world trade in poultry products and because it is the low-cost producer of pork among countries that are free of foot-and-mouth disease.

Wang et al. (1998) stated, “The results are by necessity based on a simplified trade model. Were we to fully model the taste differences that exist across countries, it seems likely China would be an exporter of pork loins and chicken breasts and a large importer of less-expensive cuts and variety meats. Another simplification concerns the dollar-Yuan exchange rates. Casual observation would seem to suggest that the Yuan is undervalued relative to the dollar. The trade effects would have been much greater had we built in an appreciation of the Yuan. A third simplification is the arbitrarily low price transmission elasticity chosen for the study.”

Wang et al. (1998) further concluded that Chinese meat consumption will continue to be sensitive to per capita incomes. Continued growth in incomes at levels close to those seen recently will cause large increases in demand for meat products. If markets are allowed to decide where these additional supplies should originate, U.S. exports of poultry and pork should increase dramatically. Additionally, so long as the trade increases generated by market liberalization are close to the levels projected in this study, the price impact in U.S. and Chinese markets will be relatively small.

Jung and Koo (2000) analyzed the structure of Korean meat and fish product demand. The Korean meat and fish demand patterns were estimated, using the Linear Approximate Almost Ideal Demand System (LA/AIDS). The Korean meat was categorized into Hanwoo (Korean traditional cattle) beef, imported beef, pork, and chicken, while the fish group was divided into fish, crustacean, and mollusk. On evaluating seasonal effects on meat, they reported that the consumption of Hanwoo beef and imported beef increases in the spring and fall and decreases during the winter. Pork consumption increases in the winter, but it is not statistically significant. Chicken consumption increases during summer and fall.

The expenditure elasticity for imported beef is the most elastic, indicating that Korea will increase beef imports as the country increases its expenditure for meat and fish products (Jung and Koo, 2000). Jung and Koo (2000) found that, in the case of Hanwoo beef, the own-price elasticity is larger than the expenditure elasticity in absolute value while it is the opposite for imported beef. If price and income (expenditure for meat and fish products) change at the same time, Hanwoo beef consumption would be more affected by price than income. However, consumption of imported beef is more sensitive to income than the price of imported beef.

Jung and Koo (2000) also estimated cross-price elasticity which shows competitive or complementary relationships among products. They stated that Hanwoo beef has a competitive relationship with pork and imported beef. There is a substitute relationship between fish and meat products, indicating that fish is a substitute for meat in Korea. Fish consumption in Korea would increase if prices of meat products increased where prices of fish products remain constant.

Because of trade liberalization, meat imports in Korea will increase in the future. If per capita income continues to increase, beef imports would also increase since Korean consumers prefer beef to other meat, and Hanwoo beef is in short supply and expensive. The price of Hanwoo beef is generally two times higher than that of imported beef. Consumers in Korea are willing to pay a premium for Hanwoo beef because they prefer Hanwoo beef to imported beef. However, if cheap and better-quality imported beef were introduced to Korean consumers, then Hanwoo beef would not be able to maintain market share in Korea (Jung and Koo, 2000).

3. Market Structure Issues

As the U.S. has become a larger player in the world meat market in the 1990s, events in other major exporting and importing countries have had a greater effect on domestic prices and production. Not only are domestic producers affected by world prices and quantities of meats traded, but they are also affected by the changing composition of the trade, i.e. the products being traded. As a result, the U.S. market outlook is now determined in larger part by the global market than was the case before the export surge of the 1990s (Greene and Southard, 1998).

According to Martinez (1997), production for the open market is being replaced by multi-year contracts and vertically integrated operations – many pork packers and processors obtain a steady supply of high-quality hogs by entering into contractual arrangements with independent producers or by direct ownership of production facilities and breeding operations.

Contracts are the dominant form of transaction in several livestock industries and such transactions are gaining momentum in many agricultural sectors (Roe, Sporleder, and Belleville, 2004).

A food marketing system consists of several stages of production and distribution, with value added to the product at each stage. In the pork industry, these include *breeding*, where genetic stock is selected for hog producers; *hog production*, where a breeding herd is maintained to produce pigs that are nursed and grown to market weight; *packing/processing*, where hogs are slaughtered and divided into wholesale pork cuts, approximately 75 percent of which is further processed; and the *retail* stage, including the operations of restaurants and grocery stores (Martinez, 1997).

What is vertical coordination, then? Martinez (1997) reported that vertical coordination refers to the systematic transfer of product from one stage to the next in a “vertical” direction, from production of the raw commodity to delivery of the finished product to consumers. Vertical coordination can be achieved in many ways, including *open market exchange*, *contractual arrangements*, and *vertical integration*.

• In *open market exchange*, no commitments are made for selling the product before it is ready for sale. The finished product is taken to market and sold at the prevailing, or "spot," price. Producers, processors, and retailers rely on the market both to deliver the quantity and quality of inputs they desire and to provide an outlet for their own products.

• Under *contractual arrangements*, purchasers have greater control over production compared with open market exchange, because commitments are made prior to completion of production.

• *Vertical integration* refers to ownership of successive stages of production by a single firm.

Products are transferred from one stage to another according to management decisions. Methods of achieving vertical coordination can be classified based on the degree of control that firms have over production. At one end of the spectrum is open market exchange, which represents the least control over production. At the other end of the spectrum is vertical integration, which represents the most control. Contracts fall between, representing varied, intermediate degrees of control (Martinez, 1997). Martinez (1997) further stated that the challenge for policymakers will be to facilitate coordination across the stages of production in the most efficient way, while at the same time discouraging anticompetitive behavior and any other impacts potentially harmful to both consumers and producers.

Roe, Sporleder, and Belleville (2004) added that while significant theory exists to derive stylized optimal contracts and much effort has gone into documenting and explaining the proliferation of contract use, few empirical studies have measured the marginal effect of changes in a broad array of contractual elements on producer preferences. Their study contributed to this field of work by using a stated choice experiment to document producers' marginal valuations for a variety of contractual elements that shape future streams of profits from hog finishing. Roe, Sporleder, and Belleville (2004) found that many facets of a typical marketing contract can impact its acceptance by producers. The organizational form of the contractor is also important with many producers showing a strong preference for cooperative forms. Contractual elements that constrain the producer, such as longer contracts and higher minimum delivery requirements, are less preferred.

4. Pork Trade and Government Policy Issues

4.1. Government Policy

4.1.1. Trade Agreements

Regional trade agreements (RTAs) have become a fixture in the global trade arena, and their role in world trade is increasing. Defined as arrangements among separate economies to reduce trade barriers among members, RTAs have been established in every region of the world (Burfisher and Jones, 1998). Burfisher and Jones (1998) further explained that agriculture is the source of most U.S. gains from RTAs. Gains from trade liberalization are roughly proportionate to the size of the trade barriers being reduced or dismantled in a trade agreement. Because agriculture still faces relatively high trade barriers in the world market, it stands to gain relatively more than many other sectors from U.S. inclusion in trade agreements.

Mattson et al. (2001) reported, "The Canada – United States Free Trade Agreement (CUSTA) and the North American Free Trade Agreement (NAFTA) became effective in 1989 and 1994, respectively. When NAFTA is fully implemented, these two agreements will create the largest single market in the world. CUSTA has been fully implemented for bilateral trade between the United States and Canada. The objective of CUSTA was to phase out agricultural tariffs over a ten-year period and decrease the use of domestic subsidies affecting trade flows. CUSTA and NAFTA mandated that trade flows of meat and livestock within North America be based on competitive factors."

NAFTA is making an important contribution to the extension of U.S. agricultural trade with Canada and Mexico (USDA, Briefing Room: NAFTA). NAFTA is having a dramatic impact on U.S. trade of some agricultural commodities - boosting exports and/or imports substantially above levels that would have occurred without the agreement – while generating a subtle positive effect on most of the others (Link and Zahniser, 1999). Improvement in infrastructure, another important facilitator of trade, is an additional outcome of the agreement (Link and Zahniser, 1999). As trade barriers fall, producers and consumers in Canada, Mexico, and the United States are benefiting more fully from their relative strengths (USDA, Briefing Room: NAFTA).

