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By

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ABSTRACT

DEVIATIONS FROM PURCHASING POWER PARITY AND THE UNITED STATES-CANADIAN HOG/PORK MARKET: A STRUCTURAL MODEL

By

Steven R. Koenig

An unprecedented increase in Canadian hog and pork exports to the United States and a decline in U.S. exports to Canada occurred from 1976 to 1985. These trends were accompanied by diverging hog production cycles, a depreciating Canadian dollar vis-a-vis the U.S. dollar, and slow adjustment of hog/pork prices between the two countries. This paper examines the influence that lags in the adjustment of prices to exchange rate changes had on the U.S.-Canadian hog/pork market during this period. To quantify this influence, a monthly structural econometric model of the market is developed and estimated using deviations from purchasing power parity (PPP), an equilibrium condition. Results indicate that deviations from PPP influence hog supply response in Canada, but not in the U.S. Estimation results further indicate that structural changes in both hog/pork markets may be taking place.

ACKNOWLEDGEMENTS

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Chapter 1

Research Overview

1.1 The Enigma of U.S.-Canada Hog/Pork Trade

Since 1971 hog and pork trade volume between the United States and Canada has expanded rapidly. Expanding trade volume was accompanied by two major shifts in bilateral trade patterns (Figure 1). In the first shift, the United States became a net exporter, as annual hog and pork (hog/pork) exports to Canada increased by 1200 percent from 1971 to 1977. Then in 1979, the U.S. returned to being a net hog/pork importer, as Canadian production and exports increased continuously (63 percent and 1800 percent) from 1977 to 1985.

This research attempts to explain whether dramatic increases in hog/pork trade and diverging production levels since 1976 are a consequence of slow price adjustments between the two nations. Specifically, this is accomplished by measuring the impact of 'sticky prices' on supply and demand functions in the two countries as measured by deviations from purchasing power parity (PPP). Deviations from PPP occur when the ratios of hog/pork prices and the exchange rate between the two countries are not in equilibrium.

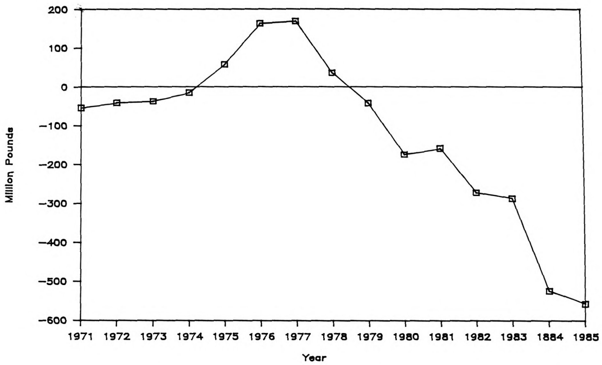


Figure 1. U.S. Net Pork Exports to Canada, 1971-85

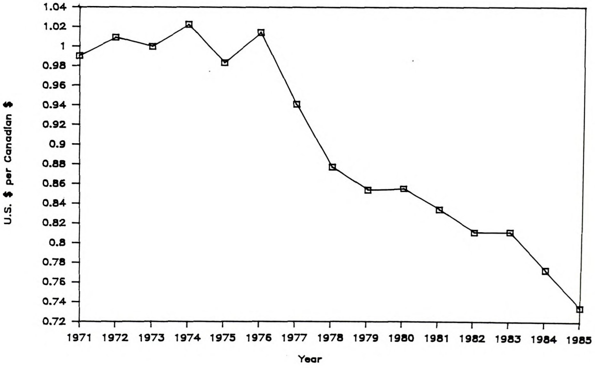


Figure 2. U.S. and Canadian Dollar Exchange Rate, 1971-85

PPP disequilibrium has occurred for extended periods since 1971, coinciding with increasing trade volume and alternating hog/pork trade volume. Moreover, this disequilibrium coincides with the March 1973 dissolution of the Bretton Woods Agreement on exchange rates.

Following dissolution of the Bretton Woods Agreement, the U.S. and Canadian dollars were allowed to 'float' against each other with minimal government interference. Like pork trade volume, the exchange value of the two currencies fluctuated somewhat in the years immediately after the currencies were allowed to float. But in 1976, the Canadian dollar began depreciating against the U.S. dollar, a trend which continued until 1985. The Canadian dollar lost over 30 percent of its value against the U.S. dollar during this period (Figure 2). The depreciation coincides with the dramatic increase in Canadian hog/pork exports to the U.S. which began in 1977.

The extent of currency depreciation/appreciation influences on export and import prices (the terms of trade) and trade volume depends on the speed of adjustment of prices to these currency value changes. The speed of adjustment, in turn, depends on the short-run and long-run elasticities of supply and demand curves in each country, the relative size of the two markets, and the degree to which the markets are integrated.

In a "perfect market," a one time change in the exchange rate should, through arbitrage, quickly adjust prices to the change, thus maintaining similar prices (adjusted for transfer costs) in both countries. Yet, evidence presented in Chapter 2 suggests that arbitrage does not always perform quickly--leaving extended periods of significant price differences between the two markets.

The model developed here is unique because it uses purchasing power parity theory to represent the relationship between exchange rate adjustment and price adjustment. By using such a variable in the analysis, it should help determine whether lags in the adjustment of prices to exchange rate changes affected relative supply and demand functions and influenced U.S.-Canada hog/pork trade volume since 1976.

1.2 Objectives

The primary objective of this paper is to develop a structural model of the U.S.-Canadian hog/pork market which quantifies the influence that adjustment lags of prices to exchange rate changes have had on this market from 1976 to 1985. Quantification is determined by examining the influence that deviations from PPP equilibrium have had on supply and demand conditions in the U.S.-Canadian hog/pork market. By quantifying the influence on supply and demand conditions, it can be determined whether trade volume between the two countries is affected by PPP deviations.

The secondary objective of the paper is to construct a model of the U.S.-Canadian hog/pork market which captures structural changes that have occurred since the 1970s, such as a shift in the demand for pork. Results obtained from the model developed could be useful for domestic policy and trade policy analysis.

1.3 Methodology

To meet the objectives of the paper a supply and demand trade model of U.S.-Canadian hog/pork market is specified. This econometric model is estimated with monthly time series data from March 1976 through March 1985. The theoretical framework for the model is based on concepts found in supply-demand trade models and spatial equilibrium models.

In the model, seven behavioral equations are specified and related by five identities. Three additional identities are used to relate hog/pork trade between the United States and Canada. Of the seven behavioral equations, two regional supply response equations for Canada are estimated, while one regional supply response equation for the U.S. is estimated. National demand for pork storage stocks and demand for consumption equations are specified and estimated for both countries.

The supply response equations are estimated using ordinary least squares (OLS) technique, since the assumption is made that production lags predetermine supply. The simultaneous determination of price in the demand for

storage stocks and the demand for consumption equations required the use of two-stage least squares estimation procedures (2SLS).

Finally, model estimations were used to compute supply and demand elasticities at the means of the explanatory variables. Elasticities are then compared with similar estimated elasticities reported by previous research efforts.

1.4 Organization of the Study

The paper is organized into seven remaining chapters. Chapter 2 provides background and a historical perspective of the U.S.-Canadian hog/pork market and its trade in two time periods: 1971 to 1977 and 1978 to 1985. The conceptual framework for the model is presented in Chapter 3. It includes a discussion of spatial equilibrium models and supply-demand trade models, and relevant aspects of purchasing power parity theory. Specification of the model's equations and a review of previous specifications is presented in Chapter 4. Chapter 5 outlines equation estimation techniques and data handling procedures. Model results are presented and compared with other studies in Chapter 6. Chapter 7 provides a discussion of policy implications and future research suggestions. Finally, Chapter 8 summaries the paper.

Chapter 2

Historical Perspective: 1971-1985

2.1 Introduction

This chapter presents an historical perspective of hog/pork trade between the United States and Canada since 1971. The chapter begins by providing background and definitions of pork trade, spatial markets, the terms of trade, and barriers to U.S.-Canada hog/pork trade. The chapter includes a literature review of important structural variables and events suggested as influential to the U.S.-Canadian hog/pork market and its trade volume. To simplify, the discussion is divided into two periods: 1971 to 1977 and 1978 to 1985. Most of the discussion will concentrate on the latter period, since it is the study's focus. Appendix A provides a discussion of hog/pork trade history with countries outside of North America.

2.2 Trade Background

2.2.1 Definitions

The term pork is defined to include dressed pork and the dressed pork equivalent of hogs (hereafter the term "pork" will refer to the previously used "hog/pork" term).[1] No distinction is made between dressed pork and the dressed pork content of hogs, since the difference between the two products is merely the stage of processing. Hogs are the raw material which can only be processed into pork meat, the finished product. When a distinction is necessary, they will be referred to as hogs and dressed pork.

Dressed pork is defined to include both processed and unprocessed (fresh and frozen) pork products. Unprocessed products include carcasses, carcass sides, and various pork cuts. Pork cuts include hams, back loins, shoulders, butts, picnics, bellies, and spareribs. Processed pork is distinguished from unprocessed pork by being canned, cured, cooked or altered in some fashion. Processed products often carry brand names, which further distinguishes them from unprocessed products.

Over 90 percent of the pork trade volume between the United States and Canada in a given year is classified as unprocessed. Hams typically represent the largest share of this volume, followed by shoulders, butts, picnics, and bellies. The remaining 10 percent of trade volume is classified as processed pork products. This volume has been relatively stable through time.

Spatial Markets

Although this paper analyzes pork trade at the aggregate level, it recognizes that regional spatial pork markets do occur in North America. An example of a regional market is the market centered around packing facilities in Detroit, Michigan. These facilities serve markets in southern Ontario, southern Michigan, northern Indiana, and northwest Ohio.

Regional markets are influenced by local market conditions and can be affected differently by macro-level conditions. Despite the presence of these regional spatial markets, an analysis at the aggregate level is still valuable, since regional supply and demand functions are often similar and are affected similarly by macro-level variables. When appropriate, important regional pork markets, such as the Quebec or the Western Canada pork market, will be discussed.

Terms of Trade

The terms of trade is defined as the ratio of the price of pork exported to the price of pork imported. When an improvement in the terms of trade occurs for a country, it implies that the export price has risen relative to the import or domestic price. When export prices exceed import prices, exports should increase and when import prices exceed export prices, imports from other countries should increase.

2.2.2 Trade Barriers

When compared to other traded agricultural commodities and manufactured goods, dressed pork trade between the United States and Canada has been relatively free of government interference. On the other hand, hog trade is more restricted because Canada imposes a quarantine on U.S. hog imports. Until March 1985, the U.S. imposed few barriers on hog imports from Canada. An outline of hog and dressed pork trade restrictions and barriers follows.

2.2.2.1 Non-Tariff

Health and sanitary regulations have been the primary non-tariff trade barriers. An exception was the temporary import quotas on Canadian hog and dressed pork imports imposed by the United States from August 12, 1974 to August 11, 1975. Under the quotas, hog imports were limited to 50,000 head and dressed pork imports to 36 million pounds. Due to exceptions, actual imports during the period were approximately 50 million pounds of pork and 60,000 head of hogs. Imposition of the quotas resulted from a brief increase in Canadian hog imports in early 1974.

Canadian government swine health regulations relating to Pseudorabies, a contagious disease of cattle and swine, have had the largest influence on bilateral pork trade. These health regulations were in place prior to 1971 and have two major requirements. First, they require that all hog imports come from certified disease-free herds. Second, they require that all hogs entering Canada be quarantined for a 30-day period. These requirements effectively prohibit U.S. slaughter hogs from entering Canada.

In the United States, government health and sanitary regulations have had little influence on trade between the two nations. However, controversy developed in early 1985 concerning chloramphenicol, a therapeutic drug used by Canadian hog producers. Banned for use in the U.S. by the U.S. Food and Drug Administration, concerned parties in the U.S. urged a ban on Canadian dressed pork and hog imports.

Pressure to ban Canadian imports came partially from U.S. pork producers, who saw the regulation as a method to stem the increasing flow of Canadian pork imports in 1984 and 1985. Canadian producers had been using the drug long before Canadian hog and dressed pork export volume increased.

Five states did impose bans on Canadian hog and dressed pork imports based on state health regulations prohibiting the use of chloramphenicol. States imposing bans (Iowa, Minnesota, Nebraska, South Dakota, and Wisconsin) all have significant hog producing and/or pork packing industries. With political and diplomatic pressures mounting, the Canadian government suspended use of the drug in June 1985. Following the suspension, these five states indicated they would relax or remove their bans on Canadian imports.

2.2.2.2 Tariffs

Tariffs imposed by both countries on hogs and unprocessed pork from 1971 to 1980 were generally equivalent at $0.005 per pound (Table 1). Canada did cancel tariffs for several brief periods to encourage U.S. imports. Both nations removed the tariffs in 1980 as a result of the Tokyo Round of Multilateral Trade Negotiations under the General Agreement on Tariffs and Trade (GATT).

Trade of these products remained unhindered by tariffs until April 3, 1985, when the U.S. Customs Service was directed by the U.S. Department of Commerce to require bonding of unprocessed pork and hog imports from Canada.

Table 1. Tariffs on Hog and Pork Imports, 1971-84

Year	Hogs U.S.	Hogs Canada	Fresh or Frozen Pork U.S.	Fresh or Frozen Pork Canada
	--- Dollars* per pound ---			
1971	0.006	0.005	0.007	0.005
1972	0.005	0.005	0.005	0.005
1973	0.005	Free	0.005	Free
1974	0.005	Free	0.005	Free, 0.005 a
1975	0.005	0.005	0.005	0.005
1976	0.005	0.005	0.005	0.005, Free b
1977	0.005	0.005	0.005	Free, 0.005 c
1978	0.005	0.005	0.005	0.005
1979	0.005	0.005	0.005	0.005, Free d
1980	Free	Free	Free	Free
1981	Free	Free	Free	Free
1982	Free	Free	Free	Free
1983	Free	Free	Free	Free
1984	Free	Free	Free	Free

* Tariff dollar amounts are in each countries currency for imports from the other country.
a: Tariff began June, 1974.
b: No tariff was charged after May 26, 1976.
c: Tariff resumed July 1, 1977.
d: No tariff was charged beginning July 1, 1979.
Source: Agiculture Canada, Livestock Market Review, various issues.

Bondings were set at \$0.053/per pound dressed weight and \$0.0376/per pound live weight (Canadian currency). Bond funds were collected from importers and placed in an escrow account pending the final outcome of a U.S. countervailing duty investigation covering both products.[2] On August 15, 1985 a permanent duty of \$0.04386 Canadian per live pound was placed on hogs. The duty on fresh or frozen pork imports was removed.

Tariffs on processed pork products (cured, canned or prepared) used by both countries have remained relatively constant since 1971. For Canadian pork entering the United States, tariffs range between two and three cents per pound. For U.S. pork entering Canada, the tariff structure is a little more complicated, but ranges from one cent per pound up to a 25 percent value-added-tariff. In general, tariffs represent a small fraction of the value of these pork products and these products represent a small fraction of the total pork trade volume.

In summary, with minimal and relatively equivalent tariffs on all classifications of dressed pork and hogs, the influence of these tariffs on the expansion and shifts in pork trade volume have been minor. On the other hand, non-tariff barriers imposed by Canada have effectively prohibited U.S. hogs from entering Canada since 1971. The influence of these regulations on Canadian exports is

considered minor and probably was not a significant factor in the decline of U.S. exports since the late 1970s.

2.3 Trade From 1971 to 1977

2.3.1 Trade History

Prior to 1971, pork trade between the two countries can be characterized as stable and unimportant to either country's pork market, especially for the United States market. During most of this period, Canada was a net pork exporter to the U.S., with net export volume never exceeding 75 million pounds. Pork exports or imports generally represented less than five percent of either country's production or consumption.

Stable trade volume began to change after 1971. For the U.S., annual pork export volume to Canada expanded continually until peaking in 1977 (Table 2). For Canada, export volume to the U.S. remained stable in 1972, 1973 and 1974, but declined sharply in 1975, remaining low until 1978 (Table 3). By 1975, the combination of these two trends changed Canada from a net exporter to a net importer.

At the peak in 1977, Canadian net pork imports from the U.S. had reached 170 million pounds, the highest net import level in bilateral trade since at least 1960. This change is demonstrated in Figure 3, which graphs bilateral pork exports. Notice that while pork exports from Canada declined nearly 66 percent from 1971 to 1977, U.S. exports to Canada increased by over 1200 percent.

Table 2. United States Pork Balance Sheet, 1971-85

Year	Commercial Production	Total Imports	Total Exports	Canadian Imports	Canadian Exports	Apparent Consumption	Per Capita Consumption
			--- Million Pounds ---				--- Pounds --
1971	15,815	510	198	69	15	16,127	78.71
1972	14,241	556	236	76	35	14,712	70.91
1973	13,043	549	279	82	45	13,298	63.45
1974	14,100	520	204	80	65	14,493	68.47
1975	11,585	444	317	35	93	11,852	55.44
1976	12,488	476	422	29	192	12,667	58.64
1977	13,052	446	398	30	199	13,202	60.52
1978	13,209	526	421	79	115	13,293	60.28
1979	15,270	521	449	111	69	15,353	68.82
1980	16,432	590	417	211	37	16,574	73.48
1981	15,716	565	452	198	40	15,927	69.88
1982	14,121	664	365	301	29	14,425	62.68
1983	15,117	779	361	321	34	15,369	66.15
1984	14,720	1183	311	543	19	15,396	65.57
1985	14,728	1164	259	571	14	15,642	65.98

Note: Total exports includes shipments to U.S territories.
Note: Pounds are expressed in dressed carcass weight and include the trade volume of hogs expressed in a dressed carcass weight equivalent.
Source: Complied from publications of the United States Department of Agriculture and Statistics Canada.

Table 3. Canadian Pork Balance Sheet, 1971-85

Year	Commercial Production	Total Imports	Total Exports	U.S. Imports	U.S. Exports	Apparent Consumption	Per Capita Consumption
		--- Million Pounds ---					--- Pounds ---
1971	1,499	18	113	15	69	1,402	65.0
1972	1,451	45	130	35	76	1,377	63.1
1973	1,409	55	140	45	82	1,308	59.3
1974	1,433	70	122	63	80	1,392	62.1
1975	1,201	100	90	93	35	1,211	53.3
1976	1,182	196	93	192	29	1,274	55.3
1977	1,195	202	108	199	30	1,294	55.3
1978	1,386	120	156	115	79	1,345	57.2
1979	1,646	74	197	69	111	1,522	64.0
1980	1,929	39	301	37	211	1,660	69.0
1981	1,876	44	308	40	198	1,617	66.4
1982	1,888	32	412	29	301	1,514	61.4
1983	1,956	43	425	34	321	1,571	63.1
1984	2,131	32	615	19	543	1,546	61.5
1985	2,184	38	631	14	571	1,595	62.8

Note: Pounds are expressed in dressed carcass weight and include the trade volume of hogs expressed in a dressed carcass weight equivalent.
Source: Compiled from various publications of Statistics Canada.

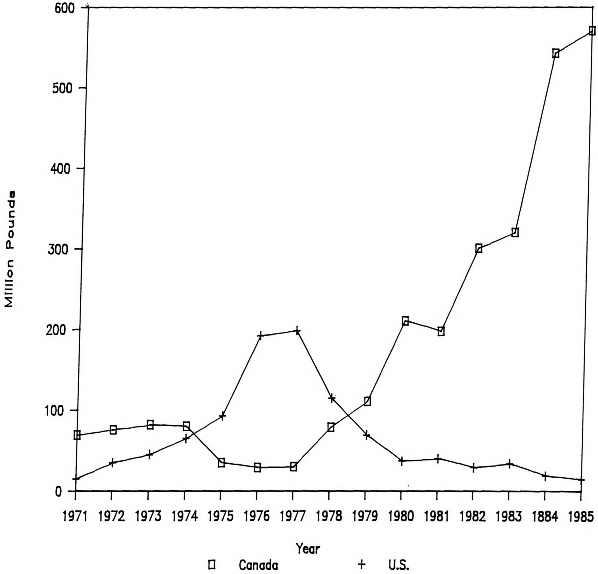


Figure 3. Pork Exports to the Other Country, 1971-85

The change in trade volume and its importance to domestic pork markets is further seen in Table 4. During this period, U.S. pork imports as a percent of Canadian consumption increased from just one percent to over 15 percent. While in the U.S., exports as a percent of domestic production increased from negligible amounts to over 1.5 percent in 1976 and 1977. A relatively small figure when compared to the impact on total Canadian consumption, but expected, since U.S. production was over ten times larger than Canadian production at that time.

Relative Prices

Farm level hog prices differed significantly between the two countries for extended periods between 1975 and 1977. When adjusted for exchange rates, prices were generally higher in Canada than the U.S., suggesting that the terms of trade where more favorable for the U.S.

Figure 4 graphs annual dressed hog prices adjusted for exchange rates at two comparable markets, Toronto and the average of seven central U.S. markets. The graph indicates that prices in the two markets diverged considerably in 1976. Table 5 provides a more detailed presentation by comparing prices monthly from June 1975 to June 1977. It indicates that price differences were greatest from November 1975 through November 1976. This period coincides with an increase in U.S. exports and a decline in Canadian exports.