To examine NAFTA's trade impact, the Economic Research Service of USDA estimated the trade changes resulting from CFTA (Canada-U.S. Free Trade Agreement) and NAFTA for 38 commodities or commodity groupings, isolating the influence of agreements from population growth, changes in macroeconomic performance and exchange rates, unusual weather patterns, and other factors. For commodities subject to quotas or other quantitative restrictions before CFTA and NAFTA, the volume of trade during 1994-2000 was compared with previously allowed quantities. This assumed no over-quota trading except where analysts determined that previous limits were not enforced. For commodities subject to tariffs prior to CFTA and NAFTA, economic models and assessments by commodity trade specialists were used to estimate the impact of tariff changes.

Trade liberalization through NAFTA expands agricultural producers' ability to compete in a greater marketplace, as more market-oriented domestic policies increase producers' reliance on trade. As the market of North American become more integrated, regional production shortfalls will increasingly be mitigated by trade flows. Evidence to date appears to support the claim that NAFTA is creating incentives for resources, labor, and capital to remain in the U.S. agricultural sector (Raney and Shagam, 1997).

Offutt, Somwaru, and Bohman (2002) stated the most compelling argument for trade liberalization is that the future of developed-country agriculture lies in the markets of the developing world. Food markets in developed countries are mature; that is, they grow only slowly with population growth. Expansion in market share of one food product generally comes at the expense of another. The future of U.S. agriculture is with markets in developing countries, where income growth has strong implications for the level and composition of food demand. In economic terms, domestic U.S. demand for food is stable. In order to maintain returns to agriculture as productivity rises, demand also has to increase. The growth must come from outside the U.S., and indeed from outside the developed world.

Since the end of the last trade round, developing countries have sought a more effective influence on the World Trade Organization and negotiations under its auspices. Offutt, Somwaru, and Bohman (2002) raised these questions: Will their quest for meaningful participation and increasing technical proficiency make a difference in the outcome of the next round? What will the European Union (EU) and Japan ultimately be willing to negotiate in the way of reform? They reported, "Much is at stake in the next trade round. While attention is most frequently trained on commodity-by-commodity impacts of trade liberalization, the most compelling economic story lies with the potential for income gain in developing countries. The long-observed relationship between increases in income and spending on food - Engel's Law - is one of the few tenets in economics that seems to hold over time and across countries. Still, even a compelling structural argument for trade liberalization has to acknowledge the costs of adjustment in reaching reconfiguration of world agricultural markets. To be serious about handicapping the prospects for reform will require serious thought about how to get from the current policy structure to the next."

4.1.2. Japanese Safeguard Policy

The Safeguard is a World Trade Organization-sanctioned restriction that protects domestic markets from surges in imported products (Haley and Southard, 2002). The agreement on Safeguard is available at the WTO website: http://www.wto.org/english/docs_e/legal_e/25-safeg.pdf (Accessed October, 2004).

Japanese pork imports are subject to a differential duty mechanism known as the "gate price". The gate price system is the main barrier to pork imports (USDA, 2004). According to USDA (2004), the current system, negotiated under the 1995 Uruguay Round Agreement on agriculture, directs importers to pay a simple tariff (4.3 percent in the case of fresh, chilled or frozen pork) as long as the value of imports meets or exceeds the established gate price. When the value of imports, priced on entry into Japan, is below the gate price, importers not only pay the tariff, but also pay a duty equal to the difference between the import value and the gate price. As heir to domestic price stabilization policies, the gate price system is intended to minimize cheap imports. However, in practice, traders generally mix pork product shipments so that the average value of the shipment invoice rarely falls below the gate price. For example, low-value hams can be shipped together with higher-value loins so that traders end up only paying the simple tariff.

While Safeguard imposition typically lowers demand for all imported pork, frozen products tend to decline the most. Since fresh pork tends to have larger margins and limited shelf life, demand for imported fresh pork has not declined as dramatically as has demand for frozen pork under past Safeguard scenarios. And, since fresh products comprise more than half of U.S. exports to Japan, the Safeguard has impacted U.S. pork exports to a lesser degree than those of other countries such as Denmark, whose exports to Japan are nearly all frozen (Haley and Southard, 2002).

Some analyses have used global models to explore what might happen to Japan's pork market if government support for domestic production were reduced. USDA (2004) pointed out that a major problem in such an exercise is that the gate price system makes it difficult to quantify Japan's border barrier facing imports. Pork is typically traded in the form of specific cuts and, within Japan and other countries, pork prices vary substantially by cut. The lack of transparency caused by the gate price system makes modeling the barriers difficult.

Regarding this policy, USDA (2004) concluded, "Japan's support to pork has a large impact on world pork trade, as well as on consumer prices and domestic production in Japan. Japan's own calculation of its Aggregate Measurement of Support (AMS) shows pork with higher trade-distorting 'amber box' support than any other commodity. Yet, the precision of these estimates suffers from the lack of transparency imposed by the gate price system. Current negotiations in the WTO about a new multilateral agreement on agricultural trade may lead to changes in Japan's import regime, with lower and more transparent trade barriers, and to new disciplines on domestic support to hog farmers. Such changes are likely to benefit Japan's consumers and foreign pork producers."

4.2. Exchange Rates

The exchange rate – the price of a currency in terms of another currency – is arguably the single most important variable in determining the economic environment for trade sectors. Exchange rates affect trade by determining the relationship between international and domestic prices (Shane, 2001). Exports are becoming increasingly important for U.S. livestock and poultry producers. Consequently, meat industry participants are concerned about the potential impacts of variations in relative currency values (Miljkovic, Brester, and Marsh, 2003). According to Shane (2004), historically, movements in exchange rates have accounted for approximately 25 percent of the change in U.S. agricultural value. Other factors, such as the income growth rate in developing countries, the growth and productivity of foreign agricultural sectors that compete with the U.S., and weather conditions accounted for much of the rest.

Using a sample of bilateral trade flows across ten developed countries between 1974 and 1995, Cho, Sheldon, and McCorriston (2002) explored the effects of exchange rate uncertainty on the growth of agricultural trade as compared to other sectors. Based on a gravity model that controls for other factors likely to determine bilateral trade, the results show that real exchange rate uncertainty has had a significant negative effect on agricultural trade over this period. Moreover, the negative impact of uncertainty on agricultural trade has been more significant compared to other sectors (Cho, Sheldon, and McCorriston, 2002).

Miljkovic, Brester, and Marsh (2003) studied quantifying the impacts of relative exchange rates on U.S. beef, pork, and poultry export prices. In addition, the impact of GATT and NAFTA agreements on exchange rate pass-through were considered. They have applied Knetter's model, which has been used to study the competitiveness of U.S. exports for wheat, feed grains, soybeans, soybean by-products, cotton, rice, and high-value food products to U.S. meat exports to identify the potential impacts of changes in relative exchange rates on meat export prices. Miljkovic, Brester, and Marsh (2003) concluded that currency devaluations in major U.S. export markets negatively influenced U.S. meat export prices. However, this was not true for every market destination and for all meat products. Results also indicated that GATT trade liberalization positively influenced U.S. beef and poultry export prices.

4.3. Empirical Trade Studies

There have a number of studies concerning bilateral trade flows. Mathematical programming and econometric models have commonly been used to estimate trade flows and their effects on domestic prices under a variety of existing economic environments.

The United States and Canada are two of the world's largest exporters of agricultural goods and compete with each other in major foreign markets. They share a common interest in reducing government interference in world agriculture and encouraging international trade (Mattson et al., 2001). Mattson et al. (2001) measured the factors affecting the flows of Canadian exports of beef, live cattle, pork, and live hogs to the United States and determined the effects of Canadian exports of these commodities on U.S. prices. Two equations were specified and solved simultaneously: an export supply equation and a price equation. These two equations were estimated using 3-stage least squares estimation with monthly time series data for 1981-1999. Their estimated model indicates that trade liberalization under CUSTA has had a significant influence on beef and live cattle exports to the United States. Hog exports to the United States increased significantly since 1994 after accounting for all other influencing factors. Canadian pork exports to the United States were not affected by CUSTA. The appreciation of the U.S. dollar relative to the Canadian dollar has had a significant positive effect on Canadian exports. Increased Canadian production has also had a positive influence on the amount of imports from Canada of pork and live hogs. Price differences between Canada and the United States influence Canadian exports of live cattle to the United States.

Miljkovic, Marsh, and Brester (2001) econometrically analyzed Japanese import demand for U.S. wholesale beef and pork and measured the impacts of exogenous shocks in the Japanese market on U.S. export quantities and derived slaughter prices. They used a modified version of Hooper and Kohlhagen's trade model which assumes that demand for beef and pork imports is a derived demand, with quarterly data from January, 1989 thru April, 1997. Their regression results indicate that Japanese trade restrictions, currency fluctuations, and income growth significantly affect U.S. beef and pork exports to Japan. However, the marginal impacts on domestic livestock prices are relatively small since U.S. beef and pork exports constitute a relatively small percentage of domestic red meat supplies.