Table 4. Pork Import-Export Ratios, 1971-85*

	Exports as a Percent of Production		Imports as a Percent of Consumption		Exports to the Other Country as a Percent of Production		Imports From the Other Country as a Percent of Consumption	
Year	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada
1971	1.25	7.54	3.16	1.28	0.09	4.60	0.43	1.01
1972	1.66	8.96	3.78	3.27	0.25	5.24	0.52	2.54
1973	2.14	9.94	4.13	4.20	0.35	5.82	0.62	3.29
1974	1.45	8.51	3.59	5.03	0.46	5.58	0.55	4.53
1975	2.74	7.49	3.75	8.26	0.80	2.91	0.30	7.68
1976	3.38	7.87	3.76	15.38	1.54	2.45	0.23	15.07
1977	3.05	9.04	3.38	15.61	1.52	2.51	0.23	15.38
1978	3.19	11.26	3.96	8.92	0.87	5.70	0.59	8.55
1979	2.94	11.97	3.39	4.86	0.45	6.74	0.72	4.53
1980	2.47	15.60	3.56	2.35	0.23	10.94	1.27	2.23
1981	2.88	16.42	3.55	2.72	0.25	10.55	1.24	2.47
1982	2.58	21.82	4.60	2.11	0.21	15.94	2.09	1.92
1983	2.39	21.73	5.07	2.74	0.22	16.41	2.10	2.16
1984	2.11	28.86	7.68	2.07	0.13	25.48	3.53	1.23
1985	1.76	28.89	7.44	2.38	0.09	26.14	3.65	0.87

* The term pork includes the dressed pork equivalent of hogs.
Source: Compiled from publications of Statistics Canada and the U.S. Department of Agriculture.

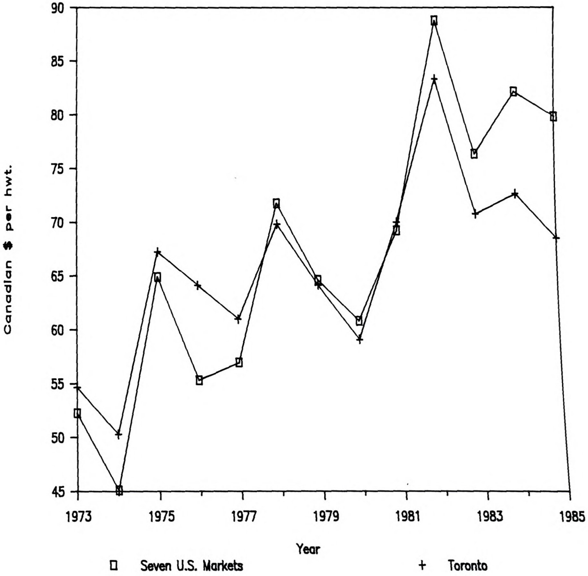


Figure 4. Annual Dressed Hog Prices at Toronto and Seven U.S. Markets, 1973-85

Table 5. U.S. and Canadian Hog Price Differentials*

Year/Month	Seven U.S. Markets Price	Toronto Index 100 Price	Price Differential
	---Canadian Dollars per Dressed cwt.---		
1975 June	$68.24	$69.50	$1.23
1975 July	76.54	77.20	.64
1975 August	78.12	77.83	-.28
1975 September	81.61	84.41	2.73
1975 October	77.90	78.90	.97
1975 November	65.50	73.68	8.07
1975 December	63.64	73.87	10.09
1976 January	63.61	70.53	6.88
1976 Febuary	62.63	69.62	7.03
1976 March	58.96	67.10	8.26
1976 April	60.15	65.98	5.93
1976 May	60.99	67.65	6.80
1976 June	62.54	68.95	6.59
1976 July	59.25	68.96	9.99
1976 August	55.47	66.24	10.93
1976 September	48.63	63.58	15.33
1976 October	40.13	54.81	15.09
1976 November	40.43	51.92	11.66
1976 December	51.26	55.43	4.09
1977 January	51.88	53.67	1.77
1977 Febuary	53.64	55.27	1.59
1977 March	51.23	56.34	4.86
1977 April	50.45	53.71	3.10
1977 May	56.90	61.57	4.45
1977 June	60.24	65.05	4.55

* Price differential is the Canadian price less the United States price.
Source: Agriculture Canada, Livestock Market Review. USDA, Livestock and Poultry: Outlook and Situation Report.

2.3.2. Market Conditions

2.3.2.1 Dollar Appreciation

Canadian dollar appreciation relative to the United States dollar is a possible explanation for the divergence of prices and trade volume changes in 1976 and 1977. Figure 5 shows that the quarterly Canadian dollar exchange value peaked in the third quarter of 1976--coinciding with the greatest period of price difference between the markets (Table 5). This correlation suggests that exchange rate appreciation could have been a factor in creating the price differential.

The relationship between prices and exchange rate is further demonstrated in Figure 6, which shows deviations from absolute purchasing power parity (PPP) for monthly weighted average dressed hog prices at Toronto, Ontario and at seven central U.S. markets.[3] The figure indicates that negative deviations peaked during the last half of 1976. The negative deviations indicate that Canadian hog prices relative to U.S. hog prices were greater than would be suggested by the rate of currency exchange. Thus, for an extended period of time there was an adjustment lag of prices to exchange rates between the two countries.

2.3.2.2 Relative Supply

As suggested by Boswell (1976), a smaller supply of pork in Canada relative to the United States during the period may have caused the price differences and hence influenced pork trade volume. Traditionally, pork

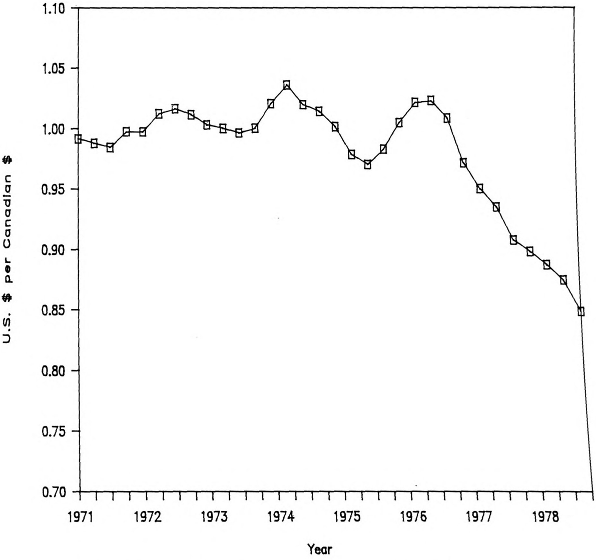


Figure 5. Quarterly U.S.-Canadian Exchange Rate, 1971-78

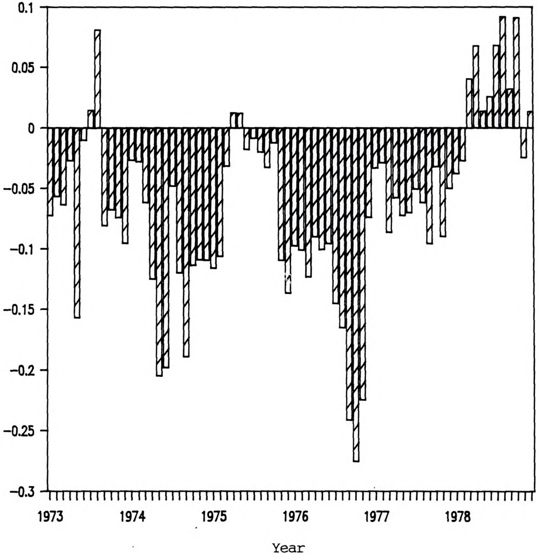


Figure 6. Deviations from PPP, Seven U.S. Markets vs. Toronto 100 Index Price, 1973-78

production in the two countries has followed similar trends or cycles. However, from 1971 through 1977, differences in production patterns or hog production cycles did occur.

From 1971 through 1975 production patterns in the two countries were similar (Figure 7, Figure 8). Production declines were in response to low prices during 1970 and 1971. The low prices had resulted from high pork supply levels during this same period.[4]

After 1975, production patterns of the two countries diverged. Canadian production fell sharply in 1975 and remained relatively constant in 1976 and 1977. Conversely, U.S. production also decreased sharply in 1975. But unlike Canada, United States production recovered by 12 percent in 1976 and 1977. In those two years, U.S. pork exports to Canada increased by over 100 percent, suggesting a correlation between relative production levels and trade volume.

Boswell (1975) suggested that the two major determinants of pork production are hog prices and feed costs. He further suggested that hog to feed price ratios may have caused the divergence in the two hog production cycles.

Following large Soviet Union grain purchases in early 1973, North American feed grain prices increased dramatically during much of 1973 and 1974. The large increase in feed grain costs, representing the largest share of variable production costs, encouraged breeding herd liquidation and discouraged future production plans in both countries.[5]

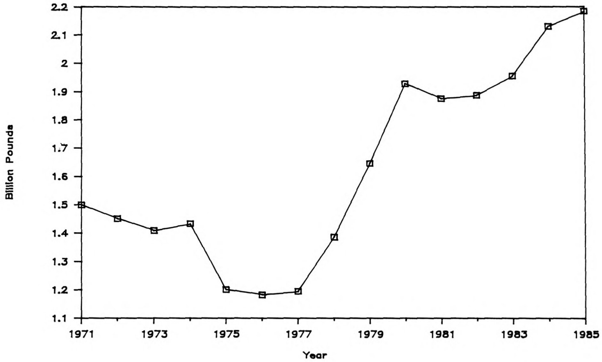


Figure 7. Canadian Pork Production, 1971-85

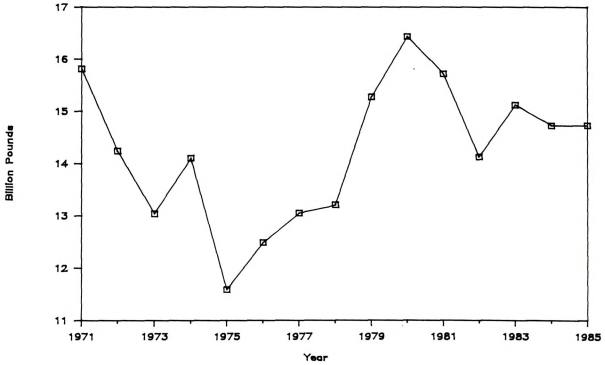


Figure 8. U.S. Pork Production, 1971-85

As a result, U.S. breeding herd inventory declined 20 percent and the Canadian inventory declined 16 percent in 1974. Most of Canada's herd reduction occurred in Western Provinces.

The higher feed grain costs discouraged production in Western Canada (Alberta, Manitoba, Saskatchewan and British Columbia) for a longer period than in the U.S. or Eastern Canada (Quebec,Ontario and Atlantic Provinces). Western Canada hog slaughter is graphed in Figure 9 and indicates a 36 percent decline. After dipping in 1974, Eastern Canada hog production actually increased in the following years. As a result, Western Canada's share of total Canadian commercial hog slaughter declined from 42.2 percent in 1974 to 32.2 percent in 1976 (Table 6).

Contraction of Western Canada production occurred for a longer period, because the region is a major grain producing region. Increased opportunity costs of feeding grain to hogs encouraged herd liquidation. Moreover, this region had a larger percentage of production occurring on farms where hog enterprises were secondary to grain enterprises. When grain prices increased these producers reduced breeding herds or eliminated hog enterprises altogether, contributing to the protracted contraction.

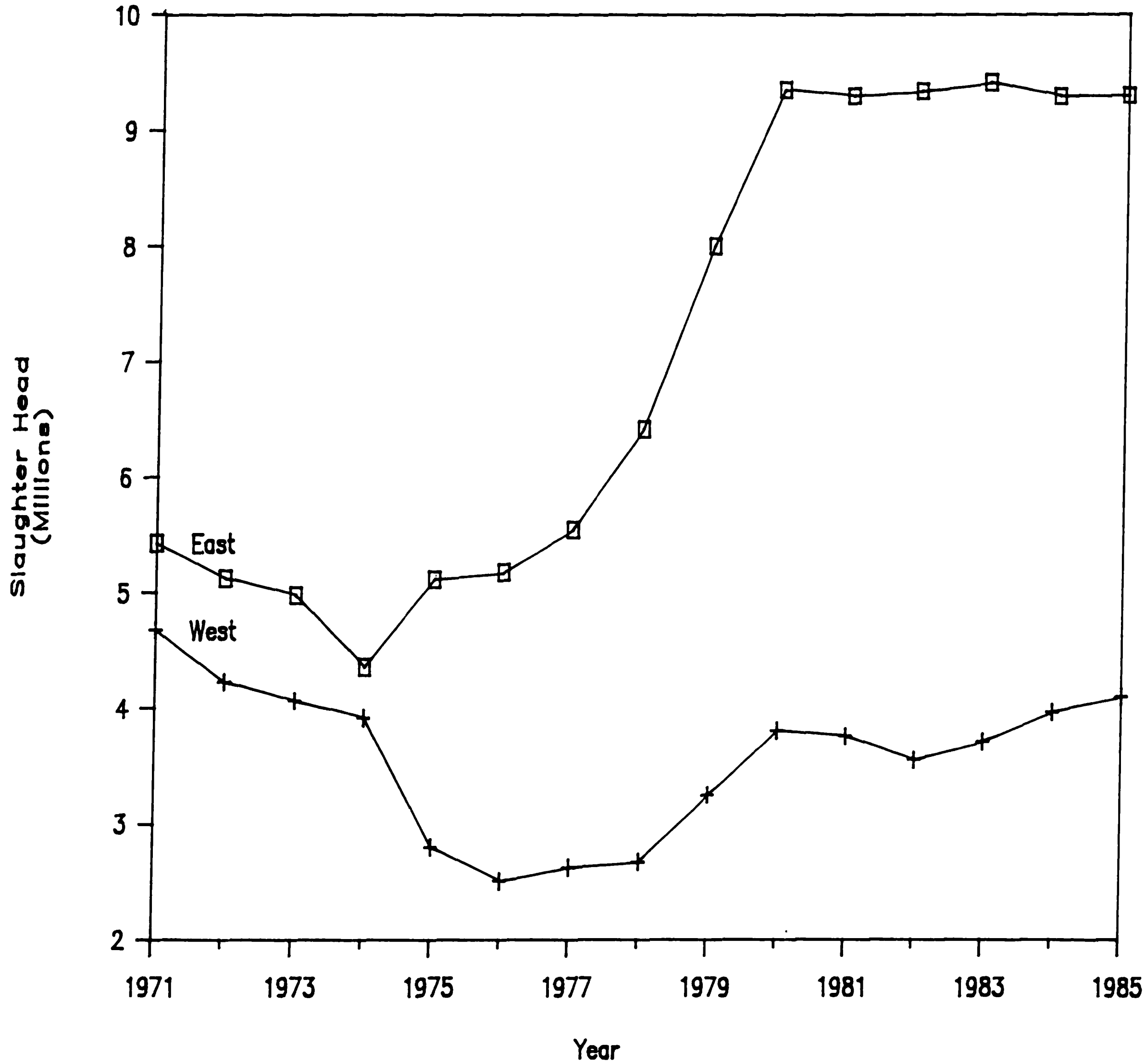


Figure 9. Canadian Regional Commercial Hog Slaughter, 1971-85

Table 6. Canadian Hog Production by Location, 1971-85

Year	Quebec	Ontario	Eastern Canada	Western Canada
	--- Percent of Total Production---			
1971	31.0	19.1	53.7	46.3
1972	31.3	20.1	54.8	45.2
1973	30.4	21.2	55.1	44.9
1974	29.9	24.6	57.8	42.2
1975	31.5	29.4	64.6	35.4
1976	33.2	30.4	67.4	32.6
1977	32.2	31.9	67.8	32.2
1978	33.3	33.5	70.5	29.5
1979	34.0	33.6	71.1	28.9
1980	35.6	31.9	71.1	28.9
1981	36.2	31.1	71.2	28.8
1982	35.7	32.6	72.4	27.6
1983	34.3	33.1	71.7	28.3
1984	35.0	30.5	70.1	29.9
1985	34.0	29.6	68.2	31.8

Note: Eastern Canada includes the Alantic Provinces, Ontario, and Quebec. Western Provinces include: British Columbia, Alberta, Saskatchewan, and Manitoba.
Production is defined as commercial hog slaughter.
Source: Agriculture Canada, Livestock Market Review.

2.3.2.3 Increased Export Demand

U.S.-Canada pork trade volume is somewhat dependent on the export volume with other countries. Boswell (1976) suggested that increased Japanese demand from 1975-1977 had influenced price differences between the two countries.

The Japanese market for pork (mostly fresh and frozen classifications) has traditionally been either the largest export market or second largest export market for both countries.[6] From 1975 through 1977, Japanese demand for pork imports increased and exports from the United States and Canada expanded to fill the demand. Increased Canadian exports occurred despite a large drop in Canadian production during the period (Figure 10). Thus, with higher Japanese exports (representing over six percent of 1977 production) available domestic pork supplies diminished--pressuring domestic prices.

2.4 Trade From 1978 to 1985

2.4.1 Trade History

The United States' position as a net exporter of pork to Canada began to change in 1977 (Figure 1). Annual U.S. exports to Canada declined steadily from their 1977 peak of 199 million pounds to only 14 million pounds in 1985 (Table 2, Figure 3). Conversely, Canadian pork exports to the U.S. increased from a mere 30 million pounds in 1977 to 571 million pounds in 1985, an increase of 1800 percent in just seven years (Table 3, Figure 3). This was an unprecedented shift in pork trade between the two nations.

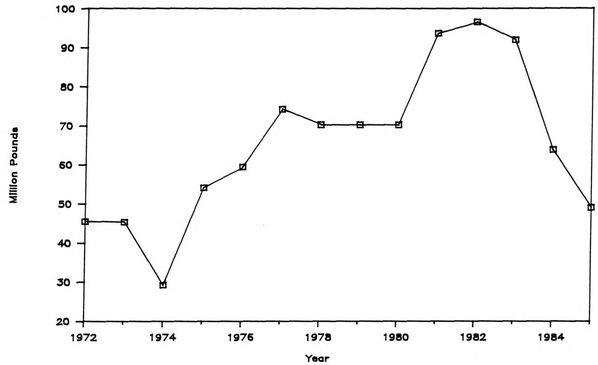


Figure 10. Canadian Pork Exports to Japan, 1972-85

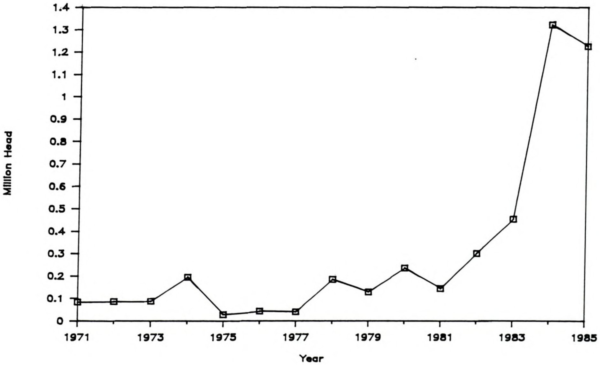


Figure 11. Canadian Hog Exports to the U.S., 1971-85

Much of the increase in Canadian pork exports resulted from expanding hog exports (Figure 11). From 1977 to 1984, annual exports increased from 41,238 head to 1,322,015 head, an increase of over 3100 percent. Table 7 indicates that much of the increase occurred from 1983 to 1984, when hog export volume increased by 866,752 head.

The rapidly expanding U.S. market and its importance to the Canadian pork industry can be seen in Table 4. By 1985, pork exports to the U.S. accounted for over 26 percent of 1985 Canadian pork production. This compares with only 2.5 percent of production in 1977. For the larger United States pork market, Canadian imports as a percentage of consumption increased from only 0.2 percent in 1977 to 3.5 percent in 1985. For comparison, U.S. pork imports as a percent of Canadian consumption decreased from 15.4 percent in 1977 to only 0.9 percent in 1985.

2.4.2 Market Conditions

Expanding Canadian pork exports began to garner attention in the United States by 1983. U.S. pork producers seeing Canadian trucks unloading hogs at U.S. slaughter plants blamed the rapidly expanding imports for the low hog prices they were experiencing. The expanding imports became increasingly controversial. A number of hypotheses were presented in the literature to explain the rapid expansion in Canadian exports and low hog prices.

Table 7. Hog Slaughter and Trade, 1971-85

Year	Commercial Hog Slaughter United States	Commercial Hog Slaughter Canada	Live hog Exports From Canada to the U.S.
	--- 1,000 Head ---		
1971	94,437.9	11,351.8	83,668
1972	84,707.1	10,977.3	87,445
1973	76,795.0	10,656.7	88,324
1974	81,761.9	10,700.1	195,727
1975	68,686.8	9,164.4	29,352
1976	73,783.9	8,969.2	43,915
1977	77,303.0	9,076.8	41,238
1978	77,315.2	9,939.5	185,627
1979	89,099.1	12,000.8	129,643
1980	96,074.1	13,977.5	235,931
1981	91,575.0	13,681.8	144,083
1982	82,189.7	13,448.5	302,814
1983	87,584.3	13,687.8	455,263
1984	85,168.0	13,850.7	1,322,015
1985	84,469.0	14,430.6	1,225,131

Source: USDA, Livestock and Meat Statistics,1983, USDA, Livestock and Poultry Situation and Outlook Report. Agriculture Canada, Livestock Market Review.

Differences in relative supply and demand conditions between the two countries and the depreciation of the Canadian dollar are frequently cited as reasons for the increase in Canadian exports. Expansion of the Canadian pork industry and its divergence from U.S. production trends received the most attention in the literature. Lags in price changes to exchange rate adjustment received little attention.

This section begins by discussing price trends and is followed by a literature review of explanations for terms of trade changes. The chapter concludes by discussing the influence of the pork processing industry on the trading system.