On the other hand, Fabiosa (1999) studied welfare improving collusion in the Japanese pork import market. In order to determine whether foreign suppliers have a incentive to collude to influence policy parameters, and whether such collusion is welfare improving, Fabiosa (1999) examined three specific goals: (1) to provide a detailed description of the trade policies affecting pork imports in Japan; (2) to analyze the impacts of the GATT safeguards; and (3) to provide new supply and demand elasticity estimates from highly disaggregated and more recent monthly data.

Under the present pork import policy regime, there is always an incentive for foreign suppliers to collude to avoid exceeding the SG (Safeguard) trigger. The strength of this incentive depends on the magnitude of the underlying supply, demand, and policy parameters. Measured by the net profit of suppliers, the more inelastic (elastic) the supply function the stronger (weaker) the incentive, and the more elastic (inelastic) the excess demand function the stronger (weaker) the incentive to collude. Rules for sharing the market under the collusion scenario use a multi-plant monopolist structure that includes provision for trade of export quota rights to allow a low-cost supplier to increase its share and improve efficiency. It is shown that this collusion is welfare improving (Fabiosa, 1999).

CHAPTER 4

AN ECONOMETRIC MODEL

1. Introduction and Industry Background

According to Haley, Jones, and Southard (1998), expansion of a country's hog production capacity is limited by its resource base. Of the three key hog production resources – land, labor, and capital - land is most likely to constrain future growth in pork production. Land is a key factor in pork production. First, land is necessary to house the animals. Although the land requirement for an animal housing facility is minimal, large production facilities may require an extensive low population buffer zone around the housing unit due to odors and other localized environmental impacts. Second, as in the U.S. and Canada, hog feed supplies are frequently drawn from the domestic land base. The absence of a land base adequate to supply feed can be mitigated, however, by importing feed, as is done by Denmark. Third, land is a non-substitutable input into the hog production process for manure utilization. An adequate land base for spreading manure residues is essential, simply because no other economically viable means of manure disposal currently exits. Recent expansion of large, intensive pork production facilities has made manure utilization a topic of public debate in the major pork production countries. Nations with a large land endowment, accompanied by good feed supplies and low levels of environmental regulation may have an advantage in expansion of pork production.

Theoretically, the set of assumptions about production of the Heckscher-Ohlin Theorem leads to the conclusion that the production-possibilities frontier will differ between two countries solely as a result of their differing factor endowments (Appleyard and Field, 2001). With identical technology in both countries, constant returns to scale, and a given factor-intensity relationship between final products, the country with an abundant land factor will be able to produce relatively more of the land factor-intensive good.

The factor-proportion theory states that a country's comparative advantage is based on its endowment of the factors of production. Sawyer and Sprinkle (2003) stated the factor-proportions theorem in the following way: *A country will have a comparative advantage in goods whose production intensively uses its relatively abundant factor of production. A country will have a comparative disadvantage in goods whose production intensively uses it relatively scarce factor of production.*

The relative abundance of open land in a country tends to make the land factor less costly relative to the cost of that same factor in another country. Given the intensive use of open land in modern pork production, countries with abundant open land may have a comparative advantage in expanding pork production in the future. This study attempts to empirically analyze the relationship between pork production and measures of "open land" in recent years. We developed and estimated a multi-country, multi-year model of growth in pork production for this purpose.

2. Development of the Econometric Model

2.1. Panel Data

Our study of the impact of land on pork production uses time-series data on a cross-section of pork producing countries. Baltagi (1995) lists several benefits from using this type of panel data. When briefly summarized, these include the following:

1) Panel data control for individual heterogeneity. Panel data suggest that individuals, firms, states, or countries are heterogenous. Time-series and cross-section studies not controlling for this heterogeneity run the risk of obtaining biased results. As an empirical example, Baltagi (1995) mentions cigarette demand across 46 American states for the years 1963-1988. Consumption is modeled as a function of lagged consumption, price, and income. These variables vary with states and time. However, there are a lot of other variables that may be state invariant or time invariant and may affect consumption. For example, one may not be able to get the percentage of the population that is Mormon in each state for every year religion variable, nor does one expect that to change much across time. For TV and radio advertising variables, this is nationwide and does not vary across states. Omission of these variables leads to bias in the resulting estimates. Panel data are able to control for these state- and time-invariant variables whereas a time-series study or a cross-section study cannot.

2) Panel data give more informative, more variability, less collinearity among variables, more degrees of freedom and more efficiency. Time-series studies are plagued with multicollinearity. For example, in the case of demand for cigarettes above, there is high collinearity between price and income in the aggregate time series for the USA. This is less likely with a panel across states since the cross-section dimension adds a lot of variability, adding more informative data on price and income.

3) Panel data are better able to study the dynamics of adjustment. Cross-section distributions that look relatively stable hide a multitude of change. For example, in measuring unemployment, cross-sectional data can estimate what proportion of the population is unemployed at a point in time. Repeated cross-sections can show how this proportion changes over time. Only panel data, if long enough, can estimate what proportion of those who are unemployed in one period remain

unemployed in another period. Panels can also relate the individual's experiences and behavior at one point in time to other experiences and behavior at another point in time.

4) Panel data are better able to identify and measure effects that are simply not detectable in pure cross-sections or pure time-series data.

5) Panel data models allow us to construct and test more complicated behavioral models than purely cross-section and time-series data.

6) With panel data being used, biases resulting from aggregation over firms or individuals are eliminated.

2.2. The One-Way Random Effects Linear Regression Model

When developing the model in this study, it is appropriate to view individual specific constant terms as randomly distributed across cross-sectional units. Consider, then, a formulation of the model

$$y_{it} = \alpha + X'_{it}\beta + u_{it} \qquad i = 1, \ldots\ldots, N\,;\, t = 1, \ldots\ldots, T \qquad (4.1)$$

where y_{it} is the ith cross-sectional observation on the dependent variable in the tth time period; α is a scalar; β is a $(K \times 1)$ coefficient vector; X_{it} is a $(K \times 1)$ nonstochastic vector of observations on K explanatory variables. The i subscript, therefore, denotes the cross-section dimension whereas t subscript denotes the time-series dimension. The panel data application in this study utilizes a one-way error component model for the disturbance, with

$$u_{it} = \mu_i + \varepsilon_{it} \qquad (4.2)$$

where the component μ_i is the random disturbance and ε_{it} denotes the remainder disturbance. Note that the random disturbance μ_i is constant through time and it accounts for any individual specific effect that is not included in the regression. The remainder disturbance ε_{it} varies with individuals and time and can be thought of as the usual disturbance in the regression. Because of the separate cross-sectional error term μ_i, this model is sometimes called one-way random effects model (Baltagi, 1995; Greene, 2002a; Judge et al., 1985). It is assumed that

$$E\,[\mu_i] = 0,$$

$$\text{Var}\,[\mu_i] = \sigma_\mu^2,$$

$$\text{Cov}\,[\mu_i, \varepsilon_{it}] = 0 \tag{4.3}$$

The random effects model is a generalized regression model. All disturbances have variance

$$\text{Var}\,[\mu_i + \varepsilon_{it}] = \sigma^2 = \sigma_\mu^2 + \sigma_\varepsilon^2 \tag{4.4}$$

But for a given *i,* the disturbance in different periods are correlated because of their common component, $\mu_{i,}$

$$\text{Corr}\,[\mu_i + \varepsilon_{it}, \mu_i + \varepsilon_{is}] = \rho = \sigma_\mu^2 / \sigma^2 \qquad \text{if } t \neq s \tag{4.5}$$

The efficient estimator is generalized least squares. *LIMDEP,* which was utilized as a tool of regression analysis in this study, uses a two-step procedure. The variance components are first estimated by using the residuals from ordinary least squares regressions. Then feasible GLS estimates are computed using the estimated variances (Greene, 2002a).

Although fixed effects models are often estimated for panel data, this approach was not appropriate for our estimation because we included some variables that differed by country but did not vary over time.

2.3. The Model of Systematically Varying Parameters

This formulation of the linear regression model allows the response coefficient for the explanatory variables to differ for each cross-sectional unit and each time period (Judge et al., 1985). Equation (4.1) above is modified to allow β to vary by cross section i and time t:

$$y_{it} = \alpha + X'_{it}\beta_{it} + u_{it} \qquad i = 1, \ldots\ldots, N\,;\ t = 1, \ldots\ldots, T \qquad (4.6)$$

where β_{it} is a $(K \times 1)$ coefficient vector, possibly unique to ith cross section and tth time period. Let

$$\beta_{it} = Z_{it}\gamma \qquad (4.7)$$

where Z_{it} is a $(K \times M)$ matrix of variables that "explain" the variation in the β_{it} across observations and γ is an $(M \times 1)$ vector of associated coefficients. In general, the matrix of explanatory variable Z_{it} may contain (1) functions of variables already included in X'_{it}, implying that (4.6) is not linear in the original explanatory variables; (2) functions of other variables that do not appear in X'_{it}; or (3) qualitative variables that may be stochastic or nonstochastic, implying the existence of separate regression regimes (Judge et al., 1985). From (4.7), note that in this study the matrix of explanatory variables Z_{it} contains functions of other variables that do not appear in X'_{it}. Combined with (4.7), equation (4.6) generates

$$y_{it} = \alpha + X'_{it}Z_{it}\gamma + u_{it} = \alpha + W'_{it}\gamma + u_{it} \quad i = 1, \ldots, N; t = 1, \ldots, T \quad (4.8)$$

where $W'_{it} = X'_{it}Z_{it}$ is a $(1 \times M)$ vector of observations on interaction variables. Under the assumptions mentioned about u_{it}, the best linear unbiased estimator of γ, and thus β_{it}, is the least squares estimator (Judge et al., 1985).

3. Model Specification

3.1. Estimated Model

We maintain that pork production responds to changes in pork demand and simultaneously, that the response to pork demand is affected by land availability. World pork consumption and per capita real GDP of each country were used as indicators of changes in pork demand. Increasing world pork consumption increases the demand for total pork production, and increased world demand has the potential to stimulate production increases in any pork-producing country. Also, since pork is a normal good, an increase in per capita real GDP results in growth of households' purchasing power and, *ceteris paribus*, increases domestic demand for pork.

Assuming that "open land" is a limiting resource for pork production, the responsiveness of pork production in any country to an increase in demand will be affected by the availability of open land. We employed population density and arable land per unit of pork production as proxies for land availability. If a country is densely populated, increases in pork production can be restricted because of difficulty in finding locations for new or expanded production facilities away from populated areas. Higher arable land per unit of pork production may enhance the ability of countries to increase pork production since the greater availability of arable land facilitates increases in both feed production and manure spreading.

We use percentage change in pork production as a dependant variable due to differences in size of countries. Percentage change in pork production is modeled as a function of world consumption and per capita real GDP. The general reduced form of the supply response model is represented as:

$$PCP_{it} = \alpha + \beta_{1it} Con_t + \beta_{2it} PCGDP_{it} + \mu_i + \varepsilon_{it} \qquad (4.9)$$

where i = country, 1, … , 17; t = 1985, … , 2003; α is a scalar; PCP_{it} is percentage change in pork production in country i and year t; Con_t is world pork consumption in year t; GDP_{it} is per capita real GDP in country i and year t. As mentioned earlier, utilizing a one-way error component model for the disturbance, the random disturbance μ_i is constant through years and it accounts for any individual specific effect that is not included in the regression. The remainder disturbance ε_{it} varies with individual countries and years and can be thought of as the usual disturbance in the regression.

In order to allow flexibility in estimating the impact of land resource constraints on pork production, we added population density and arable land per unit of pork production independently as additional exogenous variables. The responses of pork production to changes in world pork consumption (β_{1it}) and to changes in per capita real GDP (β_{2it}) are affected by the land constraints and specified as:

$$\beta_{1it} = \gamma_1 + \gamma_2 Popden_i + \gamma_3 Araland_{it}$$

$$\beta_{2it} = \gamma_4 + \gamma_5 Popden_i + \gamma_6 Araland_{it} \qquad (4.10)$$

where $Popden_i$ is population density in country i and $Araland_{it}$ is arable land per unit of pork production in country i and year t; $Popden_i$ is calculated by dividing population of year 2000 as a base year by total area. $Araland_{it}$ is measured by dividing arable land of year 2000 by one year-lagged production. Incorporating land availability measures (4.10) into equation (4.9) results in the following estimating equation:

$$\begin{aligned} PCP_{it} = \alpha &+ \gamma_1 Con_t + \gamma_2 Popden_i * Con_t + \gamma_3 Araland_{it} * Con_t \\ &+ \gamma_4 PCGDP_{it} + \gamma_5 Popden_i * PCGDP_{it} + \gamma_6 Araland_{it} * PCGDP_{it} \\ &+ \mu_i + \varepsilon_{it} \qquad (4.11) \end{aligned}$$

Finally, we include population density and arable land per unit of pork production in the estimating equation to allow for direct effects on percentage change in pork production:

$$\begin{aligned} PCP_{it} = \alpha &+ \gamma_1 Con_t + \gamma_2 Popden_i * Con_t + \gamma_3 Araland_{it} * Con_t \\ &+ \gamma_4 PCGDP_{it} + \gamma_5 Popden_i * PCGDP_{it} + \gamma_6 Araland_{it} * PCGDP_{it} \\ &+ \beta_3 Popden_i + \beta_4 Araland_{it} + \mu_i + \varepsilon_{it} \qquad (4.12) \end{aligned}$$

A 3-year moving average smoothing method was applied to percentage change in pork production, world consumption, and per capita real GDP to reduce some of the abrupt fluctuations in the data. Additional years of data before 1985 were collected to avoid losing observations when taking the moving average of these variables. We also extend the estimating model to allow groupwise heteroscedasticity. Thus, the variance of the unique component of the compound disturbance is allowed to vary across countries.

3.2. Data

This study considers pork production across 17 major pork-producing countries: Australia, Brazil, Bulgaria, Canada, China, the EU, Hungary, Japan, Korea, Mexico, the Philippines, Poland, Romania, the Russian Federation, Switzerland, the Ukraine, and the U.S. We employed yearly data from 1985 through 2003 for each country. The choice of the period is based on data availability. Pork production data for the empirical model were extracted from the raw data file of Production, Supply and Distribution of Foreign Agricultural Service, USDA. Pork consumption data were from Custom Query of PS&D of Foreign Agricultural Service. Arable land and population data were obtained from FAOSTAT, Food and Agriculture Organization of the United Nations. Finally, GDP data were acquired from statistical databases of the Statistics Division, United Nations.

The EU has grown in size with successive waves of accessions. Denmark, Ireland, and the United Kingdom joined in 1973, followed by Greece in 1981, Spain and Portugal in 1986, and Austria, Finland, and Sweden in 1995. The European Union welcomed 10 new countries in 2004: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia. Bulgaria and Romania expect to follow a few years later, and Turkey is also a candidate country. In the study, we consider the following 13 major production countries as the EU: Austria, Belgium-Luxembourg, Denmark, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, and the United Kingdom. Separate data for Switzerland are available only from 1985 to 1999. Among former Soviet Union countries, only the Russian Federation and the Ukraine are included as pork producers. Yearly data from 1988 to 2003 are employed for these two countries because separate data are not available before Soviet Union dissolution. Total observations in this study are 322.

4. Hypotheses

As previously stated, pork production is expected to respond to changes in pork demand and this responsiveness to pork demand is impacted by land availability. World pork consumption and per capita real GDP of each country are used as indicators of pork demand, while population density and arable land per unit of pork production are used as proxies for land availability. In the study, we test the followings hypotheses:

(1) $\beta_{1it} > 0$: Pork production responds positively to increases in world pork consumption across countries.

(2) $\gamma_2 < 0$: Responsiveness to world pork consumption is lower (higher) in countries with higher (lower) population density.

(3) $\gamma_3 > 0$: Responsiveness to world pork consumption is higher (lower) in countries with more (less) arable land per unit of pork production.

(4) $\beta_{2it} > 0$: Pork production responds positively to increases in per capita real GDP across countries.

(5) $\gamma_5 < 0$: Responsiveness to per capita real GDP is lower (higher) in countries with higher (lower) population density.

(6) $\gamma_6 > 0$: Responsiveness to per capita real GDP is higher (lower) in countries with more (less) arable land per unit of pork production.