2.4.2.1 Terms of Trade

After closely following U.S. hog prices from 1977 to 1981, Canadian hog prices began to diverge again in 1982. Price differences widened substantially into 1985, providing Canadian producers with more favorable terms of trade. This price difference trend is graphed in Figure 4 and Figure 12 and coincides with the 1982 rise in Canadian pork exports.

To illustrate the magnitude of the price difference between the two markets consider the following example. In January 1985 the average dressed hog price at Toronto was $72.65/cwt. Canadian and $63.70/cwt. at seven central U.S. markets. Converting the U.S. price to a Canadian dollar price by the average monthly exchange rate of 1.3239, yields a price of $84.33/cwt. Therefore, by selling Canadian hogs

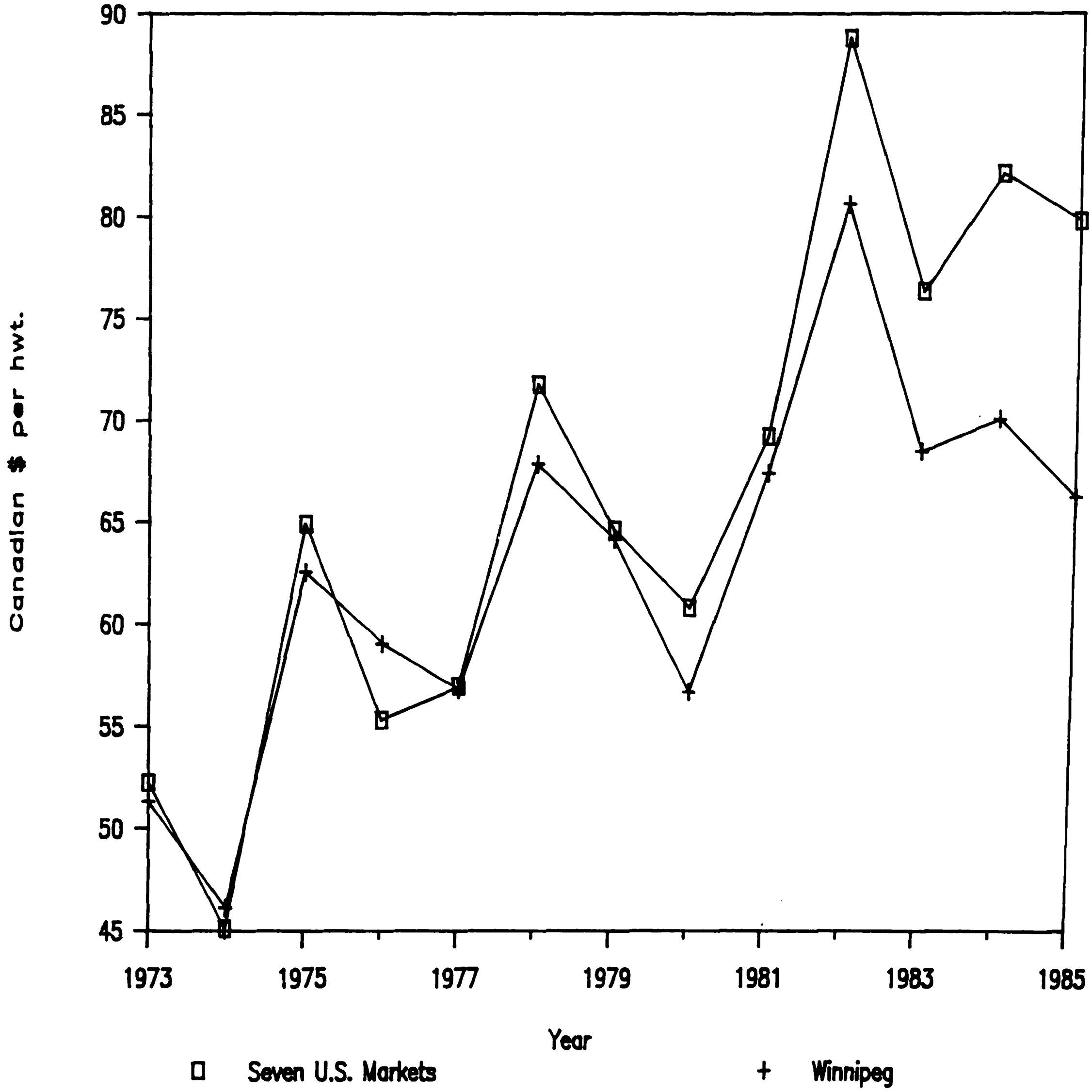


Figure 12. Annual Dressed Hog Prices at Winnipeg and at Seven U.S. Markets, 1973-85

in U.S. markets, sellers would average nearly $12 more per hundred weight (excluding transportation costs) than if the hogs were sold in Canada.

This price difference is significant since transportation costs represent only a small portion of the difference. For example, transportation costs average only $0.22/cwt per 100 miles in the U.S.[7] Consequently, since 1982 Canadian export prices exceeded domestic prices by a substantial margin.

2.4.2.2 Dollar Depreciation

Several authors, including Gilson, Goodloe, Lanoie, Owen (1984b), and Gilmour have cited exchange rates as a possible cause for the large growth of Canadian exports to the U.S. since 1977. These authors mention exchange rate adjustment as a possible factor, but do not present any analysis.

From 1977 to 1985 the Canadian dollar depreciated approximately 25 percent relative to the U.S. dollar (Figure 5, Figure 13). The depreciation was particularly steep from the third quarter of 1983 through the second quarter of 1985--a period when Canadian hog and dressed pork exports to the United States rose dramatically.

Appreciation of the United States dollar relative to the Canadian dollar is discussed in the analysis presented by the International Trade Commission (ITC) for the 1984 countervailing duty case on Canadian live hog and pork imports.[8] Their analysis concluded that an appreciating

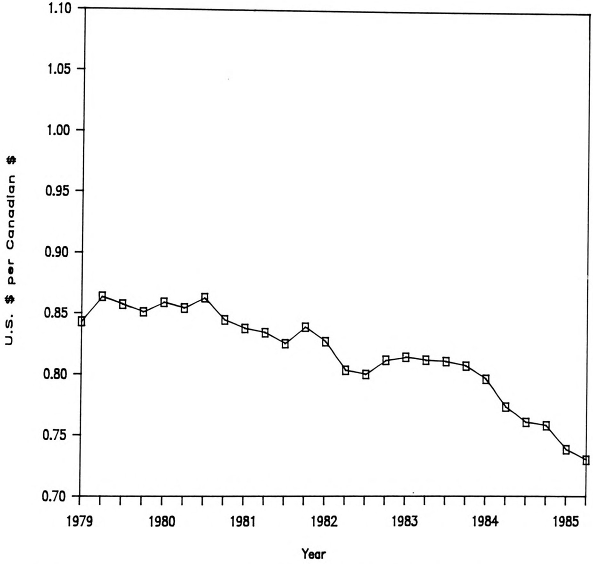


Figure 13. Quarterly U.S.-Canadian Exchange Rate, 1979-85

U.S. dollar had not provided Canadian producers with a comparative advantage in pork production and hence had not contributed to the rise in Canadian exports.

International Trade Commission findings were based on real exchange rate trends from 1980 to 1984. Real exchange rates were calculated by adjusting nominal exchange rates by the ratio of inflation rates (consumer prices indexes were used by the ITC) in the two countries. During the early 1980s, real exchange rates were relatively constant, with the Canadian dollar actually appreciating slightly for a brief period.

In ITC testimony, Martin (1985a) suggested that nominal exchange rates instead of real exchange rates are relevant for analysis. Using nominal exchange rates, he concluded that Canadian dollar depreciation had provided Canadian producers with higher prices in U.S. markets.

Martin justified his argument by estimating two simple regressions. Both pork exports (including the pork equivalent of hogs) and hog exports were regressed on average monthly exchange rates from 1980 through 1984. Martin concluded that t-statistics of 4.69 for exchange rates in the pork regression and 12.79 for exchange rates in the hog regression supported his hypothesis. Furthermore, he concluded that F-statistics of 22.0 and 163.5 for the two regressions, coefficients of determinations (R^2) of 0.32

and 0.78, and correlation coefficients of 0.57 for pork with exchange rates and 0.88 for hogs with exchange rates supported his hypothesis.

Although not used by other authors, a better method for understanding the relationship between price and exchange adjustment and export volume is found in purchasing power parity (PPP) theory. PPP theory provides a more relevant measure of the relative prices affecting pork producers' and exporters' decision sets. This is accomplished by using deviations from PPP in the empirical work. Deviations from PPP occur when the ratios of hog/pork prices and exchange rates between the two countries are not in equilibrium.

Figure 14 provides a trend of deviations from absolute PPP for monthly average dressed hog prices at Toronto and at seven central U.S. markets from 1979 through March 1985. The figure indicates that deviations were erratic in the first three years, but were consistently positive after 1981. A positive deviation means that U.S. prices, when adjusted for exchange rates, are higher than Canadian prices. During this period, positive deviations trended up until peaking in 1984 and early 1985. This same period experienced rapid growth in Canadian pork production and exports to the U.S. (Figure 3, Figure 7).

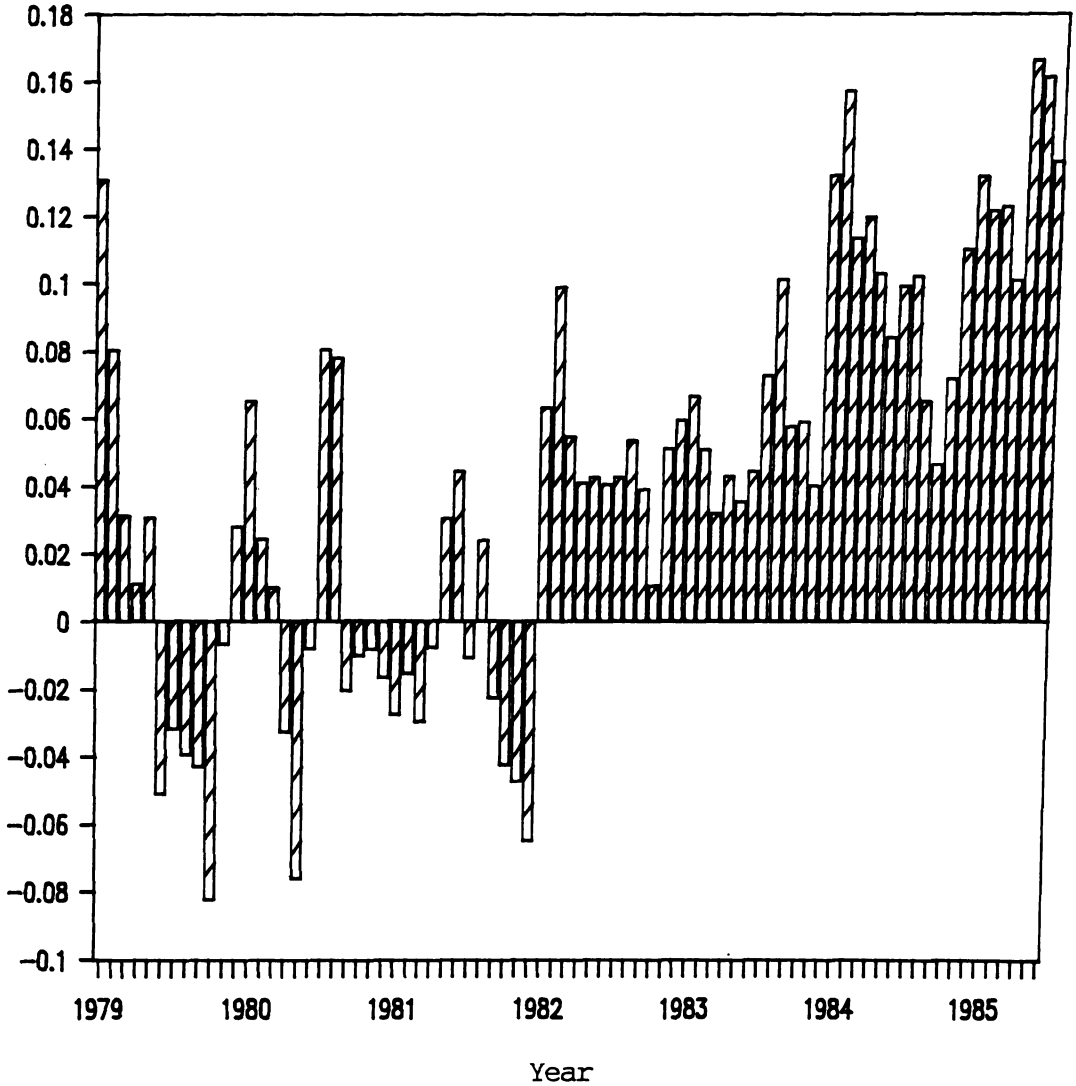


Figure 14. Deviations from PPP, Seven U.S. Markets vs. Toronto 100 Index Price, 1979-85

2.4.2.3 Demand Shift

There is a general consensus in the literature that there has been a downward shift in the demand curve for North American pork during the last decade.[9] But few suggest that this decline has influenced pork trade between the two countries.

Since 1980, per capita pork consumption trends for both countries are similar (Figure 15). Although consumption trends are similar, they do vary. For example, annual per capital consumption decreased 2.5 percent in Canada from 1983 to 1984. Yet, United States per capita consumption decreased by only 0.8 percent.

Martin (1985a), suggests that per capita consumption is not the appropriate measure of consumer demand for pork. He reasoned that consumption statistics are merely a reflection of predetermined supply. He further argues that since storage constraints limit pork supply, current production is either consumed or shipped to other consuming regions. Trends in per capita pork consumption (Figure 15) and pork production (Figure 7, Figure 8) tend to support his argument because they demonstrate a strong correlation.

An alternative measure of demand suggested by Martin is the statistic: real per capita pork expenditures. This statistic is a product of per capita consumption and the deflated retail price of pork. It measures the expenditure

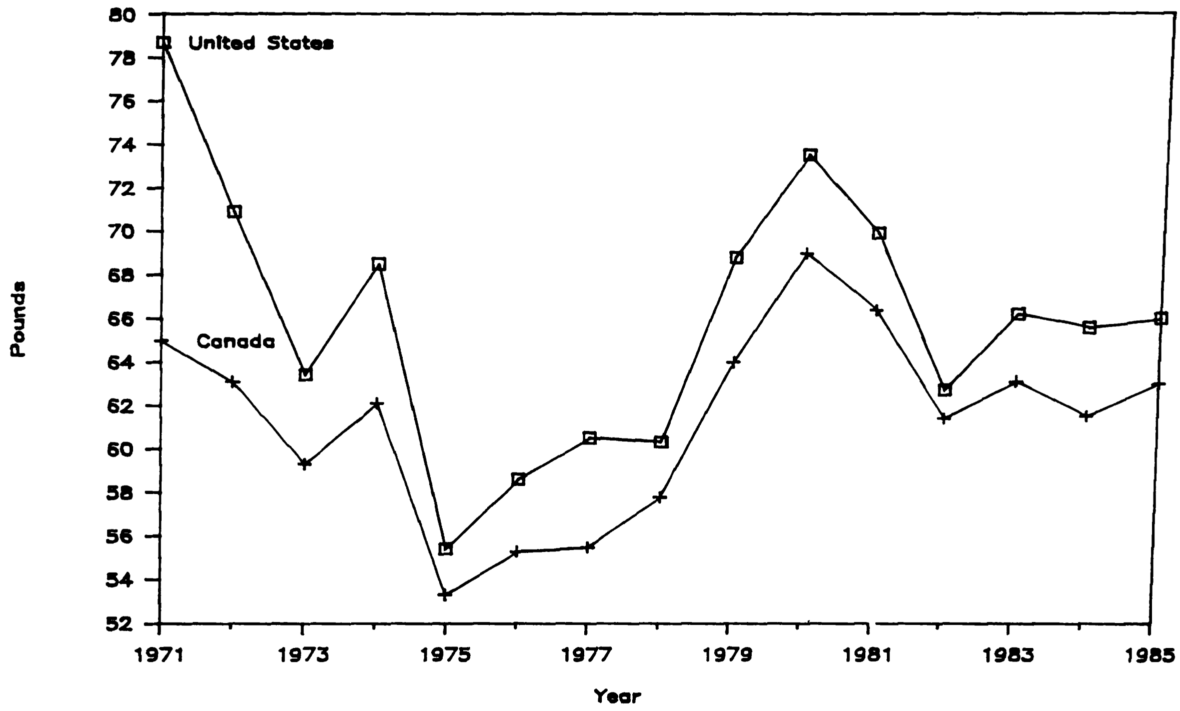


Figure 15. U.S.-Canada Per Capita Pork Consumption, 1971-85

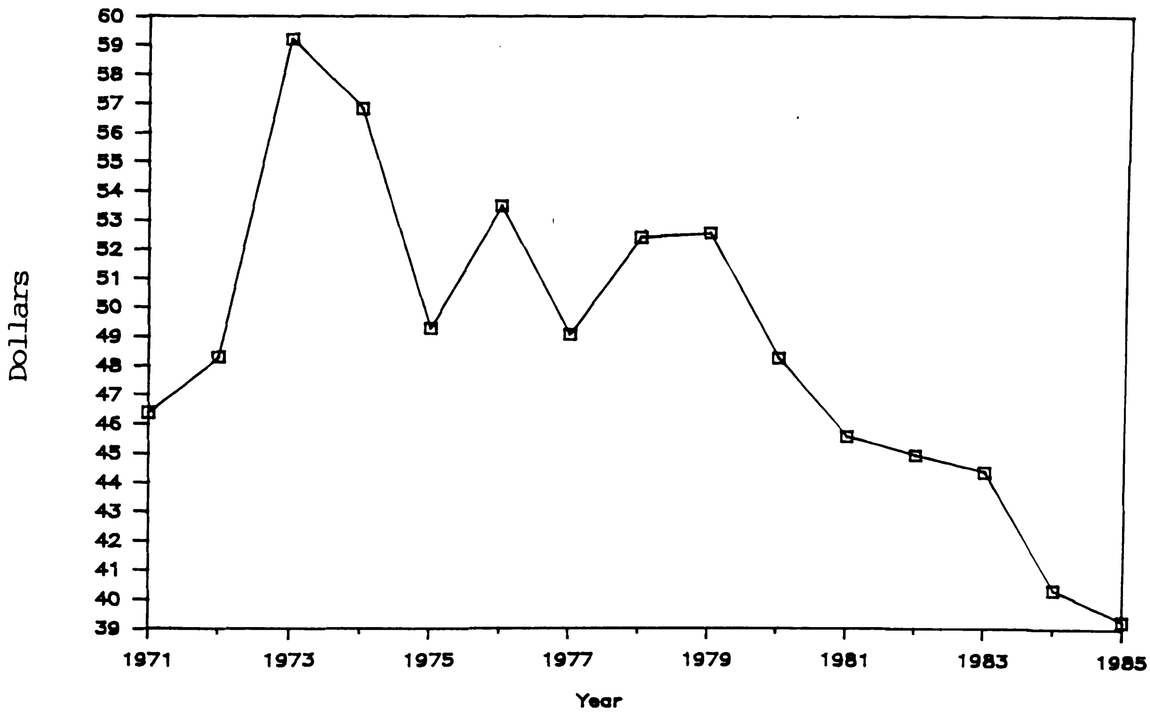


Figure 16. U.S. Real Per Capita Pork Expenditures, 1971-85

amount in constant dollars which consumers are willing to spend on pork consumption. A decrease in expenditures is hypothesized to indicate a downward shift in demand.

After increasing during the 1960s, real per capita pork expenditures in the United States began to decline in 1973 (Figure 16). By 1985, real expenditures had declined by some 35 percent, suggesting that consumer demand for pork was decreasing during the period.

A potential deficiency with this measure is that deflated prices may have declined due to efficiencies gained through technical production and marketing improvements, and lower production costs. Indeed, technical improvements in the pork industry have been substantial. Therefore, real expenditures will decrease for any reasonable demand curve.

An example of this deficiency can be found when it is applied to the demand for poultry. During the same period, U.S. real per capita expenditures for poultry diminished by over 23 percent, leading one to conclude that the demand for poultry had decreased. This sharply contrasts with per capita consumption figures, which increased by 31 percent.

Real price indexes for pork, poultry, and beef are presented in Table 8 for the United States and Canada. Real price indexes of all three meats have decreased in both countries since the late 1970s. Notice that the U.S. real price index for poultry declined more than pork, but pork declined relative to beef. In Canada, a similar relationship between beef and pork indexes exists, except

Table 8. Deflated Retail Meat Price Indexes

	Beef/Veal		Pork		Poultry	
Year	U.S.	Canada	U.S.	Canada	U.S.	Canada
			-- 1971 Dollars --			
1973	100.0	100.0	100.0	100.0	100.0	100.0
1974	92.7	99.4	89.7	91.6	85.5	102.3
1975	85.7	85.1	100.5	105.8	86.6	100.3
1976	78.4	74.0	96.3	102.6	78.5	96.2
1977	73.2	73.0	85.6	93.0	74.2	89.4
1978	83.6	97.9	89.8	106.2	76.1	94.4
1979	95.6	118.0	81.9	91.8	71.8	97.9
1980	89.0	116.3	69.7	82.7	66.5	92.8
1981	81.3	106.0	69.1	84.5	62.7	95.9
1982	77.7	95.1	73.5	88.8	58.0	90.4
1983	74.2	92.1	70.6	83.2	56.9	88.3
1984	72.0	92.6	66.8	79.6	60.4	89.9
1985	68.5	91.2	65.1	78.3	58.1	85.2

Note: Indexes are expressed in each countries currencies.
Sources: Statistics Canada, Consumer Prices and Price Indexes. USDA, Livestock and Poultry: Situation and Outlook Report.

the magnitude of difference is greater. Moreover, the poultry price index did not decline as much as the U.S. index. Differences in the changes of U.S. and Canadian price indexes can be partially explained by Canadian government regulations on poultry productions and by import restrictions on U.S. poultry imports.

In conclusion, whatever statistical measure used, it does seem likely that consumer demand for pork declined in both countries. Whether any decline affected trade volume in North America is not well documented.

2.4.2.4 Relative Supply Conditions

Gilmour, Gilson, and Lanoie suggest that production cycle differences during recent years might explain pork price divergence and trade volume shifts between the two countries. They theorize that higher Canadian production caused supplies to exceed the amount demanded by consumers, lowering the equilibrium price relative to the U.S. price.

Differences in the two countries hog production cycles are seen in Figure 7 and Figure 8. Notice that production increased from 1977 through 1980 in both countries, but at differing rates. In Canada, production increased 61 percent, while U.S. production increased by less than 26 percent.

Expanding Canadian production continued into the 1980s, while U.S. production receded after peaking in 1980. In the next two years, U.S. production dipped by 14 percent and then leveled-off at approximately 90 percent of the peak.

Instead of following the U.S. production cycle, Canadian production dipped slightly in 1981 before trending upward again. By 1985, Canadian production was over 13 percent higher than the previous peak in 1980. Obviously, production patterns of the two countries had diverged.

As in the past, expanding Canadian production had a regional dimension. Much of the expansion from 1977 to 1980 occurred in the Eastern Provinces of Ontario and Quebec (Figure 9). After 1980, nearly all of the increase was experienced in the Western Provinces (Table 6).

When examining the entire period from mid-1976 to 1985, Canadian production increased almost continuously by nearly 85 percent, while U.S. production increased erratically by less than 27 percent. The relevant question now becomes why did Canadian production, which had traditionally followed U.S. production cycles, diverge so much in the 1980s?

2.4.2.5 Canadian Production

A number of explanations have been given for the increase in Canadian pork production since 1977. Some explanations have a national scope, others are limited to a particular geographical region. The following is a brief outline of these explanations.

Stabilization Programs

Numerous federal and provincial programs designed to stabilize producer income in Canada have been cited for expanding hog production and increasing exports to the U.S. These stabilization programs were the focus of the joint

investigation by the United States International Trade Commission (ITC) and the International Trade Administration (ITA) on government subsidization of the Canadian pork industry.

The purpose of the investigation was two fold. First, the investigation was to determine whether the Canadian government was subsidizing hog production and the pork processing industry. And second, it was to determine if material injury to U.S. producers, packers, and processors may have resulted from any subsidization.

In their final determinations, the ITC and ITA reached two major decisions. First, they ruled that Canada was subsidizing hog production and that material injury to U.S. producers had resulted. On July 31, 1985 a permanent countervailing duty was levied on live hog imports at a rate of $0.04386 (Canadian) per live weight pound. Subsidization levels were determined by examining all available government programs which fit their definition of a subsidy. By adding dollar amounts dispersed to producers under these programs and then dividing by the pounds produced under the programs, a per pound subsidy amount was calculated.

In the second major decision, the ITC and ITA found insufficient evidence that material injury to packers and processors was occurring. Therefore, no countervailing duty was levied on Canadian pork imports. The two rulings are somewhat inconsistent, with political factors likely being the best explanation for the conflicting rulings.

Federal programs which received the most scrutiny by the ITC and ITA were programs developed under the Agricultural Stabilization Act of 1958 (ASA). Amended in 1975, the ASA provides price support to Canadian pork producers. The ASA guarantees producers 90 percent of the previous five years average hog price, adjusted for by an index of input prices. Under the program, producer payments are made at year end and only if the annual average price falls below the support price.

In an attempt to halt the U.S. countervailing investigation, the support level was increased to 95 percent, but with producer payments limited to the portion of production used for domestic consumption. No federal payments were made in the Canadian fiscal year of 1984-85.[10]

In addition to the federal programs, a number of provincial government stabilization programs available to Canadian pork producers were reviewed.[11] Many of these programs were initiated after the 1975 amendment to the ASA, which permitted provincial "top loading" of the federal program. Provincial programs function as companions to the federal programs by providing additional benefits to producers on top of existing federal program benefits.[12] Provincial payments are subtracted from any federal payments made to producers.

A range of other programs, mostly provincial, were also reviewed. Other types of programs examined include: credit subsidization, feed transportation assistance, and production cost covering guarantees.

The ITC and ITA determination that all these programs constituted a subsidization was controversial. Gilmour suggested that the programs had only a marginal influence on pork supply response and trade volume. Gilmour supported his argument by constructing a model of the North American pork sector to simulate three different stabilization scenarios.

In his analysis, simulations were conducted on supply response, production expectations, and an upper limit effect of Canadian subsidization on the welfare of U.S. pork producers. He concluded that the impact of the stabilization programs on Canadian supply, export volume, and U.S. producer welfare was minimal.

Gilmour, Gilson, and others suggest that these programs had only a minimal impact on producer supply response. They provide four major reasons to support their conclusion. First, the programs are designed to reduce risk and not provide for profitability, ie. marginal costs still exceed marginal revenue. Second, many of these stabilization programs were available before expansion in the industry began and did not increase production. Third, producer payments are usually insignificant and hence have little influence on producers' production decisions. Finally,

since federal payments are made at year end, without advanced knowledge of actual payment amounts, producers' supply decisions are not significantly influenced.

Feed Costs and Stocks

Gilmour and Martin (1985b) suggest that lower Canadian corn and feed grain prices may have encouraged the expansion of Canadian hog production. Canadian feed prices declined due to world grain surpluses and scientific advancements. During the last 15 years, these scientific advancements boosted yields and expanded suitable corn acreage. Canadian corn production, which occurs primarily in Ontario, increased some 300 percent in the last decade. Increased productive capacity has lowered feed prices by reducing transportation costs from the U.S.

In Western Canada, higher on farm grain stocks from 1977 through 1980 (August 1st grain stocks increased from 3 million to nearly 13 million metric tons) may have encouraged herd expansion and hog production in the late 1970s and early 1980s. The influence of prairie grain stocks on Western Canada hog production may be indirectly dependent on policies of the Canadian Wheat Board.

When grain stocks are large, the Wheat Board limits the amount of grain a farmer can sell by establishing delivery quotas. The delivery quotas, however, do not limit grain production. But production above the quota can only be used as feed or sold as feed to other farmers. Therefore, when

surplus grain supplies occur and delivery quotas are in place, the only major option to storing excess production is to feed the grain to livestock, such as hogs.

Supply Management Policies

Provincial supply management boards, established in the 1970s, placed production quotas on commodities such as poultry, eggs, and manufacturing grades of milk. These supply management quotas have been suggested as contributing in several ways to expanding Canadian pork production, especially in Provincial Quebec.

First, the quotas limit new farm enterprise options available to farmers who want to expand. Owen (1984) cites the lack of production alternatives, especially in the livestock sector, as the most important factor in the expansion of Quebec hog production. Quebec is the largest hog producing province in Canada, accounting for over 35 percent of 1984 production.

Second, Martin (1985b) suggests that some Canadian farmers speculated that production quotas for hog production would be adopted. Anticipating this, some producers expanded herd sizes and increased capital investments in order to build production histories. Furthermore, he suggests that large profits resulting from supply managed commodities may have funneled into unrestricted hog production.

A third influencing factor of these supply management quotas was the capping of feed demand. In Quebec, where an extensive commercial feed milling industry exists, many feed companies encouraged hog production to augment sagging feed sales. Production was encouraged through contract feeding and through vertical integration. Owen states that 75 to 80 percent of all hog production in Quebec is now under some form of contractual arrangement or vertical integration.

Hoof and Mouth Disease

An outbreak of Hoof and Mouth disease in Denmark in March 1982 was suggested by Gilmour as both encouraging Canadian production and lowering Canadian pork exports. After the outbreak, Japan suspended pork imports from Denmark, its leading supplier. Although the suspension lasted only until September 1, 1983, many Canadian producers anticipated a longer suspension. They responded by expanding production schedules to meet expected export demand increases. However, increased Japanese demand never materialized and Canadian exports to Japan remained flat in 1982 and 1983.

After Japan lifted the Danish pork ban, Canadian exports to Japan fell over 30 percent in 1984, to under 64 million pounds. The decline occurred despite nearly ten years of increasing export volume and three consecutive years of export volume exceeding 92 million pounds. Severe

price competition from Danish exporters who used export subsidies to regain market share explains much of the decline.

To summarize, the affect of the disease outbreak on U.S. and Canadian markets was two fold. First, Canadian production was encouraged to fill a market which never materialized. Second, heightened competition from Denmark reduced existing Canadian export volume. Lanoie suggests that these two factors probably stimulated exports to the United States.

2.4.3 Canadian Meat Packing

Several events and trends associated with the meat packing and processing industries in Canada and the United States have been cited as factors influencing increases in hog and dressed pork trade volume. The following is a list of these important events and trends.

2.4.3.1 Competitiveness

The competitive position of the Canadian pork packing and processing industries have been suggested by Lanoie as a possible explanation for the large increase in Canadian hog exports. Lanoie argues that Canadian plants are not competitive with U.S. plants due to higher input costs and lower productivity.

Export data on hogs and pork support his argument. From 1981 through 1984, annual Canadian hog exports to the U.S. increased by 818 percent, while dressed pork exports

increased by only 80 percent. This trend resulted in a larger percentage of pork exports (including the dressed pork equivalent of hogs) coming from hog exports (Table 7).

Lanoie further points out that similar occurrences were happening in beef trade between the two countries. During the same period, beef exports to the U.S. increased 42 percent, while exports of slaughter cattle grew 232 percent. Thus, he concludes that U.S. packers increasingly preferred to purchase Canadian meat on the hoof rather than as dressed meat products.

Labor costs are suggested by Lanoie as the most likely reason for differences in competitiveness. During a period when American packers and processors were obtaining wage freezes or reductions, labor costs in Canadian plants were on the rise. Industry-wide labor contracts in 1982 increased nominal wages by 11 percent and placed average Canadian wages at 110 and 112 percent of American wages in 1983 and 1984. With the exception of 1976, this was the first time this had occurred.

Recognizing that international comparisons of productivity levels are often complex, Lanoie provides labor productivity indexes for the two countries. He concludes that industry productivity was lower in Canada relative to the U.S. Reasons for the lower productivity range from plant obsolescence, to slow introduction of new production technologies, to plant location.

Lanoie also cites economies of scale favoring U.S. packing-processing industries. U.S. plants are generally larger and closer to higher concentrations of hog production and consumers than are most Canadian plants.

The above discussion does suggest why a larger percentage of pork (including the dressed weight of hogs) was being exported as hogs, but it does not explain why Canadian pork exports expanded.

2.4.3.2 Labor Strikes

A short-term explanation for the dramatic 1984 increase in hog exports is cited by Gilmour, Gilson, and Lanoie. They suggest that labor strikes at large Canadian meat packing-processing plants in the third quarter of 1984 encouraged hog exports to the United States for processing. If this was a significant factor in the 190 percent increase in hog exports that year, then settlement of the strike would lower exports. Monthly export figures show no significant export increase during the strike or drop after the strike, indicating a strong demand for hogs by U.S. packing plants was occurring for other reasons.

2.4.3.3 Leaner Pork

Leaner and more desirable Canadian dressed pork and hogs has been cited by Gilson and Gilmour as contributing to the increase of Canadian export volume to the U.S. Consumer preference for leaner meat products in the U.S. is well

documented by Cornell, but documentation of Canada's ability to supply leaner dressed pork or hogs is less certain.

2.4.3.4 Quebec Pork Industry

The proximity of Quebec hog production and packing-processing plants to major Eastern U.S. markets may have contributed to the increases in Canadian exports. Proximity to major East Coast markets provides Quebec with a transportation advantage over the major U.S. hog producing regions of the Middle West. Moreover, Quebec packers and processors are considered better able to meet specific needs of this market by supplying it with higher quality hams and table cuts.

Quebec is the largest hog producing region in Canada and is the major provincial supplier of dressed pork to the United States. Quebec dressed pork exports to the U.S. increased from just 28.6 million pounds in 1978 to 138 million pounds in 1982. It represented nearly 57 percent of all Canadian dressed pork exports to the U.S. in that year. The majority of these exports go to U.S. markets along the East Coast.

2.4.4 Summary

This chapter has outlined two periods in U.S.-Canada pork trade and market conditions. These two periods are associated with different trends in pork trade between the two countries. From 1971 to 1977, United States exports to Canada increased with the U.S. becoming a net pork exporter. From 1977 to 1985, Canadian exports increased

sharply as Canada became a net exporter of pork to the U.S. These two major shifts in U.S.-Canada pork trade volume are correlated with periods of differing hog prices and supply and demand conditions between the two countries, and with a fluctuating exchange rate.

FOOTNOTES

1. Pork, dressed pork, and the dressed pork equivalent of hogs are all expressed on a dressed carcass weight basis.

2. Details on the countervailing duty case are provided in section 2.4.2.

3. The concept of PPP is discussed in detail in Chapter 3. Briefly, for an individual homogeneous commodity, the theorem states that the ratio of prices in each country should be in equilibrium with the exchange rate ratio between the two countries (assuming adjustments for transfer costs are accounted for). Arbitrage moves prices continually towards PPP, but absolute equilibrium is never fully realized because of the dynamic relationship of the system. When the relationship does not hold or when arbitrage fails to bring prices and exchange rates toward equilibrium, deviations from PPP occur.

4. Theoretical explanation for the cyclic relationship between price and quantity through time when production is predetermined is provided in the Cobweb Model. For a complete explanation, see Tomek 1981, p. 182.

5. Here variable production costs are defined to exclude feeder pigs costs.

6. Hay (1984) provides a complete discussion of the Japanese export market.

7. Figure reported by the United States Department of Agriculture in Livestock and Poultry Outlook and Situation Report. October, 1985.

8. United States International Trade Commission. "Live Swine and Pork From Canada." Investigation No.701-TA-224, Preliminary. Washington, D.C., December 1984.

9. Cornell (1986) provides a good review of changes in U.S. meat demand, p. 17-38.

10. The Canadian fiscal year is from April 1 to March 31.

11. International Trade Commission (1984) and (1985) provide an outline of the numerous federal and provincial programs available to Canadian pork producers.

12. Goodloe (1985), Gilson (1985), and Gilmour (1986) provide analysis of the stabilization programs and the countervailing duty process. A complete review of Canadian government agricultural policy, market interventions and regulations can be found in Forbes (1982). A discussion of the red meat sector can be found on pages 89-98.

Chapter 3

Theoretical Framework

3.1 Introduction

An econometric model of the North American pork market is specified for estimation to quantify the influence of lags in the adjustment of prices to exchange rate fluctuations on the market. The theoretical framework for the model is based on two types of equilibrium models: spatial price equilibrium models and supply and demand trade models. Concepts borrowed from these two models include the geographical relationship of markets, a method to incorporate a storage demand component into the model, and a method to relate equations in order to determine trade flows.

This chapter begins by reviewing these two types of theoretical models and proceeds by examining relevant aspects of purchasing power parity theory. The chapter concludes by discussing the theoretical framework used to construct the paper's econometric model.

3.2 Conceptual Framework

3.2.1 Spatial Price Equilibrium Models

Spatial price equilibrium models are frequently selected to analyze geographical price relations and trading patterns in a multi-region trading system. These models

permit the estimation of net equilibrium commodity prices in each geographical region and the quantity traded between regions, provided ridge assumptions are made.

These models function by determining each region's supply and demand schedules and the transfer costs between regions. Each region's individual supply and demand schedules are then mathematically summed to determine aggregate supply and aggregate demand functions. Once aggregate supply and demand are determined, a price which equates these functions together is found. This equilibrium price is adjusted by each region's transfer costs (eg. transportation costs) and is inserted back into each region's supply and demand equations to determine production and consumption levels. Differences between amounts supplied and demanded at equilibrium price, identify whether the region has a surplus or a deficit of the commodity.

Once surplus and deficit regions are identified, optimal or least cost trading patterns between regions can be determined by linear programing techniques, providing supply and demand relationships are assumed to be linear. More specifically, estimated supply and demand equations can be incorporated into a net revenue model to solve for spatial equilibrium and trade patterns among regions.[1]

Spatial equilibrium models are frequently used to analyze geographical markets within a country. They are also the most common class of agricultural trade model, particularly for conducting trade policy experiments. These

models are often selected to analyze trade between countries since they avoid the difficult problem of estimating import and export functions. They also provide a convenient way to handle storage components--increasing the explaining power of the analysis without adding burdensome complexity. By including a storage equation, a more complete and dynamic model can be estimated. Also, the storage equations function to smooth-out variations in seasonal demand and seasonal production patterns.

The spatial equilibrium models important to this paper are North American pork sector studies by Martin (1975), Pieri (1977), and MacAulay (1978). The models in these studies are used to conduct policy experiments on quotas, tariff levels, and exchange rate adjustment. All three used quarterly recursive competitive spatial equilibrium models which use quadratic programing techniques to solve for trade direction and volume between regions. The models are recursive because supplies are treated as predetermined.

These models use different approaches to account for currency exchange rate changes. Martin simply converts U.S. prices to Canadian prices and estimates supply and demand functions in both countries using Canadian currency. This is an acceptable procedure when exchange rates are fixed or very stable, but unacceptable when exchange rates float or fluctuate, since it assumes that prices move in tandem with exchange rates. Pieri used a conversion approach suggested by Elliot (1972), in which equations are estimated in

national currencies and then converted to a common currency by multiplying price parameters by the actual exchange rate.

MacAulay treats exchange rates as an ad-valorem tariff, so that the exchange rate is merely added to a fixed cost of transport. This approach allows for supply and demand functions to be estimated in individual currencies, while the net revenue function is solved for in a common currency. A major limitation with this approach is that exchange rates are proportional to prices, implying that deviations from purchasing power parity do not occur.

Criticism of spatial equilibrium models used for agricultural trade applications often centers around the assumption that price differences between trading regions are exactly equal to transfer costs. Kolstead (1986) suggests that frequently poor performance of empirical studies using these models occurs because simple competitive theory is inadequate. More specifically, trade between markets is subject to interferences by governments and market participants, yielding imperfectly competitive markets. Thus, he concludes that models of competitive spatial equilibrium are not always appropriate for analyzing international agricultural trade.

Other limitations of spatial equilibrium models when applied to international trade include: an inability to handle non-linear demand functions and balance of

payment constraints, restrictive assumptions concerning transfer costs and homogeneity of product, and large and costly data requirements.

Given these limitations, particularly the assumption that regional prices only differ by the cost of transfer, and realizing the objective of this paper is not to determine optimal trading patterns, a spatial equilibrium model was not selected. However, this paper's model does borrow their geographical treatment of regional supply and demand functions and their method of handling the storage component.

3.2.1.1 An Application to U.S.-Canada Trade

To illustrate how spatial equilibrium theory might be applied to determine the equilibrium price of pork and trade volume, consider the simple two region model presented in Figure 17. In Panel 1 and Panel 2, hypothetical supply and demand functions are presented for the U.S. and Canada. Assume that no trade occurs between the two regions, that prices are in a common currency, and that perfect competition exists between all market participants. For each region, market equilibrium occurs at the intersections of their supply and demand functions: p2 for the U.S. and p1 for Canada.