5. Model Estimation Statistics and Results

5.1. Model Estimation Statistics

5.1.1. R^2 statistics, MSE, and Standard Error

The R^2 statistics, indicators of the goodness of fit of the model, were computed consistently with the calculation of the F statistic. As seen in Table 4.1, the statistical results of R-squared (R^2) is 0.2034, indicating that independent variables in the model explain about 20 percent of the data variation. Adjusted R-squared ($\overline{R}^2$), mean square error (MSE), and standard error (SE) of the estimating equation are 0.1831, 0.0019 and 0.0566, respectively.

5.1.2. F-test and t-test

The F-test is a valid test of the no-regression hypothesis that the true coefficients of all regressors in the estimating equation (4.12) are 0. This is not exactly F-distributed but asymptotically F-distributed in finite samples. The F-ratio and its significance were obtained from the estimating equation. It shows that the equation has F-value with 9.99, leading to the rejection of the joint null hypothesis at the significance level less than 0.01 that the true coefficients of all the non-intercept parameters are 0.

The t statistic is the parameter estimate divided by the standard error when the hypothesis is that the true parameter is 0. The t statistics were computed using asymptotic formulas that are correct for large sample sizes but only approximately correct for smaller samples. The t ratios and their significance levels are presented in Table 4.1, by using [a] as significant at the 1 percent level, [b] at the 5 percent level, and [c] at the 10 percent level. We also performed the one-tailed t-tests at the 5 percent significance level for the hypotheses in 3.3 that γ_2 and γ_5 are less than zero, and γ_3 and γ_6 are greater than zero. Test results are also presented in Table 4.1.

5.1.3. Partial F-test

World consumption and per capita real GDP are both included in the estimating equation three times: as stand-alone variables and as interaction terms with population density and arable land per unit of pork production. To test if world consumption and per capita real GDP impacted pork production, we specified joint hypotheses tests for three variables. The following null hypotheses were tested using the partial F-test:

$$H_0: \gamma_1 = \gamma_2 = \gamma_3 = 0 \text{, and}$$

$$H_0: \gamma_4 = \gamma_5 = \gamma_6 = 0 \qquad (4.13)$$

where γ_1, γ_2, and γ_3 are parameter estimates related to world consumption and γ_4, γ_5 and γ_6 are parameter estimates related to per capita real GDP in the estimating equation. The partial F-test can be expressed in terms of R^2 obtained from the restricted model which exclude explanatory variables related to per capita real GDP (R_R^2) and the unrestricted model which include every explanatory variable (R_{UR}^2) (Jung and Koo, 2000).

$$\frac{(R_{UR}^2 - R_R^2)/q}{(1 - R_{UR}^2)/(n-k)} \sim F_{q,n-k} \tag{4.14}$$

where R_R^2 and R_{UR}^2 are R^2 values of the restricted and unrestricted models, respectively. If the calculated value is larger than the critical value of the F-statistic, the joint null hypothesis (4.13) is rejected. The first null hypothesis was that world consumption had no impact on pork production. We rejected the first null hypothesis, H_0: $\gamma_1 = \gamma_2 = \gamma_3 = 0$ at the 1 percent significance level because the calculated F-value was 14.69 and the critical F-statistic was 3.78. The calculated F-value of 19.52 also led to the rejection of the second null hypothesis that per capita real GDP had no impact on pork production, H_0: $\gamma_4 = \gamma_5 = \gamma_6 = 0$. We concluded that at least one of these three variables of each hypothesis was significantly different from zero.

5.2. Estimation Results

In the following discussion, we focus primarily on the responsiveness of pork production to pork demand across countries. We expect a negative effect of population density ($Popden_i$) and a positive effect of arable land per unit of pork production ($Araland_{it}$) on the response of pork production to changes in both world consumption and per capita real GDP. Simultaneously, we expect pork production to respond positively to increases in world pork consumption and per capita real GDP.

Table 4.1 lists the variables used in the empirical model based on the estimating equation (4.12) and gives the regression results. The estimating equation generally yields significant coefficient estimates of the model with the expected signs. The estimated impacts of both population density (γ_2) and arable land per unit of pork production (γ_3) on the responsiveness of pork production to world pork consumption are significant at α=0.05 level, where γ_2 and γ_3 are -0.2644 and 0.0078 with expected signs, respectively. On the other hand, the estimated impact of population density (γ_5) on the responsiveness to per capita real GDP is significant at α=0.05 with coefficient of -1.7237, while that of arable land per unit of pork production (γ_6) is not statistically different from zero. We find that the inclusion of population density and arable land per unit of pork production affects the response of pork production to changes in world consumption, while only population density significantly affects the response of pork production to changes in per capita real GDP. Thus, our finding suggests that the responsiveness to world pork consumption is lower (higher) in countries with higher (lower) population density, and greater (smaller) in countries with more (less) arable land per unit of pork production. The responsiveness to per capita real GDP across countries is lower (higher) in countries with higher (lower) population density, but not significantly affected by arable land availability. For example, an increase (decrease) of 1 person per hectare in population density is associated with about 0.026 percent decrease (increase) in the response of pork production to changes in world consumption (β_{1it}). An increase (decrease) of 10 hectares of arable land per unit of pork production is associated with about 0.008 percent increase (decrease) in the response of pork production to changes in world consumption. Additionally, an increase (decrease) of 1 person per hectare in population density results in approximately 1.72 percent decrease (increase) in the response of pork production to changes in per capita real GDP (β_{2it}).

Table 4.1. Parameter Estimates of the Estimating Equation

Estimated model

$$PCP_{it} = \underset{(-3.447)^{a}}{-0.07989} + \underset{(1.896)^{c}}{0.00042}\,Con_t \underset{(-2.157)^{b}}{-0.26442}\,Popden_i * Con_t + \underset{(2.307)^{b}}{0.00778}\,Arland_{it} * Con_t$$

$$+ \underset{(1.133)}{0.00180}\,PCGDP_{it} \underset{(-2.176)^{b}}{-1.72375}\,Popden_i * PCGDP_{it} \underset{(-0.906)}{-0.02187}\,Arland_{it} * PCGDP_{it}$$

$$+ \underset{(5.079)^{a}}{57.37993}\,Popden_i + \underset{(0.647)}{0.18152}\,Arland_{it}$$

One-tailed t-test at $\alpha = 0.05$ (with $t_{crit} = 1.645$)

Hypotheses	Decision
$H_0: \gamma_2 \geq 0$ $H_1: \gamma_2 < 0$	Reject H_0
$H_0: \gamma_3 \leq 0$ $H_1: \gamma_3 > 0$	Reject H_0
$H_0: \gamma_5 \geq 0$ $H_1: \gamma_5 < 0$	Reject H_0
$H_0: \gamma_6 \leq 0$ $H_1: \gamma_6 > 0$	Do not reject H_0

R^2	$\overline{R}^2$	MSE	SE (reg)	df
0.2034	0.1831	0.0019	0.0566	313

Note: Numbers in parentheses below each estimated parameter represent asymptotic *t* ratios. [a], [b] and [c] represent statistical significance at 1%, 5% and 10%, respectively. $\overline{R}^2$ is the adjusted R-squared; MSE is the mean square error; SE is the standard error of regression; and df is the degree of freedom.

Table 4.2 depicts the response of pork production to changes in demand across countries. The response to both world pork consumption (β_{1it}) and per capita real GDP (β_{2it}) are evaluated at year 2003 as a critical year. As for the response of pork production to world pork consumption, we have 13 out of 17 countries with expected positive signs ($\beta_{1it} > 0$) but the remaining 4 countries have negative calculated values of β_{1it} in year 2003. Using Wald statistics (Greene, 2002b) to test for the statistical significance of β_{1it}, we have 10 countries with a positive response and a significance level of 10% or higher. The country with the highest population density, Korea, has a calculated β_{1it} that is negative and statistically significant. The response of pork production to changes in per capita real GDP does not yield expected signs across countries, having only 5 countries with positive numbers. Testing the statistical significance of β_{2it}, we have the 3 most densely populated countries (the Philippines, Japan, and Korea) with a negative response significant at the 5% level.

As previously mentioned in 4.1.3, the joint null hypothesis H_0: $\gamma_4 = \gamma_5 = \gamma_6 = 0$ was tested using the partial F-test and the result leads to the rejection of the null hypothesis. Of the three variables including per capita real GDP in the estimation, only the coefficient estimate of the interaction of population density and per capita real GDP was individually statistically significant. Although we expected per capita real GDP to have a demand-related positive effect on pork production, the negative effect in our results in Table 4.2 may be due to increased objections to hog production facilities as income in a country increases. This effect would likely be even greater in countries with higher population densities, as shown in Table 4.1, by the negative and significant coefficient of an interaction variable between population density and per capita real GDP.