In Figure 17, the United States is the pork deficit region and Canada the pork surplus region. This occurs since the U.S. equilibrium price, p2, is higher than the Canadian equilibrium price, p1. In the United States, at a

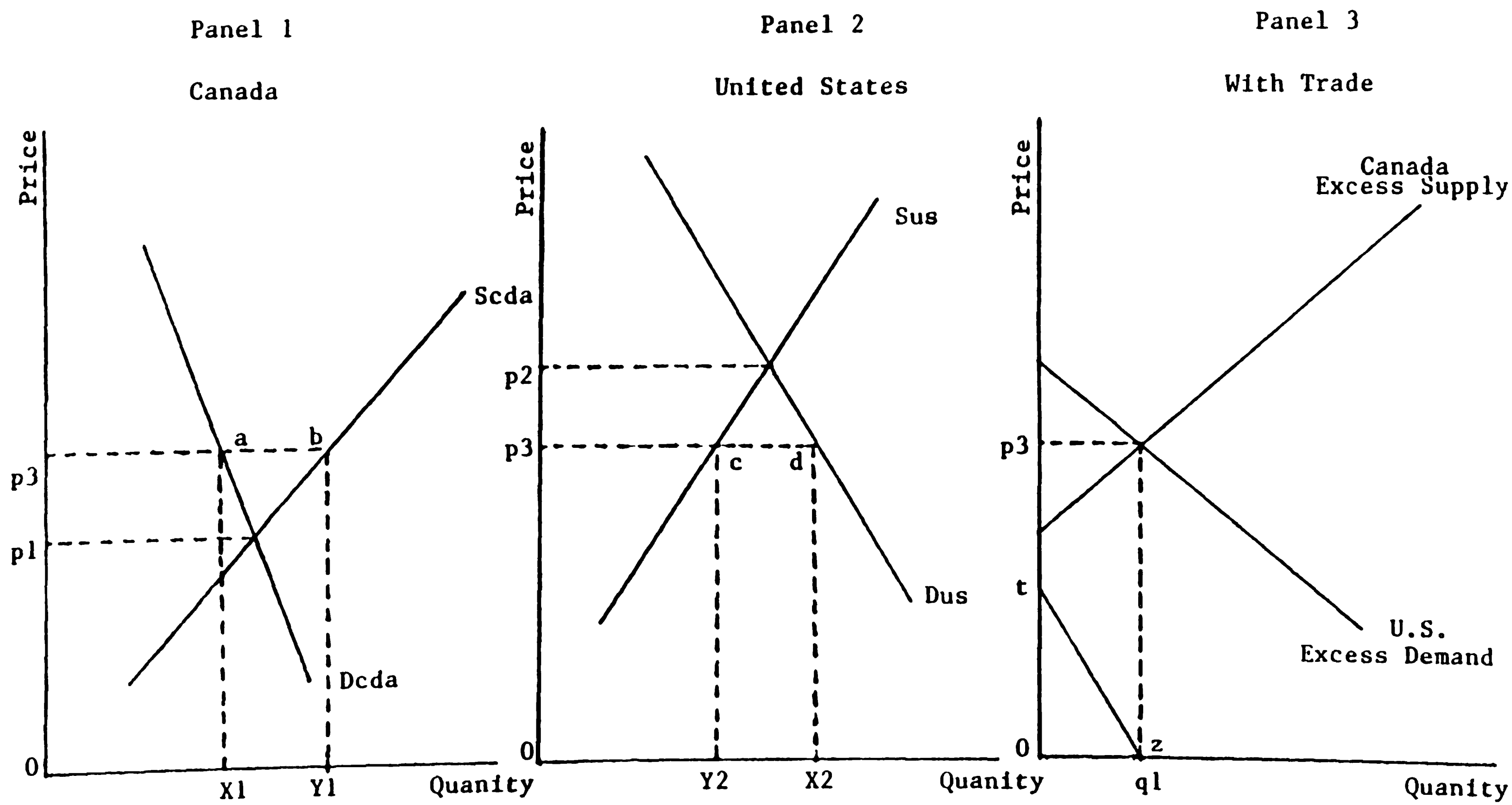


Figure 17. Two Region Spatial Equilibrium Model

pork price below p2, demand would exceed the amount producers are willing to supply, requiring imports to satisfy demand. In Canada, at prices above p1, supply will exceed the amount consumers desire at that price, with the surplus pork being exported to the other region.

From each country's supply-demand schedules, an excess supply curve for Canada and an excess demand curve for the U.S. can be constructed (Panel 3).[2] If trade, with no transfer costs, is allowed to occur between the two countries then a new trade equilibrium price, p3, is established at the intersection of the Canadian excess supply curve and the U.S. excess demand curve.[3] This new trade equilibrium price determines equilibrium trade volume, which is indicated by q1 in Panel 3 of Figure 17. The quantity supplied in each country is represented by Y1 and Y2, and the quantity demanded is represented by X1 and X2.

The diagonal line with end points t and z in Panel 3 represents the volume of trade which occurs when transfer costs are introduced.[4] At point t, transfer costs equal or exceed the difference between p1 and p2 and so no trade occurs between the two regions. At point z, transfer costs are zero, so trade volume is at the maximum amount of q1. Therefore, moving along line tz from point t towards point z, transfer costs decrease which increases the trade volume until it reaches its maximum at point z.

If arbitrage is complete, price differences between countries will not exceed transfer costs, limiting trade volume to a point on line tz. As mentioned previously, perfect price transfer between two markets is an unrealistic assumption to make for many trading systems, particularly U.S.-Canada pork trade.

In the above simple two country spatial equilibrium model, changes in the trading position of either country and the equilibrium price of the trading system result from either a shift in regional supply and demand curves or a change in transfer costs. Important here is that both these variables can be affected by exchange rate adjustments.

3.2.2 Excess Supply and Excess Demand Models

Another set of models used to evaluate the trade of agricultural commodities are excess supply and excess demand models. These models have been used in studies by Johnson (1977), Chambers (1981), and others to evaluate the devaluation of the United States dollar in the 1970s. In these studies, the elasticity of excess supply and excess demand curves are estimated to analyze the effect of a one percent adjustment in exchange rates on export or import volume.

Like spatial equilibrium models, these models estimate supply and demand functions to determine whether the country is an exporter (excess supply) or an importer (excess demand). Once excess supply and excess demand is known, trade volume is determined by using accounting identities.

An alternative method is to include estimates of export and import functions within the system of equations. Like the excess supply and excess demand functions, these export and import functions are jointly determined with price. Identities are used to relate all of the functions.

3.2.3 Purchasing Power Parity

3.2.3.1 Overview

To quantify the impact of price adjustment on the Canadian and United States pork markets resulting from exchange rate changes, a theorem is needed which relates price levels to exchange rates. A variant of the purchasing power parity (PPP) theorem incorporates this relationship.

The theorem, which was first put into a theoretical framework by Gustav Cassel nearly 70 years ago, states: "the equilibrium value of currencies should be intimately linked to their internal purchasing power."[5] In other words, the theorem states that bilateral exchange rates should reflect the relative purchasing power of their currencies; that exchange rates should adjust to reflect different rates of price inflation. Further, if movements in the exchange rate and the relative inflation rates diverge, PPP theory suggests that aggregate real trade flows could be induced.

Purchasing power parity is defined by an 'absolute version' and a 'relative version'.[6] The absolute version states that the equilibrium exchange rate between two countries currencies equals the ratio of prices between the two countries. The relative version states that changes in

the equilibrium exchange rate equals changes in the ratio of prices between the two countries, as measured from a base period.

These two versions can be expressed mathematically as:

Absolute PPP: $er(x/y) = P_x/P_y$

Relative PPP: $er(x/y)/er^\circ(x/y) = (P_x/P_y)/(P^\circ_x/P^\circ_y)$

where er is the ratio of currency units; P is the price level or an aggregate price index; x is a country; y is another country; ° is the base period.

Definitions of price in the two versions depends on the interpretation and application of the theorem. At one extreme, the commodity arbitrage view of PPP, only the price of tradable goods is appropriate. This view stresses commodity arbitrage as the mechanism which influences the relationship between prices and exchange rates. At the other extreme are those who advocate broader price indexes, emphasizing the role of equilibria in asset markets as the major factor governing the relationship between prices and the exchange rate.

The theoretical and empirical PPP literature is extensive and diverse, a result of its many different interpretations. Different interpretations occur since the theorem defines a relationship between prices and equilibrium exchange rates, but does not specify how the two variables are related.

Katseli-Papaefstratiou (1979), Officer (1976), and Frenkel (1978) review the major interpretations of PPP theory. Katseli-Papaefstratiou placed the interpretations into three major groups.

First, the theorem is viewed within the context of the monetary approach of the balance of payments. Here money stocks are considered to affect prices which in turn influence exchange rates; suggesting a causal relationship between prices and exchange rates. Second, the theorem is viewed as an equilibrium condition between relative prices and the exchange rate. Both price and the exchange rate are determined simultaneously as functions of some exogenous variables and the other endogenous variable. The third major view of the theorem is that of a spatial-arbitrage or commodity-arbitrage relationship.

The spatial-arbitrage hypothesis, in its narrowest definition, states that a traded homogenous commodity will have the same price in all trading countries--a relationship known as the "law of one price." Moreover, the view states that price changes or exchange rate adjustments are quickly transferred to other countries, even without the flow of the commodity. This interpretation is based on the assumption that markets are fully integrated and that equalized prices are adjusted for transfer costs.

3.2.3.2 Utilization of PPP in the Model

The spatial-arbitrage interpretation of PPP is utilized by the model to express the relationship between pork prices and U.S.-Canada exchange rates. This paper assumes that spatial-arbitrage is not perfect, implying that deviations from PPP occur. When the ratio of relative pork prices is not equivalent to the exchange rate, deviations from purchasing power parity occur. Deviations are viewed as lags in the adjustment of relative prices to exchange rate changes.

A variable representing deviations from absolute PPP is placed into each behavioral equation of the model. Using previous notation, the variable (DPPP) is expressed as:

$$DPPP = (P_x/P_y) - er(x/z)$$

where P equals the average price of pork at the farm market level; er equals the average exchange rate in units of country x currency per country z currency; x equals the U.S.; y equals East or West Canada; and z equals Canada.

The deviation from PPP variable is considered to have both an explained component and an unexplained component. Explained deviations result from transfer costs. Transfer costs (tariff levels, grading differences, transport costs), are relatively constant and can be easily accounted for by adjusting prices in the equation.

More important to this paper are unexplained deviations from PPP. Unexplained deviations have a short-term and a long-term component. Short-term deviations reflect brief

lags in the adjustment of prices and exchange rates between markets to new information. These lags result from physical, contractual, and market structure conditions.

Long-term deviations from PPP occur when a positive or negative deviation occurs for several months or more. Long-term trends in PPP deviations suggest a sustained alteration in the terms of pork trade between the two countries. Besides exchange rate adjustment, changes in the terms of trade could also result from different relative supply and demand conditions. Such differences could be caused by real factors, such as differences in relative opportunity costs, e.g. government subsidization programs.

PPP Assumptions

This paper makes several assumptions concerning PPP. First, exchange rates are assumed to be exogenous to the model developed. This is justifiable because the dollar value of pork trade is a small fraction--less than 0.5 percent--of the entire dollar volume trade between the two countries. Therefore, changes in pork prices and trade volume should have a relatively small influence on U.S.-Canada exchange rates.

Another PPP assumption concerns the relationship between relative pork prices and relative input prices. Relative prices of domestic factors of production (inputs) are assumed to adjust more slowly to U.S.-Canada exchange rate changes than do relative prices of pork. This is because many of these inputs, such as labor and fixed

capital, are non-tradable. Moreover, the price of feed, a major input cost, is also considered to adjust more slowly than pork prices themselves; resulting from extensive feed grain programs in both countries.

The slower adjustment of feed prices is demonstrated in Figure 18. Here monthly deviations from PPP for consumer price indexes (CPI), farm feed price index (FPI), and farm level pork prices are graphed from January 1973 to March 1985. In the figure, PPP deviations are less for pork than for the broader indexes, particularly for CPI. The large PPP deviations since 1977 for CPI and FPI suggest that exchange rates did not adjust for inflation

The final assumption made is that Canada is considered to be in the "small country" situation. Canada is considered the small country since Canadian pork production ranges from only 9 to 14 percent of U.S. production. This assumption implies that a Canadian dollar devaluation will have a greater impact on Canadian production and trade with the U.S. than would a corresponding devaluation of the U.S. dollar.

Given the final assumption, Canadian supply-demand response is considered more sensitive to PPP deviations than the U.S. supply-demand response. Canadian prices are considered more dependent on the much larger U.S. supply and demand conditions than U.S. prices are on Canadian supply and demand conditions. Canada is considered to be a "price

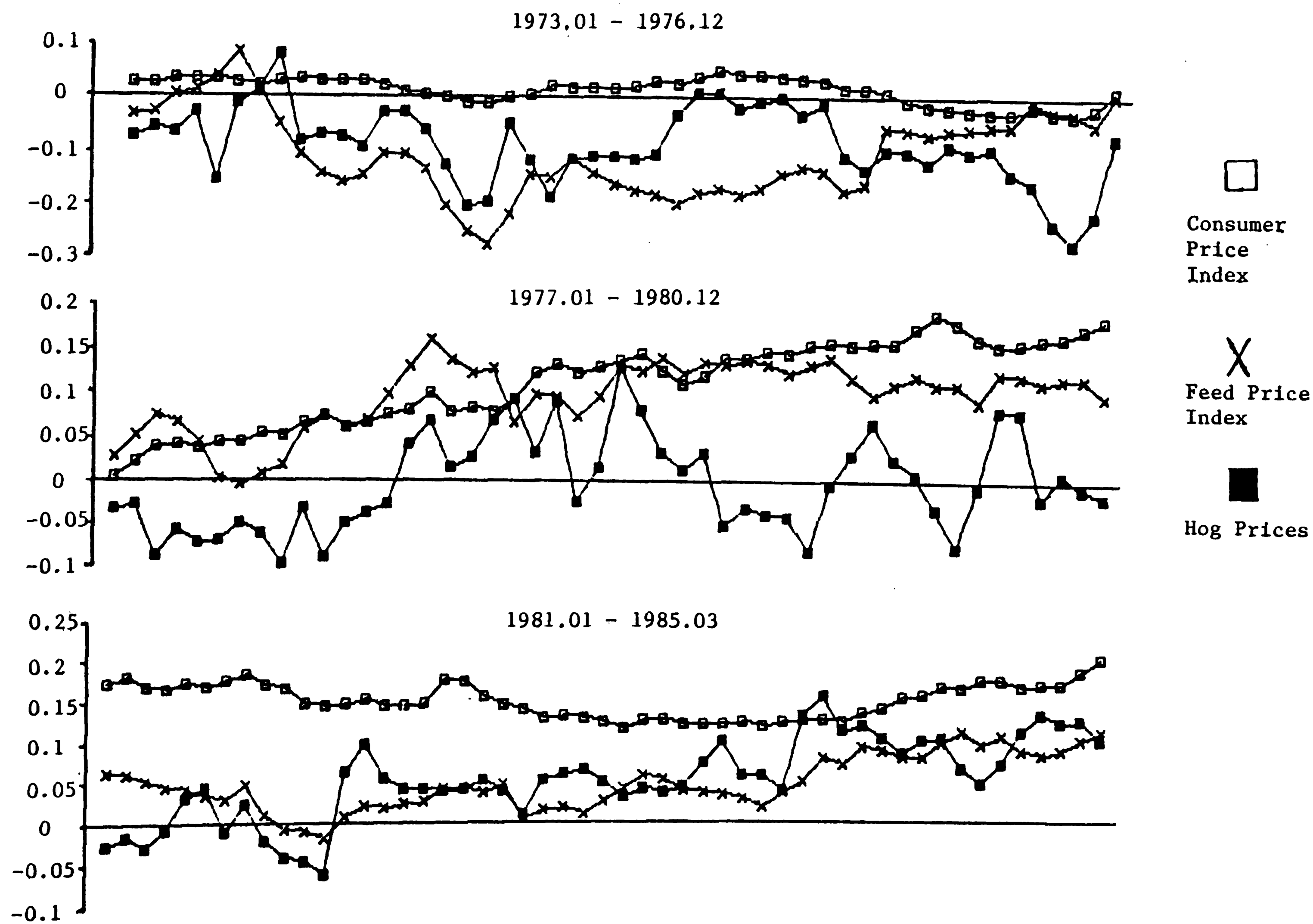


Figure 18. PPP Deviations

taker" in the North American pork market. A change in bilateral exchange rates yielding PPP deviations will, therefore, have more of an impact on Canada.

When a positive PPP deviation occurs, Canadian exports are encouraged because U.S. prices are greater than Canadian prices. A positive deviation is analogous to an exchange rate devaluation. A negative deviation has the opposite meaning, implying prices are greater in Canada than in the U.S. This situation is analogous to a currency appreciation and Canadian exports would be expected to decline.

The extent to which the deviation affects Canadian pork prices or exports depends on the elasticity of Canadian excess supply. An elastic Canadian excess supply curve indicates that the percentage adjustment in exports would exceed the percentage adjustment in prices caused by the deviation. An inelastic excess supply curve leads to the opposite effect.

3.2.3.3 PPP Literature

The empirical literature utilizing purchasing power parity theory at the individual or commodity group level is limited and inconclusive, particularly literature on U.S.-Canada trade. Studies by Dunn (1970) and others in the 1970s conclude that partially aggregated commodity prices in Canada are unresponsive to exchange rate adjustment, but are responsive to price changes.

Richardson (1977) investigates commodity arbitrage or the "law of one price" for aggregated commodity groups between the United States and Canada. Using time series regression analysis, he presented three major conclusions. First, commodity price arbitrage does take place between the two countries, but not significantly for all commodity groups. Second, when arbitrage for a commodity does take place it is never perfect. Third, Canadian prices respond symmetrically and comparably to U.S.-Canadian exchange rate changes, at least in the same way and to the same degree as they respond to U.S. prices.

The empirical evidence for the third conclusion was based on monthly data from 1965 through 1974, a period of stable exchange rates. Moreover, these results were based on aggregated commodity groups and not on an individual homogeneous commodity. Based on these two observations, the relevance of Richardson's third conclusion to this study is questionable.

Conclusions one and two are consistent with other studies, but the third conclusion is not supported by other studies, including work by Isard (1977). Isard presents evidence "that exchange rate changes substantially alter the relative dollar-equivalent prices of the most narrowly defined domestic and foreign manufactured goods for which prices can be readily matched."[8] Furthermore, he concludes that these relative price changes persist for extended periods and are not transitory.

Isard also used times series regression analysis to determine if variations in the ratio of import unit value to export unit value of five commodity groups were related to fluctuations in exchange rates. He compared United States aggregated manufacturing data with similar data from Japan, West Germany, and Canada. Japanese and West German data generally supported Isard's hypothesis, however, the Canadian data did not.

The failure of exchange rate fluctuation to influence price levels may have occurred because exchange rate changes were minimal during the 1968 through 1975 period of study. The time period, along with the fact that manufactured goods were studied, minimizes its relevance to this study.

In summary, past studies analyzing the relationship between U.S.-Canada prices and U.S.-Canada exchange rates have drawn conflicting conclusions. Richardson concluded that U.S. and Canadian prices responded to exchange rate changes, while Isard found no support for this finding. The relevance of either authors' findings to non-adjustment of hog prices is questionable because of the time period and the commodity groupings selected.

3.3 Model Framework

Spatial equilibrium and supply-demand trade models provide the theoretical framework for the model constructed in this paper. The model of the North American pork market consists of three regions: the United States, Canada, and "the rest of the world." The latter region is assumed to be

exogenous to the model. Although this assumption could bias model results, this region is not endogenized because its volume has been relatively stable and since it represents a small proportion of either country's trade.

In the model, pork supply and demand conditions within each country along with these conditions outside of North America determine U.S.-Canada pork trade volume. Each country's supply and demand equations are equated to determine whether the country has a pork deficit (excess demand) or pork surplus (excess supply). At market equilibrium, the amount of excess supply in one country must equal the amount of excess demand in the other country. The amount traded is equal to the excess supply or excess demand. The relationship can be stated as: excess Supply = excess demand = quantity traded.

This equilibrium is really a partial equilibrium since the "rest of the world" variables, the cross-price effects of structural variables, and the income elasticity are all exogenous to the model. These variables, along with monetary variables (currency exchange rate), are exogenous due to the complexity required to make them endogenous.

Determining which country has an excess supply or excess demand position is readily accomplished because there are only two endogenous trade regions. By subtracting each country's supply and demand functions from each other and adjusting for trade with the "rest of the World," it can be determined whether each country has an excess supply

(exporter) or an excess demand (importer). Whether the country is an exporter or importer depends on structural and monetary variables, which affect supply and demand functions and hence relative prices in each country.

Price is assumed to be the mechanism which clears the North American pork market. If prices change relative to the other country, arbitrage should work to reduce any differences between the two markets until price is once again equivalent (after transfer costs are taken into consideration). Non-equivalence of prices between the two markets could result from different relative supply and demand conditions or from lags in the adjustment to exchange rate changes.

Differences in relative supply and demand functions can result from a number of factors, such as different production costs or opportunity costs. Lower production costs in one country relative to the other should encourage production in that country at a price lower than in the other country.

Model Equations

The model specifies supply and demand functions for the two endogenous regions and relates the functions to determine net pork trade. Demand for pork functions are defined by a demand for consumption and a demand for storage equation. The demand for storage equation is borrowed from

previous spatial equilibrium models of the North American pork market. Storage smooths variations between seasonal demand and seasonal production patterns.

In the model, demand for consumption is dependent on the price of pork in the current period. This joint (simultaneous) determination of demand and price signifies that price is endogenous in the system. On the other hand, supply in the current period is considered to be predetermined, dependent on past conditions and events. Therefore, current period supply is not dependent on the current period price.

Borrowed from previous spatial equilibrium models is the geographical treatment of the Canadian supply response. The model estimates supply response for three regions: the United States, Eastern Canada and Western Canada. Canadian supply response is simply the sum of the supply response estimations for Eastern and Western Canada.

Previous spatial equilibrium models estimate demand for consumption and storage for Eastern and Western Canada. For the purpose of this paper, these geographical estimations were deemed unnecessary since these functions are hypothesized to be insignificantly different between the two regions. Demand estimations by MacAuley and storage equations by Martin (1975) tend to support this assumption.

Further discussion of the model framework and specification of the equations are provided in the next chapter.

FOOTNOTES

1. Further discussion of net revenue models, spatial equilibrium and linear programing can be found in Samuelson (1952). Takayama and Judge (1971) have developed the mathematical techniques necessary to solve for spatial equilibrium using quadratic programing techniques.

2. Excess supply for Canada is constructed by taking the horizontal difference from supply and demand curves above equilibrium at p1, point a minus point b. Excess demand curve for the U.S. is constructed by the horizontal difference between demand and supply below equilibrium at p2, point d minus point c. The slope of the excess demand and excess supply curves depends on the elasticity of the supply and demand curves in each country.

3. The point where the new trade equilibrium price, p3, occurs depends on the elasticities of the excess supply and excess demand curves. The more elastic the excess supply curve is relative to the excess demand curve, the closer p3 will be to the price in the exporting country, p1. Conversely, the more elastic the excess demand curve is, the closer p3 will be to the price in the importing country, p2.