Table 4.2. Response of Pork Production to Pork Demand across Countries

Response to World Consumption[1]		Response to Per Capita Real GDP[2]	
Country	β_{1it}	Country	β_{2it}
Australia	0.001377801[a]	Canada	0.001208393
Russian Federation	0.000993760[a]	Brazil	0.000959844
Ukraine	0.000627947[a]	U.S.	0.000855788
Canada	0.000605622[a]	Mexico	0.000428317
Brazil	0.000544052[a]	Bulgaria	0.000110460
U.S.	0.000498375[a]	Russian Federation	-0.000016809
Mexico	0.000466808[a]	Hungary	-0.000271515
Bulgaria	0.000382869[a]	Romania	-0.000321960
Romania	0.000349514[a]	European Union[3]	-0.000498389
Hungary	0.000214641[c]	Poland	-0.000516361
Poland	0.000160874	China	-0.000573415
European Union[3]	0.000114699	Ukraine	-0.000808689
China	0.000093877	Australia	-0.000946914
Switzerland[4]	-0.000022355	Switzerland[4]	-0.001236083
Philippines	-0.000204641	Philippines	-0.002663938[b]
Japan	-0.000438415	Japan	-0.004076075[b]
Korea; Republic of	-0.000813532[c]	Korea; Republic of	-0.006366808[b]

Note: For β_{1it} and β_{2it}, countries are sorted in a descending order by the response to world consumption and the response to per capita real GDP, respectively. Both β_{1it} and β_{2it} are evaluated at year 2003 as a critical year. We used Wald statistics (Greene, 2002b) to test for the statistical significance of β_{1it} and β_{2it}. [a], [b] and [c] represent statistical significance at 1%, 5% and 10%, respectively.

1. $\beta_{1it} = \gamma_1 + \gamma_2 Popden_i + \gamma_3 Araland_{it}$, where $Popden_i$ is population density in country i; $Popden_i$ is measured by dividing population of year 2000 as a base year by total area. $Araland_{it}$ is arable land per unit of pork production in country i and year t; $Araland_{it}$ is calculated by dividing arable land of year 2000 by one-year-lagged production.
2. $\beta_{2it} = \gamma_4 + \gamma_5 Popden_i + \gamma_6 Araland_{it}$, where $Popden_i$ and $Araland_{it}$ are previously stated.
3. We consider the following 13 major production countries as EU: Austria, Belgium-Luxembourg, Denmark, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, and the United Kingdom.
4. The response of Switzerland to both world consumption and per capita real GDP is evaluated at year 1999 due to data availability.

CHAPTER 5

SUMMARY AND CONCLUSION

1. Study Summary

This study describes the international pork market. The pork sector of the agricultural economy is an important global food supplier, a customer for many productive resources, and a contributor to the income of farmers in the world. Developments in production, particularly advances in genetics and breeding, improved farming techniques, and better management practices have resulted in larger operations. Increasing the scale of production has been accompanied by considerable increases in productivity. The competitiveness of the pork industry in global markets is strengthened by its inexpensive and high-quality products. Countries endowed with a favorable climate, low feed costs, advanced production technology, and advantageous market structure are leading hog producers. A combination of demographic and economic factors has influenced the changing demand for world pork products. These factors include demographic shifts, changes in consumer preferences, fluctuations in incomes and relative prices, and the development of new technology and marketing techniques.

Second, related research is discussed. Literature reviews are categorized into pork production issues, consumer demand issues, market structure issues, and pork trade and government policy issues. We chose the topic of location of pork production from the literature for future analysis, and focused on the empirical studies related to land availability and environmental regulations on production. The availability of land is an important factor for production expansion to achieve competitiveness in the global market by leading the pork industry to new scale economies and declining costs. Environmental regulations, and the added costs generally associated with compliance, are considerations often factored into the choice of a business location. Previous research has suggested that geographic variations in environmental regulations and enforcement can induce a migration of industries across state or country boundaries to "pollution havens" where compliance costs associated with environmental regulation are lower.

Finally, given the apparent importance of "open" land to expansion of large-scale hog production, we attempted to develop an empirical model to examine the relationship between measures of land availability and changes in pork production. When developing the model in this study, the random effects linear regression model was used. The panel data application in this study adopted a one-way error component model for the disturbance, including the random disturbance and remainder disturbance. Also, the formulation of the one-way random effects linear regression model allowed the response coefficient for the explanatory variables to differ for each cross-sectional unit. This study examined the response of pork production to pork demand across countries while investigating factors affecting the responsiveness to changes in pork demand. We considered that pork production responds to changes in pork demand and, simultaneously, the response to pork demand is affected by land availability. World pork consumption and per capita real GDP were used as indicators of changes in pork demand. Assuming that land is a limiting resource for pork production, we regarded population density and arable land per unit of pork production as proxies for land availability. The general reduced form of the supply response model maintained that pork production was a function of world pork consumption and own-country per capita real GDP. Simultaneously, population density and arable land per unit of pork production were included as exogenous variables affecting the responses of pork production to changes in world pork consumption and per capita real GDP.

2. Conclusion

β_{1it} shows how production in country *i* and year *t* responds to a change in world consumption. The coefficient of the population density/world consumption interaction term was negative and significant, as expected, suggesting that countries with higher (lower) population densities have lower (higher) values of β_{1it}. The coefficient of the arable land/world consumption interaction term was positive and significant, as expected, suggesting that countries with more (less) arable land per unit of pork production have a higher (lower) value of β_{1it}. We expected β_{1it} to be greater than zero, reflecting a positive response of pork production to increases in world consumption. Calculation of β_{1it} for the last year of data (2003) resulted in positive values of β_{1it} for 13 of the 17 countries.

In a similar manner, β_{2it} shows how production in country *i* and year *t* responds to a change in per capita real GDP. As expected, the coefficient of the population density/per capita real GDP interaction term was negative and significant, suggesting that countries with higher (lower) population densities have lower (higher) values of β_{2it}. The coefficient of the arable land/per capita real GDP interaction term was not statistically significant, suggesting that β_{2it} is not significantly affected by arable land availability. We also expected β_{2it} to be greater than zero, reflecting a positive response of pork production to increases in per capita real GDP. Calculation of β_{2it} for the year 2003 resulted in positive values of β_{2it} for only 5 of the 17 countries. The observed negative effect of per capita real GDP on pork production may be due to increased objections to hog production facilities with higher income levels, and this effect is greater in countries with higher population densities.

As shown in Table 4.2, compared with the densely populated countries of the Philippines, Japan and Korea with virtually insurmountable land constraints, countries with relatively large land endowments and much less dense population, such as Australia, the Russian Federation, Canada, Brazil, and the U.S. seem to have the potential to expand production in the future and meet expected increases in world demand for pork.

We conclude that the availability of land for production expansion, feed production, and waste disposal is not only a critical determinant in the industry's drive to achieve economies of size and realize declining costs but also a major determinant of competitiveness in pork markets. If a country is densely populated, increases in pork production can be restricted because of difficulty in finding locations for new or expanded production facilities away from populated areas. Citizens close to new or expanded intensive hog production facilities would be likely to articulate a broad range of proposals for regulation, from heightened scrutiny by local zoning boards to countrywide moratoria on new or expanded hog production facilities. Countries with more arable land have better prospects to increase pork production since the greater availability of arable land facilitates increases in both feed production and manure spreading.

Regulations on land use, and the added costs associated with compliance, are considerations factored into the choice of a business location. Pork producers may respond to existing or impending costs of regulation by exiting the industry or by changing the scale and/or location of production. Moving to a different state or country with wider open land might mitigate and bypass the costs of local or domestic regulations altogether. As the struggle for consensus between the hog production industry and the public continues, the economics of the tradeoffs between expansion of low-cost large-scale production operations and public demands for environmental quality are becoming more clearly defined. Increased environmental regulation of manure disposal, for example, increases the costs of producing hogs, leading to production of fewer hogs than without the new restrictions. If consumer demand and pork production in a country remain constant, imposing higher costs on the use of land resources for hog industry will increase domestic pork prices and may reduce the competitiveness in international pork markets. Because these and similar measures have implications for the ability of the hog industry to expand, the level of land availability may become a key determinant of the future scale of the pork industry.