4. Transfer costs here are defined to include transportation costs, tariffs, and exchange rate differences.

5. Katseli-Papaefstratiou, Louka. The Reemergence of The Purchasing Power Parity Doctrine in The 1970s. Princeton Univ. 1979, p.4.

6. Lawrence H. Officer (1978) discusses the relationship between absolute and relative versions of PPP.

7. Isard, Peter. "How Far Can We Push the 'Law of One Price'?". American Economic Review 67 (December 1977), p. 942.

Chapter 4

Model Specification

4.1 System Overview

The study's econometric model specification is based on theory from spatial price equilibrium and supply-demand trade models. Using these models, a recursive structural model of the United States and Canadian pork markets was developed to satisfy the paper's research objectives. Model specification treats North America as a world market for pork, consisting of two endogenous regions: Canada and the United States. Trade with countries outside of North America is treated as exogenous to the model.

The model estimates three supply response equations, two demand for storage equations, and two demand for consumption equations. Three supply equations are estimated because Canadian supply response is divided into two distinct regions: Eastern Canada and Western Canada. All seven behavioral equations are specified with a linear functional relationship. These seven equations are presented in Table 9. Eight identities, three of which are trade identities, relate the seven equations and provide a method to estimate net pork trade volume between the two countries.[1]

Table 9. Behavioral Equation Specifications

$$NUHS = \alpha_0 - \beta_1 DUCPO + \beta_2 DUHP - \beta_3 APPST + \beta_4 PDUM + \beta_5 DV4 + \mu$$

$$ECHS = \alpha_0 - \beta_1 DECFI + \beta_2 DECHP + \beta_3 APPST + \beta_4 CORNPR + \beta_5 PDUM + \beta_6 CDUM + \mu$$

$$WCHS = \alpha_0 + \beta_1 PGRAIN + \beta_2 DWCHP + \beta_3 APPSW - \beta_4 DCFM + \beta_5 PDUM + \beta_6 CDUM + \mu$$

$$USPS = \alpha_0 + \beta_1 USPS_{-1} + \beta_2 NUHS - \beta_3 DUHP + \beta_4 APPWB + \beta_5 SDUM + \mu$$

$$CDPS = \alpha_0 + \beta_1 CDPS_{-1} + \beta_2 CHS - \beta_3 DECHP - \beta_4 APPWB - \beta_5 DV3 - \beta_6 DV2 + \mu$$

$$UCON = \alpha_0 - \beta_1 DUHP + \beta_2 DUBI + \beta_3 LUSY + \beta_4 APPWB + \beta_5 HDUM + \mu$$

$$CCON = \alpha_0 - \beta\ DECHP + \beta_2 DCBI + \beta_3 LCDY + \beta_4 APPWB + \beta_5 HDUM + \beta_6 CDUM + \mu$$

NUHS = net U.S. hog slaughter.
ECHS = Eastern Canada hog slaughter.
WCHS = Western Canada hog slaughter.
USPS = U.S. month end cold storage pork stocks.
CDPS = Canadian month end cold storage pork stocks.
UCON = U.S. per capita pork consumption.
CCON = Canadian per capita pork consumption.
DUHP, DECHP, DWCHP = deflated hog prices.
APPSW, APPST = deviations from PPP.
HDUM, SDUM, PDUM, DV1, DV2, DV3, DV4 = seasonal shifters.
DUCPO, DECFI = deflated feed costs.
DUBI, DCBI = deflated retail beef prices.
LUSY, LCDY = the log of income.
PGRAIN = prairie grain stocks.
CDUM = a data dummy.
DCFM = the real net margins from cattle feeding.
CHS = Total Canadian hog slaughter.
α = the intercept.
μ = an error term.

Note: Explanatory variables for NUHS, ECHS, and WCHS are treated as distributive lags.

Specification of the seven behavioral equations is somewhat similar to that suggested in North America pork sector models by Martin (1975), MacAulay, and Pieri. To perform policy simulations, these models incorporate a set of supply and demand equations into spatial equilibrium models and solve for market equilibrium using quadratic programing techniques. More specifically, these models test the hypothesis that the North American pork sector behaves as a spatially competitive market.

In this model, unlike other models and studies, price variables are expressed in constant dollars. Prices are deflated since it is hypothesized that both consumers' and producers' decisions are not subject to money illusion. Demand for consumption and demand for storage variables are deflated by consumer price indexes. Supply response variables are deflated by regional producer price indexes.

Different deflators were selected to better simulate prices used in the decision sets of producers and consumers. Producer price indexes are used over wholesale price or consumer price indexes for the supply equations, since these indexes better represent the prices that producers base their production decisions on.

Unique to this model is the inclusion of a purchasing power parity deviation (PPP) variable in all seven behavioral equations. Deviations from PPP measures the difference between the ratio of hog prices and the ratio of exchange rate between the two countries. The two PPP

variables APPST and APPSW are constructed at the farm level. Two PPP variables are required since Canadian supply is estimated for two regions.

The two PPP variables are:

APPST = UHP/ECHP - (U.S.$/Canada$)

APPSW = UHP/WCHP - (U.S.$/Canada$)

where APPST is the absolute purchasing power parity (PPP) for Eastern Canada and the central U.S.; UHP is the dressed hog price at seven central U.S. markets; ECHP is the Index 100 dressed hog price at Toronto; APPSW is the absolute PPP for Western Canada and the central U.S.; and WCHP is the Index 100 dressed hog price at Winnipeg.

The purchasing power parity variables require a close matching of grades and prices between the two countries. In Canada, hogs are priced and graded based on a national grading scheme known as the Canadian Index 100 System.[2] Price indexes recorded at Toronto (Eastern Canada) and at Winnipeg (Western Canada) were selected as the closest match to the United States price series, because of their high volume and close proximity to the major U.S. hog producing region of the Middle West. For the U.S., the weighted average price of barrows and gilts at seven central U.S. markets was selected as the most representative of the major U.S. producing region. Finally, all hog price series were adjusted for tariff rate differences.

The chapter continues with a discussion of the three supply response equations, followed by the demand for storage equations, the demand for consumption equations, and the identities.

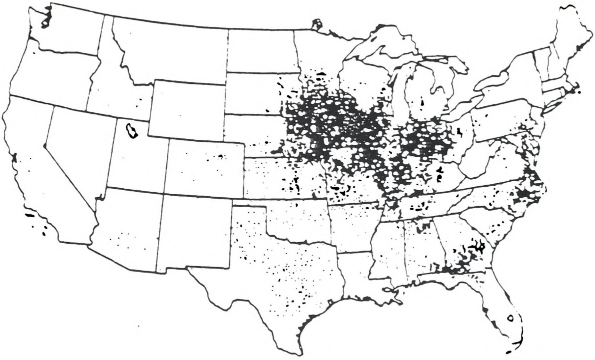
4.2 Supply Equations

In this model, Canadian supply response is the sum of supply response estimations for Eastern and Western Canada. Canadian hog supply response is divided into two different geographical regions since eastern and western producers are hypothesized to have different production decision sets. Eastern Canada includes Ontario, Quebec, and the Atlantic Provinces. Western Canada includes the provinces of Manitoba, Saskatchewan, Alberta, and British Columbia.

The United Sates market is considered to be a national market, therefore, supply response is estimated using a single equation. Use of a single equation assumes that producer supply decisions are relatively similar in different regions within the national market. Since nearly 75 per cent of production occurs in the U.S. Cornbelt, data representing this region are used as a proxy for the national market (Figure 19).

4.2.1 Recursive Supply

Current hog production is a function of past producer decisions and market conditions. Therefore, hog supply response is assumed to be predetermined or recursive. This lag in supply response results from biological and physical factors.[3]



1 Dot = 10,000 Head

Figure 19. United States Hog and Pig Sales, 1978

Biological lags result from the reproductive cycle of hogs. For example, it takes approximately 10 to 12 months for producers to increase hog production from breeding current inventories of market weight gilts.

Physical production lags occur in hog production for two primary reasons. First, lags result from delays in resource procurement, such as capital and labor. Second, lags result from delays in management decisions to alter production schedules. Producers are often reluctant to alter production schedules until a decision variable change is sustained.

In formulating production plans, producers are faced with continual short-, intermediate-, and long-term production decisions. A producers' short-term decision might be to delay hog marketing for a week or two if future price increases are anticipated. But marketing delays are short lived as increasing costs and carcass quality losses begin to offset any price increase. As a result, hog production is similar to that of a perishable commodity.

An intermediate-term production decision might be to increase farrowings of the existing herd. A long-term decision might be to expand production facilities or retain gilts for breeding herd expansion. To estimate this continual decision process, a method of weighting the past decision periods is needed.

4.2.2 Modeling Hog Production Lags

Three approaches have been used in the literature to account for hog supply response lags. First, a geometric distributive lag model specified by Nerlove (1958), has been used in past estimations. Quarterly models by MacAulay, Martin (1975), and Makai (1963) use this approach. Second, simple period lags of supply parameters have been used by Pieri, and Haygena (1970) in estimates using annual data. Simple lags are acceptable when using annual data, but are not for quarterly or monthly data. Finally, polynomial distributive lags are used by Meilke (1974) to obtain hog supply response estimates for Eastern and Western Canada, and the U.S.

Geometric and polynomial distributive lag weighting methods for the three regions are compared by Meilke. The geometric formulation places maximum response or weighting of a coefficient in one period, with weights on succeeding periods slowly declining over time. This creates a problem since maximum hog supply response occurs at least 10 to 15 months after a change in a decision variable. To capture the maximum response period, the geometric model would need to start during this 10 to 15 month period, ignoring any supply response prior to the period. Thus, this lag formulation was considered to be insufficient.

A more appropriate lag formulation for hog supply response is the polynomial distributed lag. A polynomial formulation allows the weighting of coefficients to increase

to a maximum and then decrease. Moreover, polynomial distributed lags can be specified by degree and end constraints, enabling weighting to better match its application. As suggested by Meilke, a 30-month second degree polynomial distributive lag, constrained at both ends, is used in this model.

The general form of a distributed lag model is:

$$Q_t = \alpha + \beta_0 X_{t-1} + \beta_1 X_{t-2} + \ldots + \beta_{m-1} X_{t-m} + \epsilon_t$$

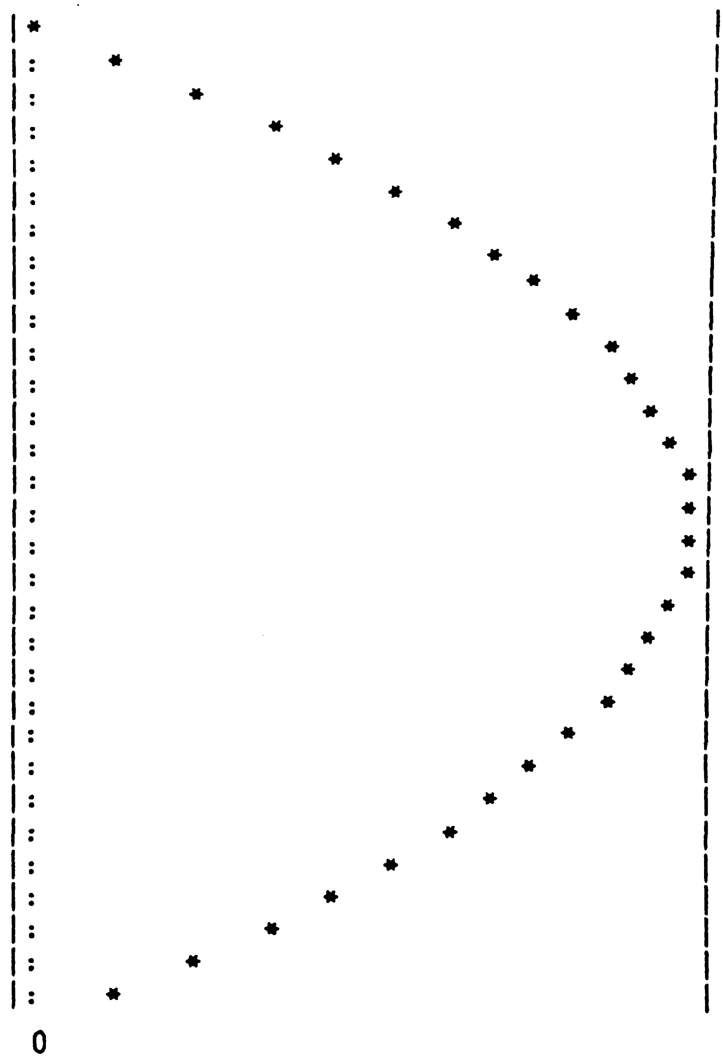
where Q_t is the quantity supplied in the current period t; m is the length of the lag; X_{t-m} is a lagged independent variable; β_0 through β_{m-1} are coefficient weights assigned to X in periods t-1 through t-m; α is the intercept; and ϵ_t is an error term.

With this lag structure the current period, t, receives no weighting, the middle month, t-15, receives the largest weighting, and the smallest weighting is applied to the first month, t-1, and the last month, t-30 (Figure 20). Fifteen months was selected as the maximum response period by assuming a 12 month biological lag and a 3 month physical lag. All supply response explanatory variables were given this same lag formulation, except for the seasonal supply shifters which were not lagged.

4.2.3 Variable Selection

Producer supply response, as measured by commercial hog slaughter, for all three regions is hypothesized to be a function of: 1) the price of hogs; 2) the cost of production (usually feed); 3) a variable representing devi-

Lag Distribution of APPST



Lag	Coef
0	0.00000
1	17.5012
2	33.8356
3	49.0032
4	63.0041
5	75.8383
6	87.5058
7	98.0065
8	107.340
9	115.508
10	122.508
11	128.342
12	133.009
13	136.509
14	138.842
15	140.009
16	140.009
17	138.842
18	136.509
19	133.009
20	128.342
21	122.508
22	115.508
23	107.340
24	98.0065
25	87.5058
26	75.8383
27	63.0041
28	49.0032
29	33.8356
30	17.5012
Sum	2893.52

Figure 20. Polynomial Distributed Lag Structure

ations from purchasing power parity; 4) seasonal production dummy variables; and 5) variables unique to each region. A number of different time series have been used to represent these variables in earlier studies. Most of these series were tried in the study, with the most theoretically correct and significant ones used in the final specification.

The specification of each equation is presented in the next sections. Each section presents the equation first, followed by the rationale for the specification.

4.2.4 United States Supply Equation

The equation specification is:

$$NUHS = \alpha_0 - \beta_1 DUCPO + \beta_2 DUHP - \beta_3 APPST + \beta_4 PDUM + \beta_5 DV4 + \mu$$

where NUHS is net U.S. commercial hog slaughter; α is the intercept; DUCPO is the deflated price of corn; DUHP is the deflated U.S. price of hogs; APPST is the Purchasing Power Parity variable; PDUM and DV4 are seasonal production dummy variables; and μ is an error term.

Discussion

Since feed costs represent 60 to 70 percent of variable production costs (excluding feeder pig costs) it is considered to be a good proxy for production costs. Early studies by Makai and Crom (1970) used corn prices as a proxy for feed costs. Most estimations completed since 1970 have used a weighted average cost of corn and soybean meal. Trial estimations using these series were found to be insignificant and so the price of corn is used. Deflated

corn prices at Omaha, Nebraska (DUCPO) are used because the price series best approximates corn prices of the major hog producing region.

Earlier hog supply response estimations by Meilke (1974), MacAulay, and Chin (1978) included the net profit margins from feeding cattle as an opportunity cost of production. The variable is not used here because most hog and cattle production occurs on specialized farms.

The price of corn actually may be a better proxy for opportunity costs than net cattle feeding margins. Many hog producers grow their own corn and for them corn can either be sold (opportunity cost) or feed to hogs (production cost). Whether viewed as a production cost or opportunity cost, the expected coefficient should be negative.

Hog to corn price ratios have been used as a proxy for profitability by Heien (1975), and discussed by Blosser (1965) and Meilke (1977). Meilke suggests that hog-corn price ratios are less useful when corn prices are fluctuating. He further suggests that large fluctuations in corn prices since 1973, may explain why the variable has recently lost its explaining power. Moreover, Blosser suggests the ratio leads to errors since the ratio implies different levels of profitability depending on price levels of the two commodities. Based on their results, and insignificant coefficients in trial estimations, the ratio was excluded from the specification.

The deflated price of hogs is included to represent profitability and is hypothesized to vary directly with hog supply response. The price series selected to represent hog prices is the deflated average price of hogs at seven central U.S. markets (DUHP). This data series is most representative of the primary Cornbelt production region.

The deviations from purchasing power parity variable (APPST) is hypothesized to have a indirect relationship with hog supply. When deviations from PPP equilibrium are positive, the U.S. pork industry experiences a decline in the terms of trade and hence a decline in exports to Canada. A decrease in exports to Canada would cause a rightward shift in the supply curve, resulting in a lower price level and hence decreases in future supply response.

Dummy variables PDUM, DV4, are used to account for seasonal production resulting from increased spring and fall farrowing periods.

4.2.5 Canadian Supply Equations

4.2.5.1 Eastern Equation

The equation is specified as:

$$ECHS = \alpha_0 - \beta_1 DECFI + \beta_2 DECHP + \beta_3 APPST + \beta_4 CORNPR + \beta_5 PDUM + \beta_6 CDUM + \mu$$

where ECHS is Eastern Canada commercial hog slaughter; α_0 is the intercept; DECFI is an index of Eastern Canada feed costs; DECHP is the deflated Eastern Canada hog price; APPST is a variable for PPP; CORNPR is Eastern Canada corn

production; PDUM is a variable for seasonal production patterns; CDUM is a data dummy variable; and μ is an error term.

Discussion

As with the U.S. supply equation, a feed cost variable is included in this equation as a proxy for production costs. Several different price series have been suggested in the literature to represent feed costs. Chin and MacAulay used the price of corn, while Martin (1975) used a weighted average price of feed grains. On the other hand, Meilke (1974) used an average of corn and barley prices plus grain shipments under the Canadian Feed Assistance Program. All these variables were insignificant at the 5 percent level, including trial estimations in this paper.

A deflated index of Eastern Canada feed prices (DECFI) compiled by Statistics Canada and used by Pieri is selected here. Although the variable is insignificant in his equation, it is conceptually more correct than the other variables since it is more representative of feed costs which contract feeders and vertically integrated firms experience.

Previous equations by MacAulay and Meilke (1974) include net cattle feeding margins as a proxy for opportunity cost. The variable is not used here, since hog production increasingly occurs in specialized production facilities, particularly in the province of Quebec.

The deflated Index 100 dressed hog price at Toronto (DECHP) was selected to represent hog prices. It is hypothesized to have a positive influence on production. The Toronto series was selected because prices at this market are often used by other markets in the region to formulate their prices.

Deviations from absolute purchasing power parity (APPST) are hypothesized to directly influence Eastern Canada hog production. When positive deviations occur, supply response should increase as producers experience more favorable terms of trade with the United States. Specifically, higher export prices and the resulting higher domestic prices encourage production increases.

A variable representing corn production (CORNPR) is included in the specification. Higher corn production levels are hypothesized to improve feed quality, stabilize supplies, and lower production costs. This enables production plans to be made with less risk. Therefore, increasing corn production is hypothesized to have a positive influence on hog production. Historically, the region has been a feed deficit region, particularly in corn production. In the last decade corn production has been on the rise.

Finally, seasonal hog production patterns, similar to the U.S., require the use of a dummy variable (PDUM). Another dummy variable (CDUM) was included in the equation

to account for an apparent data accounting condition. Chapter 5 provides a detailed discussion of the data problem.

4.2.5.2 Western Equation

The equation is specified as:

$$WCHS = \alpha_0 + \beta_1 PGRAIN + \beta_2 DWCHP + \beta_3 APPSW - \beta_4 DCFM + \beta_5 PDUM + \beta_6 CDUM + \mu$$

where WCHS is Western Canada commercial hog slaughter; α_0 is the intercept; PGRAIN is prairie province farm grain stocks; DWCHP is the deflated hog price for Western Canada, APPSW is the PPP variable; DCFM is the deflated net cattle feeding margin; PDUM is a variable for seasonal production patterns; CDUM is a data dummy variable; and μ is an error term.

Discussion

The Western equation specification is different from the Eastern equation because variables for prairie grain stocks (PGRAIN) and deflated net cattle feeding margins (DCFM) are used. Rationale for including the PPP variable APPSW, the deflated price of hogs variable DWCHP, and the dummy variables PDUM and CDUM, are the same as for the Eastern equation.

As suggested by Kerr (1968), prairie grain stocks (PGRAIN) are included in the Western equation as a proxy for the opportunity of cost of feeding grain. Higher on farm prairie grain stocks are hypothesized to have a positive influence on hog production.

The level of grain stocks in Western Canada is dependent on the policies of the Canadian Wheat Board. When grain stocks are high the Wheat Board often establishes closed quotas on grain delivered for sale. Under the quotas, a farmer's grain production exceeding his deliver quota is restricted to usage as feed on the farm or sold to another farm for feed. Thus, when grain stocks are high, hog production is encouraged. Since no price information exists on these individual transactions between farmers, on farm grain stock levels serves as a proxy for the opportunity cost of feeding the grain.

In Western Canada, cattle feeding is hypothesized to be a competing farm enterprise to hog production and hence, an opportunity cost. Cattle production in the region remains relatively strong and producers often are involved with both enterprises. Therefore, a variable measuring the profitability of feeding cattle is included. A deflated net cattle feeding margin (DCFM) variable is constructed and is hypothesized to have a negative coefficient.

The Winnipeg Index 100 dressed hog price (WCHP) is selected to represent Western Canada hog prices. Winnipeg is near a major hog producing region and is representative of the region.

4.3 Demand for Storage Stocks

Canadian and U.S. equations for month end cold storage stock demands (CDPS, USPS) are estimated using similar specifications. The variables included in the equations are: month end storage stocks lagged one month; commercial hog slaughter numbers; the deflated price of hogs; a deviations from PPP variable; and dummies for seasonal stock patterns.

The United States specification is:

$$USPS = \alpha_0 + \beta_1 USPS_{-1} + \beta_2 NUHS - \beta_3 DUHP + \beta_4 APPST + \beta_5 SDUM + \mu$$

where USPS represents month end cold storage stocks; α_0 is the intercept; $USPS_{-1}$ is the previous months ending stocks; NUHS is the net U.S. commercial hog slaughter; DUHP is the deflated U.S. hog price; APPST is the PPP variable; SDUM is the dummy for seasonal stock patterns; and μ is an error term.

The Canadian specification is:

$$CDPS = \alpha_0 + \beta_1 CDPS_{-1} + \beta_2 CHS - \beta_3 DECHP - \beta_4 APPST - \beta_5 DV3 - \beta_6 DV2 + \mu$$

where CDPS represents month end cold storage stocks; α_0 is the intercept; $CDPS_{-1}$ is the previous months ending stocks; CHS is the Canadian hog slaughter; DECHP is the deflated Eastern Canada hog price; APPST is the PPP

variable; DV2 and DV3 are dummies for seasonal stock patterns; and μ is an error term.

Discussion

Pork storage stocks smooth-out differences between seasonal production patterns and seasonal consumption patterns. Martin (1975) has suggested that the storage stock level in a given period is dependent on two components: speculation demand and transaction demand. The former is dependent on stockholders' future expectations of prices, seasonal production patterns, and seasonal consumption patterns. The latter is dependent on the volume of activity in the market place.

To represent the level of transaction demand, a hog slaughter variable (NUHS, CHS) is included in each storage demand equation. Assuming packers maintain a relatively constant proportion of their slaughter as inventory, an increase (decrease) in market activity will cause an increase (decrease) in storage demand. Thus, demand for month end storage stocks is hypothesized to vary directly with slaughter volume.

As suggested by Hacklander (1970), Martin (1975), and Pieri, the current price of hogs (DUHP, DECHP) and seasonal storage dummies are used to represent speculation demand. Storage demand is hypothesized to vary indirectly with price. More specifically, if prices increase (decrease) in the current period, then demand for storage stock levels should decrease (increase).

Dummy variables SDUM, DV3, and DV2 are used to represent seasonal expectations of storage demand. In general, pork stocks are at their lowest during spring and early summer months and highest during fall and winter months.

The deflated Eastern Canada hog price series (DECHP) is selected as a proxy for a national Canadian price series. This series is selected because Eastern Canada is the major producing and consuming region, and it is a surplus pork producing region.

Storage stock demand in the current period is hypothesized to depend directly on supplies carried over from previous periods or months. To represent this, a one month lag of the dependent variables CDPS and USPS is included in each equation.

PPP Deviations

The deviations from purchasing power parity variable APPST is hypothesized to vary indirectly with Canadian demand for storage stocks and directly with U.S. demand for storage stocks. For Canada, a positive deviation implies export prices exceed domestic prices and that stocks in excess of basic domestic requirements will be exported to the U.S., lowering demand for stocks. When negative deviations occur, Canadian prices are higher than U.S. prices and excess stock levels are not exported to the U.S., increasing stock demand. Moreover, positive (negative) deviations encourage (discourage) hog exports which in turn

decreases (increases) Canadian slaughter volume (a transaction demand) and hence, decreases (increases) pork storage demand.

For the United Sates, a positive (negative) PPP deviation implies domestic prices are higher (lower) than Canadian prices, discouraging (encouraging) exports of stocks to Canada. This relationship should increase (decrease) storage stock demand. Due to hog import restrictions, and the relatively small size of U.S. exports, transaction demand is hypothesized to not be significantly affected.

4.4 Demand For Consumption

4.4.1 Overview

Factors affecting the demand for red meat (beef, veal, pork, lamb, and mutton) are well documented by Cornell. Most specifications used for red meat demand equations include a variable for price, consumer income, seasonal demand patterns, and the price of substitutes,

This paper follows this standard specification, except that a variable representing the deviation from PPP equilibrium is included. Per capita pork demand equations for the U.S. and Canada are hypothesized to depend on the deflated price of hogs, a logarithm of per capita real disposable income, a deflated index of beef prices, deviations from PPP, and a dummy variable for increased holiday consumption.

Population is incorporated into the equations by expressing income and consumption on a per person basis. This is consistent with most other studies and the underlying theory of consumer choice.

The specification of each equation is presented below, followed by a discussion of a priori expectations for the variables included in the equations.

The United States demand for consumption equation is:

$$UCON = \alpha_0 - \beta_1 DUHP + \beta_2 DUBI + \beta_3 LUSY + \beta_4 APPST + \beta_5 HDUM + \mu$$

where UCON is the per capita pork consumption; α_0 is the intercept; DUHP is the deflated price of hogs; DUBI is the deflated price index of beef and veal; LUSY is the natural log of per capita deflated disposable personal income; APPST is the deviation from PPP variable; HDUM is a dummy variable for holiday seasonal demand; and μ is an error term.

The Canadian demand for consumption equation is:

$$CCON = \alpha_0 - \beta_1 DECHP + \beta_2 DCBI + \beta_3 LCDY + \beta_4 APPST + \beta_5 HDUM + \beta_6 CDUM + \mu$$

where CCON is per capita pork consumption; α_0 is the intercept; DECHP is the deflated price of dressed hogs at Toronto; DCBI is the deflated price index of beef; LCDY is the natural log of per capita deflated disposable personal income; APPST is the deviation from PPP variable; HDUM is a dummy variable for holiday seasonal demand; CDUM is a data dummy variable; and μ is an error term.

4.4.2 Price and Substitutes

The price of pork and its price relative to other competing meats is hypothesized to influence consumer demand for pork. Beef is considered to be the primary substitute for pork and its price is hypothesized to directly effect consumer pork consumption.

Recent increases in poultry consumption in both countries has lead some to include the price of poultry in pork demand equations. Inclusion of retail poultry prices yields mixed results. Canadian specifications by Tryfos (1973) and Martin (1975) found it to be significant. Conversely, Pieri found retail poultry price to be insignificant. On the other hand, MacAulay did not include it in either the U.S. or Canadian equation. When in U.S. specifications, mixed results have also been reported. These results suggest that poultry may not be as significant a substitute for pork as some have thought.

Trail estimations for this paper using a retail poultry price variable produced negative and insignificant coefficients. This could have been caused by multicollinearity problems or may suggest that poultry price is not as significant a factor in determining consumer demand for pork as once thought. Consumers' strong desires for leaner meats, such as poultry and fish, may make relative prices of pork and poultry less significant than in the past. Despite some

theoretical and empirical evidence suggesting its inclusion, the variable was excluded from the specification.

4.4.3 Disposable Income

Disposable personal income expressed in constant dollars is hypothesized to vary directly with per capita pork consumption. Increasing personal income enables consumers to allocate more of their limited income budget to pork purchases--increasing consumption. Decreasing personal income lowers consumption as consumers switch from costly meats, such as pork, to less costly meats or non-meat foods.

Chang (1977) discusses the selection of functional forms used in estimating U.S. meat demand. Based on his discussion, a log functional form was selected for the income variables. The logarithm of per capita disposable income approximates the relationship between consumer income and food consumption known as Engels Law. The law states that as consumer incomes rise the proportion of income spent on food purchases decreases. This ensures that income elasticity declines as consumer income increases, ie. the relationship between pork consumption and consumer income is curvilinear. Estimations by Pieri and MacAulay used this same approach; estimations by Cornell, Fuller (1961), and Tryfos are among those who did not use a log formulation.

4.4.4 Purchasing Power Parity

Pork demand is hypothesized to vary directly with deviations from PPP in the U.S. and indirectly in Canada. Positive PPP deviations should encourage Canadian pork

exports because Canadian dollar U.S. pork prices are greater than domestic prices. An increase in Canadian exports to the U.S. will increase U.S. pork supplies, which lowers U.S. prices (assuming the demand curve does not shift) and increases the quantity demanded.

For the United States, a positive (negative) deviation in purchasing power parity (APPST) should decrease (increase) prices and hence increase (decrease) consumption. Consequently, APPST is hypothesized to have a positive coefficient. For Canada, the opposite argument occurs. A positive (negative) deviation in PPP is hypothesized to increase (decrease) domestic prices and hence decrease (increase) consumption. Thus, APPST is hypothesized to have a negative coefficient in Canada.

4.5 Identity Specification.

4.5.1 Overview

A set of eight identities relate supply and demand equations and then relate them to trade. There are three supply, two demand, and three trade identities. The three supply identities convert slaughter numbers into total pork supply by weight. Demand identities convert per capita consumption into total consumption demand by weight. Trade identities relate consumption, production, storage stock changes, and trade with the "rest of the world."

These identities determine if either country has a surplus or a deficit of pork supplies. If a surplus occurs, the country is a net exporter to the other country since

exporting is assured by the accounting of the identities. Conversely, if a deficit occurs, the country must be a net importer from the other country. At equilibrium, net imports must equal net exports because the system is closed and trade with the "rest of the world" is treated as exogenous.

4.5.2 Identities

Supply

(1) USPP = NUHS x USASW

(2) CHS = WCHS x ECHS

(3) CDPP = CHS x CASW

where USPP is the total United States pork production; NUHS is U.S. commercial hog slaughter less Canadian hog imports; USASW is the U.S. average inspected slaughter weight; CHS is the total Canadian commercial hog slaughter; WCHS is Western Canada commercial hog slaughter; ECHS is Eastern Canada commerical hog slaughter; CDPP is total Canadian pork production; and CASW is the average Canadian inspected slaughter weight.

Demand

(4) USPC = UCON x USPOP

(5) CDPC = CCON x CPOP

where USPC is the total United States pork consumption; UCON is U.S. per capita pork consumption; USPOP is the population of the U.S.; CDPC is the total Canadian pork consumption; CCON is Canadian per capita pork consumption; and CPOP is the population of Canada.

Trade

(6) NPTUC = USSP - cUSPS - NUSEW - USPC

(7) NPTCU = CDPP - cCDPS - NCDEW - CDPC

(8) At equilibrium: |NPTCU| = |NPTUC|

where NPTUC is the net pork trade from the United States to Canada; NPTCU is the net pork trade from Canada to the United States; cUSPS is the change in U.S. pork stocks from the previous month; cCDPS is the change in Canadian pork stocks from the previous period; NUSEW is the net U.S. exports to the "rest of the world"; and NCDEW is the net Canadian pork exports with the "rest of the world."

FOOTNOTES

1. Pork is expressed in dressed weight and includes the dressed weight pork equivalent of hogs.

2. A detailed discussion of the Canadian Index 100 pricing and grading system and its comparison to the United States pricing and grading system can be found in Chabluk (1985).

3. Lags in hog supply response from biological and physical delays are defined and outlined by Sullivan (1976).

Chapter 5

Estimation and Data Procedures

5.1 Estimation Procedures

The simultaneous determination of pork price and demand for consumption requires the use of a simultaneous equation technique. Two stage least squares (2SLS), a limited information technique, was the estimation technique selected.[1] A full information technique, such as three stage least squares (3SLS) provides asymptotically more efficient estimates, but computer constraints prohibited its use.

Supply equations are solved using ordinary least squares (OLS), since pork supply is considered to be predetermined. Demand equations are estimated with a microcomputer version of Regression Analysis of Time Series, (RATS). Supply equations are estimated with Micro TSP.

Equations are estimated using monthly data from March 1976 to March 1985.[2] During this period U.S. and Canadian dollars floated against each other and tariffs on pork trade were minimal. Monthly data was selected over quarterly data for two reasons. First, to measure the deviations from PPP over a short adjustment period. Second, an econometric estimation using quarterly data would have been constrained by only 45 degrees of freedom.

Although, monthly data increases the degrees of freedom to 144, multicollinearity and autocorrelation problems increase. Consequently, first order autocorrelation, indicated by the Durbin-Watson test statistic, is corrected for using Cochrane-Orcutt estimation procedures.[3] Five of the seven equations required the procedure; Canadian demand for consumption (CCON) and storage stocks (CDPS) did not.

5.2 Data Procedures

Only special data handling procedures are covered in this section. Complete variable definitions including data sources can be found in Appendix B. Each variable definition includes: a brief description of the variable; any special methods used to compile the variable; units of measure; and data sources.

5.2.1 Canadian Data

Canadian data required the most attention. Generally, Canadian published data is less consistent and comprehensive than United States published data. Canadian data series occasionally required interpolation to fill in missing data points. Some series were derived due to a lack of a suitable published series.

Regional Canadian hog slaughter series ECHS and WCHS were derived since a suitable monthly series is unavailable. Regional federally inspected slaughter data is available, but is an unsuitable proxy for regional pork supply. It

excludes hogs exported and hogs slaughtered under provincial inspection. Thus, a complete regional series had to be derived.

Regional Canadian hog exports to the U.S. is unavailable on a monthly basis. Data are obtainable through the United States Department of Commerce, but on a weekly basis, through various ports of entry, and therefore, difficult to tabulate. To expedite, annual regional hog export figures reported by Livestock Market Review were used to derive monthly regional export figures. This was accomplished by using each regions' share of national annual exports through selected ports of entry, as a method to allocate national monthly hog export data between the two regions. These figures were added to the federally inspected slaughter series.

Provincial slaughter figures are only available annually. To account for provincial slaughter, annual figures were divided by twelve and added to monthly federal slaughter figures. Data bias should be minimal since provincial slaughter is generally less than two percent of the total slaughter and relatively constant.

Finally, monthly federally inspected hog slaughter data presented yet another problem. In the series, slaughter numbers increase every March, June, September, and December without exception (Figure 21). These are the last months of their respective quarters and perhaps increase due to reporting procedures. To account for this regular occur-

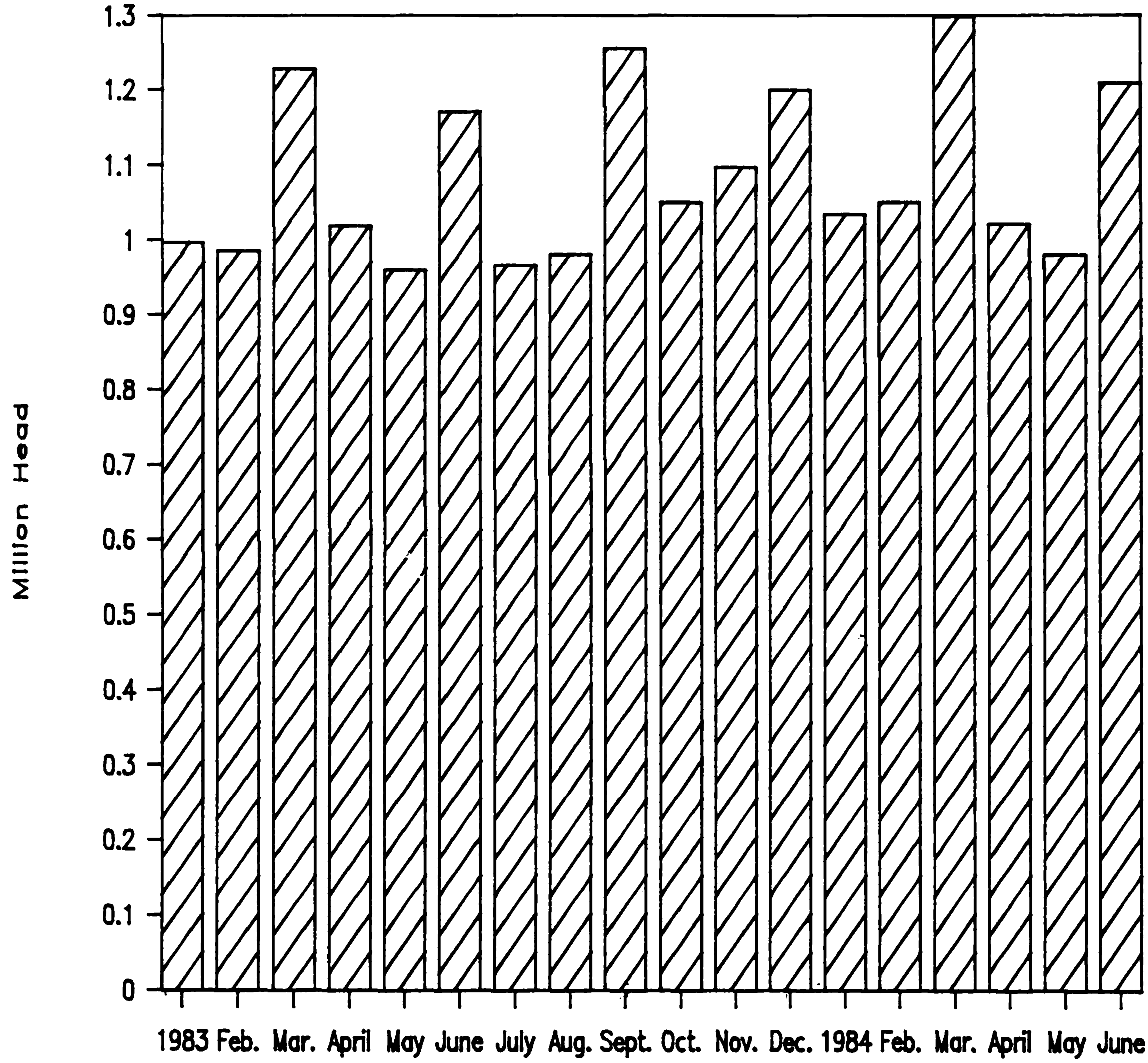


Figure 21. Canadian Commercial Hog Slaughter, 1983.01-84.06

rence, a dummy variable (CDUM) was created and placed in the demand for consumption and supply response equations. CDUM is constructed so that a one occurs in each of these months and zero in the remaining months.

Per Capita Pork Consumption

Only annual Canadian per capita pork consumption figures are published by either Agriculture Canada or Statistics Canada. Therefore, the series for monthly per capita pork consumption (CCON) was derived using a balance sheet approach. The balance sheet approach functions by first summing the quantities of production, imports, and beginning pork stocks. Next export volume and closing stocks are subtracted, with the difference being the amount consumed (divided by population yields per capita pork consumption). All data used in the calculation are monthly, except population data which are only available quarterly.

5.2.2 U.S. Data

To calculate absolute PPP at U.S.-Toronto (APPST) and absolute PPP at U.S.-Winnipeg (APPSW), U.S. hog prices were converted from a live weight to their dressed weight or carcass weight equivalent by a 0.77 conversion factor. Agriculture Canada in Market Commentary uses this same conversion factor.

United States per capita pork consumption data is available quarterly, but not monthly. To expedite, quarterly figures were used as proxies for a monthly series since manually deriving monthly figures with the balance sheet method is costly.

FOOTNOTES

1. In the statistical package RATS, 2SLS functions by first creating instruments for endogenous price variables DUHP and DECHP in the first stage of the procedure. This is accomplished by regressing, with ordinary least squares (OLS), the two price variables on all predetermined variables in the system of equations. The two newly created variables from the first stage then replace the original price variables in the estimated equations. OLS is used as the estimating technique. Computer printouts of the first stage procedure and regressors used are displayed in Appendix C.

2. Estimations begin in 1976 and not in 1973 , since a 30-month lag period had to be observed for supply equation estimations.

3. First difference techniques were tried, but did not correct serial correlation problems.

Chapter 6

Model Results

6.1 Results Overview

Model results support the hypothesis that slow adjustment of prices to exchange rate changes (PPP deviations) in the U.S.-Canadian hog/pork market have influenced supply and demand conditions in the market since 1977. However, results suggest that PPP deviations have not been a dominating factor in increasing production or expanding trade between the two countries.

Results indicate that deviations from purchasing power parity have had a positive influence on Canadian production. In the Canadian equation, both of the purchasing power parity variables (APPST, APPSW) are inelastic, with APPSW in the Western Canada equation being less inelastic at 0.18. This suggests that a one percent increase in PPP deviations yields a 0.18 percent increase in hog production.

The coefficient on the PPP variable in the Western Canada equation (APPSW) indicates that a 0.1 increase in positive deviation will increase hog production by 7,598 head or 1.6 million pounds per month. This represents roughly 2.5 percent of monthly Western production or 12 percent of monthly U.S. exports in 1985. For Eastern Canada, the response is 5,202 head or 1.1 million pounds per

month. This figure represents roughly 1.0 percent of 1985 Eastern Canada production or 3.5 percent of 1985 exports to the U.S.

Model results support the hypothesis that Canada is a small country relative to the United States, that its production is affected by PPP deviations more than the United States. This is evidenced by the fact that the PPP variable is insignificant at the five percent level in all of the U.S. equations and is highly inelastic.

The hypothesis that PPP deviations are a major factor increasing Canadian production and increasing exports to the U.S. is not supported by estimation results. On the other hand, results suggest that price adjustment lags have influenced Canadian hog production and exports to the United States, particularly production and exports of Western Canada.

Another significant estimation result is that in both countries, demand for consumption is more price inelastic than previous studies have reported. This suggests that a change in price does not have as great an impact on the amount of pork consumed as in the past. Results also indicate that consumers' income may no longer significantly influence pork demand for consumption.

The hog price variables in the Eastern Canada and the U.S. supply response equations are also more inelastic than previous studies have reported. This may be the result of

using real hog prices instead of nominal prices or it may reflect the growing concentration of pork production occurring on large scale specialized farms.