3. Future Research

There are several factors not directly related to land availability that affected pork production during the period of this analysis, such as impacts of weather shocks and inter-country differences in technological advances. Regional trade agreements have become a fixture in the global pork trade, and their role in pork production is increasing. We did not evaluate the effects of weather, technological differences, or bilateral and multilateral trade agreements on pork production and trade policy of individual countries. An outbreak of foot-and-mouth disease (FMD) and classical swine fever (CSF) contributed to a slowdown in the growth of global pork consumption and trade. A more comprehensive study would include the impacts of these and other factors affecting pork production. These issues are left for future research.

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APPENDICES

Table A. World Pork Production, Consumption, and Exports (1974-2003)

Year	Production	Consumption	Exports
1974	33,006	33,005	1,528
1975	39,126	39,072	1,111
1976	38,036	37,940	1,295
1977	39,837	39,860	1,201
1978	42,455	42,277	1,093
1979	46,922	46,640	1,199
1980	49,422	49,128	1,356
1981	49,384	48,965	1,535
1982	49,677	49,430	1,370
1983	51,800	51,205	1,571
1984	53,195	52,673	1,913
1985	55,645	55,094	1,946
1986	57,501	57,317	1,794
1987	59,401	59,115	1,953
1988	62,740	62,260	2,311
1989	63,805	63,652	2,143
1990	65,839	64,983	2,230
1991	67,198	66,996	2,089
1992	68,863	68,665	1,829
1993	70,309	69,969	2,074
1994	71,898	71,737	2,244
1995	75,911	76,038	2,360
1996	70,617	70,246	2,783
1997	74,361	74,174	2,789
1998	79,574	79,393	2,831
1999	81,759	81,747	3,311
2000	81,388	81,102	3,413
2001	83,160	82,818	3,543
2002	86,011	85,699	4,001
2003	87,964	87,548	4,246

Note: All data are reported in 1,000 metric tons (carcass weight equivalent).

Source: USDA, FAS (Foreign Agricultural Service). Production, Supply and Distribution Online. Webpage: www.fas.usda.gov/psd/Psdselection.asp (Accessed August, 2004).

Table B. U.S. Pork Production and Trade (1974-2003)

Year	Production	Exports	Imports
1974	6,500	47	221
1975	5,343	96	199
1976	5,755	143	213
1977	6,009	133	199
1978	6,075	130	225
1979	7,008	132	227
1980	7,537	114	249
1981	7,200	139	246
1982	6,454	97	278
1983	6,894	99	317
1984	6,719	74	433
1985	6,716	58	512
1986	6,379	39	509
1987	6,519	49	542
1988	7,114	88	515
1989	7,173	119	406
1990	6,965	108	407
1991	7,257	128	351
1992	7,817	185	293
1993	7,751	202	336
1994	8,027	249	337
1995	8,096	357	301
1996	7,764	440	280
1997	7,835	474	287
1998	8,623	558	320
1999	8,758	580	375
2000	8,597	584	439
2001	8,691	708	431
2002	8,929	731	485
2003	9,073	779	538

Note: All data are reported in 1,000 metric tons (carcass weight equivalent).

Source: USDA, FAS (Foreign Agricultural Service). Production, Supply and Distribution Online. Webpage: www.fas.usda.gov/psd/Psdselection.asp (Accessed August, 2004).

Table C. Japanese Pork Imports (1996-2003)

Fresh/Chilled Pork

Origin	1996	1997	1998	1999	2000	2001	2002	2003
Australia	25	403	1,549	2,139	3,824	6,325	11,364	9,466
Canada	7,242	15,804	20,347	28,314	41,133	44,661	44,370	35,078
EU-15	67	415	390	435	476	193	326	707
Korea	4,534	10,576	18,405	21,725	4,842	0	0	0
Mexico	23	267	1,910	6,622	12,927	14,356	11,956	9,338
Taiwan	79,772	12,332	0	0	0	0	0	
U.S.	77,233	89,116	101,956	112,730	128,189	134,988	137,634	120,168
Other	1	0	0	3	9	42	6	0
Total	168,987	128,913	144,557	171,968	191,400	200,565	205,656	176,760

Frozen Pork

Origin	1996	1997	1998	1999	2000	2001	2002	2003
Australia	447	2,842	4,395	2,876	2,326	2,493	1,824	2,928
Canada	32,088	38,630	41,496	62,707	70,033	108,389	134,747	131,527
Chile	0	768	5,019	4,708	8,358	10,112	21,586	28,188
EU-15	157,426	194,928	150,529	213,614	273,645	236,219	256,950	250,344
Hungary	0	0	0	196	5,413	13,197	16,852	14,414
Korea	30,328	37,925	71,793	58,774	11,997	0	0	0
Mexico	13,012	24,771	28,694	30,167	26,866	27,844	28,677	25,136
Taiwan	186,454	35,206	0	0	0	0	0	0
U.S.	64,559	47,926	58,258	54,984	60,895	109,859	111,233	125,260
Other	82	61	196	67	138	12	56	0
Total	484,396	383,047	360,380	428,093	459,671	508,125	571,925	579,800

Processed Pork

Origin	1996	1997	1998	1999	2000	2001	2002	2003
Australia	0	0	2	1	0	167	770	839
Canada	14,417	8,546	9,880	13,674	14,715	10,291	7,142	7,350
China	332	927	1,092	1,655	2,282	2,696	3,357	4,406
EU-15	1,379	591	1,729	1,764	2,961	2,043	1,076	2,245
Korea	1	12	400	339	49	0	0	0
Mexico	2,063	1,712	1,042	361	470	342	94	0
Switzerland	49	29	22	22	16	12	7	3
Taiwan	1,046	141	0	39	200	618	295	222
Thailand	104	90	96	73	49	52	162	204
U.S.	34,015	25,467	24,338	24,798	23,690	22,006	22,101	24,328
Other	2	0	3	0	1	8	4	1
Total	53,408	37,515	38,604	42,726	44,433	38,235	35,008	39,598

Note: All data are reported in metric tons (carcass weight equivalent).

Source: USDA, Foreign Agricultural Service. *Japan's Pork Safeguard*, International Trade Report, Washington DC, July 30, 2004.

Table D. Harmonized Tariff Schedule (HTS)

Harmonized Tariff Schedule of the United States (2004)

Annotated for Statistical Reporting Purpose

Heading/Subheading	Suf-fix	Article Description	Unit of Quantity	Rates of Duty 1 General	Rates of Duty 1 Special	Rates of Duty 2
0203		Meat of swine, fresh, chilled, or frozen:				
		Fresh or chilled:				
0203.11.00	00	Carcasses and half-carcasses	kg	Free		5.5¢/kg
0203.12		Hams, shoulders and cuts thereof, with bone in:				
0203.12.10		Processed		1.4¢/kg	Free (A+,CA,CL,D,E,IL,J,JO,MX,SG)	7.2¢/kg
	10	Hams and cuts thereof	kg			
	20	Shoulders and cuts thereof	kg			
0203.12.90		Other		Free		5.5¢/kg
	10	Hams and cuts thereof	kg			
	20	Shoulders and cuts thereof	kg			
0203.19		Other:				
0203.19.20		Processed		1.4¢/kg	Free (A+,CA,CL,D,E,IL,J,JO,MX,SG)	7.2¢/kg
	10	Spare ribs	kg			
	90	Other	kg			
0203.19.40		Other		Free		5.5¢/kg
	10	Bellies	kg			
	90	Other	kg			
		Frozen:				
0203.21.00	00	Carcasses and half-carcasses	kg	Free		5.5¢/kg
0203.22		Hams, shoulders and cuts thereof, with bone in:				
0203.22.10	00	Processed	kg	1.4¢/kg	Free (A,CA,CL,E, IL,J, JO,MX,SG)	7.2¢/kg
0203.22.90	00	Other	kg	Free		5.5¢/kg
0203.29		Other:				
0203.29.20	00	Processed	kg	1.4¢/kg	. Free (A,CA,CL,E, IL,J,JO,MX,SG)	7.2¢/kg
0203.29.40	00	Other	kg	Free		5.5¢/kg

Source: USITC. Harmonized Tariff Schedule of the United States (2004).
Webpage: http://hotdocs.usitc.gov/tariff_chapters_current/toc.html (Accessed August, 2004).

Table E. Major Pork Importing Countries from U.S. by Parts (1998-2003)

1) Volume

Country	HTS codes	Year					
		1998	1999	2000	2001	2002	2003
Japan	02031100	8	12	14	13	22	14
	02031210	1	1	1	1	1	1
	02031290	20	19	22	19	22	12
	02031920	14	8	11	7	4	4
	02031940	45	60	80	91	91	91
	02032100	5	4	1	3	3	5
	02032210	1	1	0	1	0	0
	02032290	23	23	22	3	4	2
	02032920	21	16	12	26	24	20
	02032940	29	37	48	87	83	107
Mexico	02031100	10	18	24	17	11	6
	02031210	2	2	14	14	13	15
	02031290	10	12	16	14	18	40
	02031920	0	0	1	1	0	1
	02031940	8	7	10	10	10	11
	02032100	0	0	0	0	1	1
	02032210	0	0	1	2	2	1
	02032290	4	2	9	20	10	5
	02032920	1	1	3	2	0	1
	02032940	8	10	19	22	16	18
Canada	02031100	0	0	0	0	0	0
	02031210	2	3	6	12	8	5
	02031290	0	0	0	0	0	0
	02031920	17	14	18	24	26	30
	02031940	0	0	0	0	0	0
	02032100	0	0	0	0	0	0
	02032210	0	0	0	0	0	0
	02032290	1	1	2	1	0	0
	02032920	0	0	1	1	1	1
	02032940	12	12	7	10	12	11
South Korea	02031100	0	0	0	0	0	0
	02031210	0	0	0	0	0	0
	02031290	0	0	0	0	0	0
	02031920	0	0	0	0	1	0
	02031940	0	1	0	0	0	0
	02032100	0	1	0	1	0	15
	02032210	0	0	0	0	0	1
	02032290	1	1	1	0	1	1
	02032920	0	1	0	1	1	0
	02032940	5	12	10	9	14	8

Note: All data are reported in 1,000 metric tons (carcass weight equivalent). Pork is categorized by HTS 8 digits.

Source: USITC. Interactive Tariff and Trade Dataweb.
Webpage: http://dataweb.usitc.gov/ (Accessed September, 2004).

2) Value

Country	HTS codes	Year					
		1998	1999	2000	2001	2002	2003
Japan	02031100	34	51	68	59	100	67
	02031200	7	4	3	4	7	3
	02031290	60	56	62	57	60	33
	02031920	58	35	54	34	19	19
	02031940	196	266	372	396	373	373
	02032100	11	10	4	11	10	13
	02032210	3	4	1	2	0	0
	02032290	72	69	63	5	6	3
	02032920	78	51	28	65	52	44
	02032940	61	82	139	223	183	204
Mexico	02031100	16	28	44	31	18	12
	02031210	7	7	22	23	22	30
	02031290	18	21	29	25	28	61
	02031920	1	1	2	2	1	2
	02031940	12	14	25	22	18	21
	02032100	0	1	1	0	2	2
	02032210	1	1	1	4	4	2
	02032290	6	4	14	31	12	8
	02032920	4	3	7	4	1	2
	02032940	19	16	31	37	23	29
Canada	02031100	0	0	0	0	0	0
	02031210	5	5	11	20	15	12
	02031290	0	0	0	0	0	0
	02031920	35	30	44	59	65	77
	02031940	0	0	0	0	0	0
	02032100	0	0	0	0	0	0
	02032210	0	0	0	0	0	0
	02032290	1	1	3	1	1	1
	02032920	1	1	4	3	5	2
	02032940	24	22	16	20	26	27
South Korea	02031100	0	0	0	0	0	0
	02031210	0	0	0	0	0	0
	02031290	0	0	1	0	0	0
	02031920	1	0	0	0	1	0
	02031940	0	1	1	0	1	0
	02032100	0	1	1	1	1	53
	02032210	0	2	1	1	1	1
	02032290	2	1	2	0	1	2
	02032920	1	2	1	1	1	0
	02032940	11	24	21	14	21	14

Note: All data are reported in 1,000,000 dollars. Pork is categorized by HTS 8 digits.

Source: USITC. Interactive Tariff and Trade Dataweb.
Webpage: http://dataweb.usitc.gov/ (Accessed September, 2004).

Table F. Major Pork Exporting Countries to U.S. by parts (1998-2003)

1) Volume

Country	HTS codes	Year					
		1998	1999	2000	2001	2002	2003
Canada	0203110000	11	11	5	2	3	4
	0203121010	0	0	1	2	0	0
	0203121020	0	0	1	0	0	0
	0203129010	33	44	45	41	52	55
	0203129020	16	17	30	32	28	32
	0203192010	0	1	2	6	7	5
	0203192090	0	0	0	1	1	0
	0203194010	18	29	29	25	35	32
	0203194090	68	86	117	132	151	165
	0203210000	0	0	0	0	0	0
	0203221000	0	0	0	0	0	0
	0203229000	3	5	5	4	5	11
	0203292000	0	0	0	0	0	0
	0203294000	31	33	38	40	44	45
Denmark	0203110000	0	0	0	0	0	0
	0203121010	0	0	0	0	0	0
	0203121020	0	0	0	0	0	0
	0203129010	0	0	0	0	0	0
	0203129020	0	0	0	0	0	0
	0203192010	0	0	0	0	0	0
	0203192090	0	0	0	0	0	0
	0203194010	0	0	0	0	0	0
	0203194090	0	0	0	0	0	0
	0203210000	0	0	0	0	0	0
	0203221000	0	0	0	0	0	0
	0203229000	4	2	0	0	0	0
	0203292000	0	0	0	0	0	0
	0203294000	25	30	42	37	37	46
Ireland	0203110000	0	0	0	0	0	0
	0203121010	0	0	0	0	0	0
	0203121020	0	0	0	0	0	0
	0203129010	0	0	0	0	0	0
	0203129020	0	0	0	0	0	0
	0203192010	0	0	0	0	0	0
	0203192090	0	0	0	0	0	0
	0203194010	0	0	0	0	0	0
	0203194090	0	0	0	0	0	0
	0203210000	0	0	0	0	0	0
	0203221000	0	0	0	0	0	0
	0203229000	0	0	0	0	0	0
	0203292000	1	1	1	0	1	1
	0203294000	1	2	1	0	1	2

Note: All data are reported in 1,000 metric tons (carcass weight equivalent). Pork is categorized by HTS 10 digits.

Source: USITC. Interactive Tariff and Trade Dataweb.
Webpage: http://dataweb.usitc.gov/ (Accessed September, 2004)

2) Value

Country	HTS codes	Year					
		1998	1999	2000	2001	2002	2003
Canada	0203110000	18	19	8	3	4	5
	0203121010	0	1	1	3	1	0
	0203121020	0	1	3	1	0	0
	0203129010	46	55	61	63	56	68
	0203129020	22	23	49	57	40	45
	0203192010	1	2	6	18	17	15
	0203192090	1	1	1	2	1	1
	0203194010	26	42	60	52	69	75
	0203194090	136	162	254	311	284	328
	0203210000	0	0	0	0	0	0
	0203221000	0	0	0	0	0	1
	0203229000	6	9	9	7	9	22
	0203292000	1	1	0	2	0	1
	0203294000	53	56	82	100	91	83
Denmark	0203110000	0	0	0	0	0	0
	0203121010	0	0	0	0	0	0
	0203121020	0	0	0	0	0	0
	0203129010	0	0	0	0	0	0
	0203129020	0	0	0	0	0	0
	0203192010	0	0	0	1	0	0
	0203192090	0	0	0	0	0	0
	0203194010	0	0	0	0	0	0
	0203194090	0	0	0	0	0	0
	0203210000	0	0	0	0	0	0
	0203221000	1	0	0	0	0	0
	0203229000	17	6	0	1	0	0
	0203292000	0	0	0	0	0	0
	0203294000	88	98	141	142	132	156
Ireland	0203110000	0	0	0	0	0	0
	0203121010	0	0	0	0	0	0
	0203121020	0	0	0	0	0	0
	0203129010	0	0	0	0	0	0
	0203129020	0	0	0	0	0	0
	0203192010	0	0	0	0	0	0
	0203192090	0	0	0	0	0	0
	0203194010	0	0	0	0	0	0
	0203194090	0	0	0	0	0	0
	0203210000	0	0	0	0	0	0
	0203221000	0	0	0	0	0	0
	0203229000	0	0	0	0	0	0
	0203292000	3	3	4	1	3	3
	0203294000	4	5	4	1	4	7

Note: All data are reported in 1,000,000 dollars. Pork is categorized by HTS 10 digits.

Source: USITC. Interactive Tariff and Trade Dataweb.
Webpage: http://dataweb.usitc.gov/ (Accessed September, 2004).