Most signs on variable coefficients are consistent with a priori information. Only income variables in the demand for consumption equations and the PPP variable in the United States supply response equation did not exhibit expected coefficient signs.

The coefficient of determination (adjusted R^2) for some equations is lower than earlier studies have reported. Lower values are reported because most previous specifications include lagged dependent variables. Including lagged dependent variables would have undoubtedly increased the adjusted R^2 of some equations, but only the demand for storage equations had a strong theoretical justification to do so.

Monthly data likely increased the presence of first order autocorrelation (serial correlation). With monthly data, underlying changes occur slowly, so adjacent time periods tend to be similar (error terms tend to be highly correlated). Serial correlation was corrected by using the Cochrane-Orcutt iterative procedure. Only the Canadian demand for consumption (CCON) and the demand for storage stocks (CDPS) did not require the procedure.

6.2 Elasticities

The chapter continues with a review of mean-average elasticities. Mean-average elasticities are presented for the seven estimated equations in Table 10. The presentation requires several caveats. First, in a set of simultaneous equations, such as the demand for consumption and the demand for storage equations, computed elasticities are only partial elasticities. Second, some elasticities are computed with insignificant coefficients and hence are unreliable estimates. Finally, comparisons to other studies can be misleading since elasticities reported here are based on deflated values.

PPP Elasticities

The deviations from purchasing power parity variable APPST is highly inelastic in the demand for consumption and the demand for storage equations. This is somewhat anticipated since the demand equations, particularly the United States equation, are less affected by PPP deviations. In the Canadian supply equations, APPST and APPSW are inelastic, with elasticities of 0.04 for the Eastern region and 0.18 for the Western region. The elasticities suggest that Western supply is more responsive to PPP deviations than Eastern supply. The highly inelastic APPST in the U.S. equation was anticipated since PPP deviations were expected to have only a small influence on the large U.S. production function.

Table 10. Mean Average Elasticities*

	United States	Canada	Western Canada	Eastern Canada
Supply Response				
Hog Price	0.179#		0.595#	0.043
Feed Price	-0.229			-2.441
Cattle Margin			-0.529	
Grain Stocks			0.120	
PPP	0.008#		0.178	0.037
Demand for Consumption				
Hog Price	-0.304	-0.410		
Beef Price	0.342	0.339		
Log of Income	-3.031	-4.149#		
PPP	0.0007#	-0.002#		
Demand for Storage Stocks				
Slaughter Volume	0.300	0.013#		
Hog Price	-0.146	-0.011#		
PPP	0.000#	0.002#		

* Mean average values of variables calculated with data from March 1973 through March 1985.
# Elasticities based on a coefficient estimate that is not significant at the five percent level.

PPP variables in the demand for storage equations is highly inelastic. The inelasticity indicates that storage demand is not greatly affected by changes in PPP deviations.

Demand Elasticities

Estimates of United States pork demand have generally indicated that demand is less price elastic than in the past. Hayenga (1985) provides a review of demand and supply elasticities estimates for the U.S. His review shows that farm level price elasticities estimates, using annual data through 1980, are now as low as -0.45. Using quarterly data, Martin's (1975) study provides an estimate of -0.37. The deflated hog price elasticity of -0.30 reported in this paper suggests that demand is continuing to become less price elastic.

A similar conclusion can be drawn from results of the Canadian demand equation. The deflated hog price elasticity of -0.41 is less than the -0.47 value reported by Martin.

The cross-price elasticity of deflated retail beef price indexes is similar in both the U.S. and Canadian equations. Elasticities of 0.342 and 0.339 compare closely to values found in studies using nominal indexes, which generally range from 0.15 to 0.50.

Most studies have reported positive disposable income elasticity of demand between 0.30 and 0.85, but negative relationships have been reported using data from the 1950s. This paper differs by using real disposable personal income

and reports highly elastic and negative elasticities in both countries. This result is of concern and merits further investigation.

Canadian demand for storage elasticities are highly inelastic. In the U.S. equation, the hog price elasticity is -0.14 and the slaughter volume elasticity is 0.30. These results suggest that these two variables significantly affect the level of storage stocks in any given month.

Supply Response Elasticities

Estimations yielded a hog price elasticity of 0.18 for the U.S. supply response equation and 0.043 for the Eastern Canada equation. These estimates compare to elasticities of 0.30 to 0.80 reported in previous supply response equations. The less elastic figures suggest that producers' supply response is less influenced by a change in price than in the past. Perhaps, growth of specialized and capital intensive hog production in both regions during the 1970s and 1980s accounts for the lower elasticity. Eastern Canada, in particular, now has a large percentage of its production occurring in specialized facilities which are often part of vertically integrated operations.

On the other hand, a price elasticity of 0.60 for Western Canada suggests that production levels are more responsive to price changes than the other regions. This is consistent with the previously mentioned theory, since Western Canada has a smaller percentage of its production occurring in modern specialized production facilities.

The elasticity of the deflated net cattle feeding margins variable (DCFM) in the Western Canada equation is higher than figures reported by previous studies using nominal values. Results suggest that a one percent increase in cattle feeding margins produces a 0.53 percent decline in hog supply response. Thus, profitability of competing cattle production is still a factor in these producers' production decision sets.

An elasticity for prairie grain stocks of 0.12 is less elastic than earlier quarterly studies by Martin (1975), 0.37, and MacAulay, 0.73. The lower figure suggests that Western production levels are less responsive to changes in grain stock levels than past studies have indicated.

Finally, the feed price variable in Eastern Canada (DECFI) and the United States (DUCPO) are both negative, but are quite different in value. The U.S. elasticity of deflated feed price (DUCPO) is −0.23, which is consistent with studies using nominal feed costs. However, the Eastern equation has a feed elasticity (DECFI) of −2.44, which suggests that supply response is very sensitive to feed price changes. A higher elasticity is expected since the region is largely dependent on outside feed supplies. However, an elasticity of this magnitude is questionable.

In summary, mean-average elasticities are generally consistent with other studies, except for income elasticity and the feed price index used in the Eastern Canada supply

response equation. Elasticities for PPP are highly inelastic in all equations, except for the two Canadian supply response equations.

6.3 Supply Response

A detailed presentation of estimation results follows in the next three sections and in Tables 11, 12, and 13. Included in each section is a summary of _a priori_ expectations, estimation statistics, important coefficients, and a comparison of results to other studies.

In the tables, coefficients are presented below the variables, followed by t-statistics in parenthesis and by mean-average elasticities in brackets. The standard error of the estimate is indicated by SEE and the sum of squared residuals by SSR. Computer generated estimation statistics are presented in Appendix C.

6.3.1 United States

Results for the United States supply response equation are presented in Table 11. Deflated hog price and corn price have hypothesized signs, the purchasing power parity variable does not. Only seasonal production dummy variables are significant at the five percent level.

Most previous studies, annual or quarterly, distributive lag or not, have shown hog price variables to be significant determinates of the level of hog supply response. This study failed to report this finding. Monthly data and the use of deflated prices might explain why the hog variable is insignificant here. Perhaps

Table 11. Estimated Supply Response Results

A) United States: NUHS

CONSTANT	DUCPO	DUHP	APPST	PDUM	DV4
6981.09	-0.077	0.370	29.84	422.05	353.45
(7.77)	(-1.94)	(1.54)	(1.44)	(2.66)	(2.10)
	[-.229]	[.179]	[.008]		

Sample Period: 3/76 to 3/85
Degrees of Freedom = 104
Durbin-Watson Statistic = 1.71

Adjusted R^2 = .53
SSR = 3325012.10
SEE = 186.11

B) Western Canada: WCHS

CONSTANT	PGRAIN	DWCHP	APPSW	DCFM	PDUM	CDUM
435.89	0.102E-3	0.00618	7.598	-0.0137	10.392	62.655
(7.62)	(5.39)	(1.10)	(10.57)	(-4.77)	(2.12)	(20.28)
	[.120]	[.595]	[.178]	[-.529]		

Sample Period: 3/76 to 3/85
Degrees of Freedom = 103
Durbin-Watson statistic = 2.10

Adjusted R^2 = .91
SSR = 31920.31
SEE = 17.77

C) Eastern Canada Supply: ECHS

CONSTANT	DECFI	DECHP	APPST	CORNPR	PDUM	CDUM
1563.68	-0.0097	0.129	5.202	0.00617	35.578	150.228
(7.82)	(-2.94)	(5.87)	(3.08)	(2.20)	(2.40)	(14.46)
	[-2.44]	[.043]	[.037]	[.908]		

Sample Period: 3/76 to 3/85
Degrees of Freedom = 103
Durbin-Watson statistic = 2.06

Adjusted R^2= .91
SSR = 319758.80
SEE = 56.26

Parenthesis = t-statistics.
Brackets = mean average elasticities.

producers are more responsive to nominal hog price changes than to changes in the real price (as used in this study), especially over the short time period of a month.

Multicollinearity between the price of hogs and the PPP variable might explain the insignificance of these two variables. Multicollinearity between these two variables could over-estimate or under-estimate the true parameter.

Results are unsupportive of the hypothesis of an inverse relationship between hog supply and PPP deviations. Failure to support the hypothesis is discounted somewhat because the variable lacks significance. Moreover, theory suggests that U.S. market size relative to the Canadian market should make the U.S. supply response less sensitive to exchange rate induced price differences than the Canadian supply response.

Estimation results do suggest that supply response is inversely related to corn prices. This finding compares favorably with results reported by Meilke (1977) using quarterly data from 1970 to 1975. Moreover, this result compares with studies by Martin (1975) and Pieri from the 1960s and 1970s using weighted average corn and soybean prices, which yielded insignificant coefficients, but with correct signs.

The poor performance (adjusted R^2 of 0.53) of the equation may be explained by the use of monthly data. Hayenga (1970) has indicated that monthly time series estimations of hog supply can lead to biased and inefficient

estimates. Monthly values are subject to bias due to differences in reporting procedures and calendar variations, such as the length of the month and the number working days per month. Monthly data variation is demonstrated in Figure 22, which graphs monthly U.S. hog slaughter numbers.

In summary, the U.S. supply equation did not perform as expected and could perhaps be improved. Failure of the equation to perform as expected may be the result of equation misspecification, multicollinearity among explanatory variables, or inaccuracy and bias associated with monthly data series.

6.3.2 Western Canada

Estimation results for the Western supply response equation are consistent with hypothesized expectations. All parameter estimates have the correct sign and are significant at the five percent level, except for the deflated price of hogs variable (DWCHP). The adjusted R^2 for the equation is 0.91, which compares with values of 0.92 to 0.96 reported in quarterly estimations by Meilke (1974), Pieri, Martin (1975), MacAulay, and Chin. These studies include a lagged dependent variable in their specifications, which is highly significant and likely improves adjusted R^2s.

The estimated coefficient on the purchasing power parity deviations variable (APPSW) strongly supports the hypothesis that positive (negative) PPP deviations have a positive (negative) influence on Western Canada production. The estimated coefficient has the expected sign and is

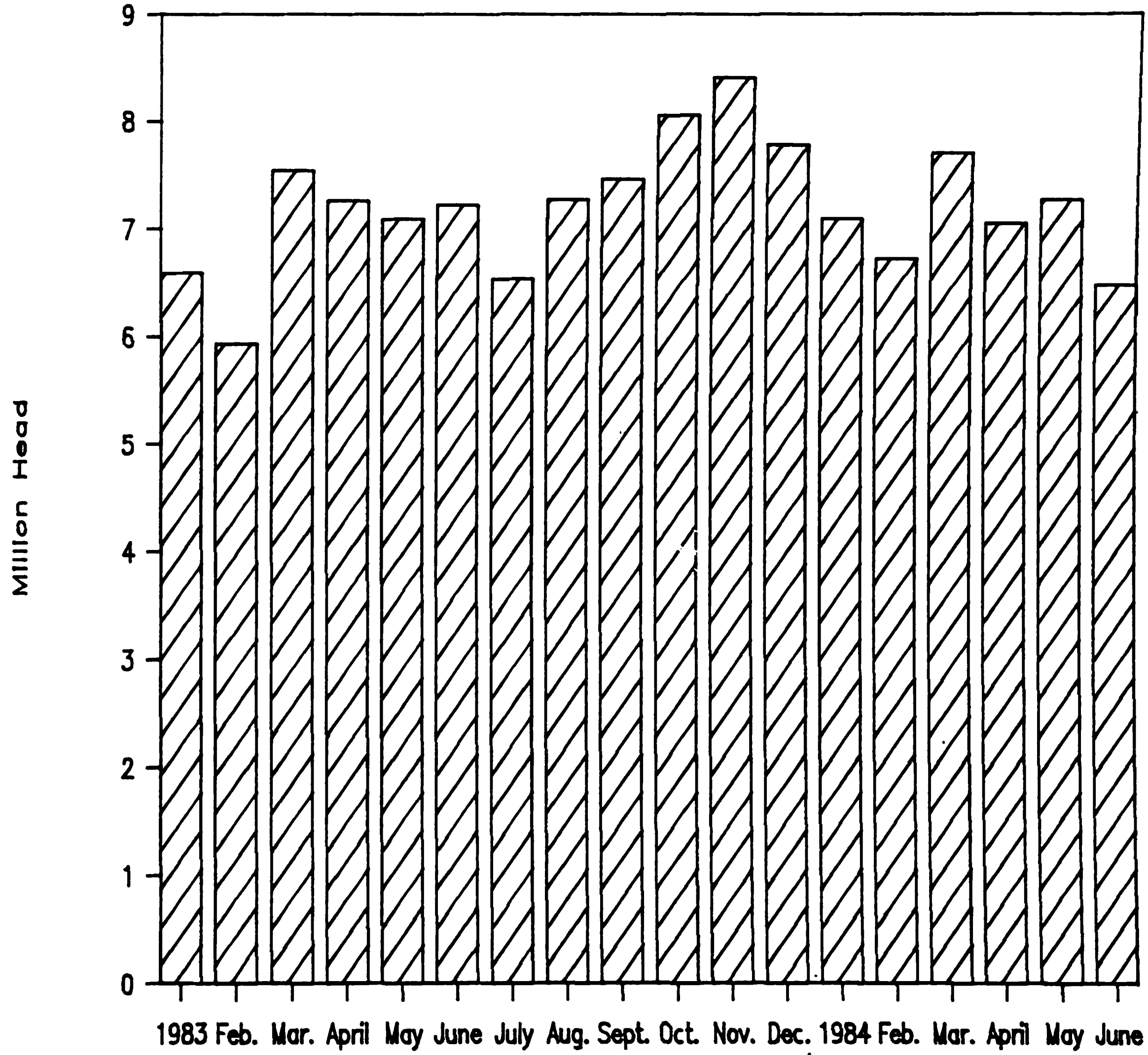


Figure 22. U.S. Commercial Hog Slaughter, 1983.01-84.06

highly significant, with a t-statistic of 10.57. The coefficient suggests that a 0.1 increase in positive deviation will increase hog production by 7,598 head or 1.6 million pounds per month.

The hypothesis that Western Canada hog production varies directly with on-farm prairie grain stocks is strongly supported by estimation results. Most estimations since Kerr (1968) first included the variable as a proxy for the opportunity cost of feeding grain, have used the variable and have reported similar results.

Results also strongly support the hypothesis that the deflated net margins from cattle feeding (DCFM) still represent an opportunity cost for hog producers in Western Canada. This finding is consistent with undeflated quarterly estimations by Martin (1975), Pieri, and Chin.

Finally, consistent with the above mentioned studies is the insignificant parameter estimate for hog price (DWCHP). This result suggests that hog production in Western Provinces remains a secondary enterprise; more dependent on the economies of prairie grain production and beef production than the price of hogs.

6.3.3 Eastern Canada

Estimation results strongly support the hypothesis that Eastern supply varies directly with deflated hog prices (DECHP), the purchasing power parity variable (APPST), corn production (CORNPR), and inversely with deflated feed costs

(DECFI). All these variables are significant at the five percent level.

All quarterly models which were reviewed include a lagged dependent variable in Eastern Canada supply response equations. Adjusted R^2 values in these models ranged from 0.79 to 0.96. An adjusted R^2 of 0.91 is reported here.

A variable representing deviations from PPP (APPST) and one representing corn production (CORNPR) have not been used in previous studies. Estimation results provide APPST with a high t-statistic, supporting the hypothesis that hog supply response during the period increased (decreased) when positive (negative) deviations from purchasing power parity occurred. The coefficient suggests that an additional 5,202 head or 1.1 million pounds of pork is produced when a 0.1 increase PPP deviation occurs.

The results further support the hypothesis that corn production in Eastern Canada (CORNPR) has a positive affect on hog production. One could argue that this finding was somewhat anticipated since the two data series follow similar trends. Both series increased during the 1970s, however, hog production leveled off in 1980, while corn production continued to trend up during the 1980s. Since corn production occurs annually, the use of annual production data in the estimation could have biased coefficient estimates.

6.4 Demand For Consumption

6.4.1 United States

High t-statistics strongly support the hypothesis that per capita pork demand for consumption (UCON) varies directly with deflated retail beef prices and inversely with deflated pork prices, as measured at the farm level (Table 12). Seasonal pork demand patterns represented by the dummy variable HDUM is also strongly supported by a high t-statistic.

The results support the hypothesis that per capita pork consumption (UCON) varies directly with deviations in purchasing power parity (APPST). However, the coefficient is only significant at the 10 percent level.

Estimation results using income as a variable usually report a positive and significant coefficient (at the five percent level). In other studies, most parameter estimations used nominal per capita disposable personal income. Parameter estimates based on nominal income are less meaningful, because this does not reflect its actual purchasing power. Here the logarithm of deflated per capita disposable income (LUSY) was found to be significant, but with a negative coefficient. This implies that increasing personal income lowers consumer demand for pork.

The importance of income in determining pork demand has been decreasing with time and might explain the negative parameter estimate. Pork consumption has declined when income levels have increased. This argument is supported by

Table 12. Estimated Demand for Consumption Results

A) United States: UCON

CONSTANT	DUHP	DUBI	LUSY	APPST	HDUM
31.8050	-0.2246	0.0613	-5.8759	1.5414	1.2250
(3.66)	(-14.08)	(8.07)	(-2.84)	(1.88)	(12.05)
	[-.304]	[.342]	[-3.031]	[0.001]	

Sample Period: 4/76 to 3/85 Adjusted R^2 = .83
Degrees of Freedom = 102 SSR = 13.9146
Durbin-Watson statistic = 1.60 SEE = 0.3693

B) Canada: CCON

CONSTANT	DECHP	DCBI	LCDY	APPST	HDUM	CDUM
28.6507	-0.0760	0.0169	-2.7603	-1.398	0.2671	1.4137
(1.43)	(-7.11)	(6.25)	(-1.15)	(-1.83)	(2.46)	(14.70)
	[.410]	[.339]	[-4.149]	[0.002]		

Sample Period: 3/76 3/85 Adjusted R^2 = .78
Degrees of Freedom = 102 SSR = 22.9260
Durbin-Watson statistics = 2.07 SEE = 0.4741

Parenthesis = t-statistics.
Brackets = mean average elasticities.

recent declining U.S. real pork expenditures (Figure 16) and declines in the percentage of income spent on pork products. Real per capita pork expenditures as a percentage of real per capita disposable income decreased from 1.47 percent in 1973 to less than 0.85 percent in 1985.

A Durbin-Watson statistic of 1.60 suggests that first order serial correlation could be a problem in the equation. This value is inside the indeterminate range of the test statistic.[1] The Cochrane-Orcutt estimation procedure designed to correct for the presence of serial correlation of the residuals was employed.

6.4.2 Canada

Estimation results for the Canadian per capita demand for consumption (UCON) equation are similar to the results for the United States equation. Signs on deflated hog price (DECHP) and deflated retail beef price (DCBI) are consistent with hypothesized expectations. Both variables have very high t-statistics. Canadian seasonal demand for pork is not as great as the U.S., however the dummy HDUM did prove to be significant.

Like the U.S. equation, the hypothesis that pork demand for consumption varies directly with real per capita disposable income (LCDY) is not supported. Unlike the U.S. equation, the parameter estimate is not significant at the five percent level. This finding is consistent with studies by Pieri, MacAulay, and Tryfos. Moreover, Tryfos, using annual data from 1954 to 1970, a linear functional form, and

nominal disposable income also found the income parameter to be negative and statistically insignificant.

Like the U.S., real expenditures on pork in Canada have been declining and so the same argument presented to explain the U.S. results can be applied to the Canadian results. Again, these results suggest that a real per capita disposable income variable may no longer be a factor in determining pork consumption demand.

Finally, the results support the hypothesis that the purchasing power parity variable (APPST) varies indirectly with per capita consumption. However, the coefficient estimate is lacking statistical significance.

6.5 Demand for Storage

6.5.1 United States

All estimated variables have coefficient signs which are consistent with hypothesized expectations. Cold storage stocks lagged one month ($USPS_{t-1}$), hog slaughter (NUHS), the deflated farm price of hogs (DUHP), and the stocks dummy variable (SDUM) are all significant at the five percent level (Table 13).

The coefficient sign on the deviations from purchasing power parity variable APPST is consistent with hypothesized expectations, but is highly insignificant. This result was expected since the volume and price influence of the Canadian market on U.S. storage demand is considered to be minimal.

Table 13. Estimated Demand for Storage Results

A) United States Demand for Storage Stocks: USPS

CONSTANT	USPS(-1)	NUHS	DUHP	APPST	SDUM
17880.31	0.7240	10.845	-1693.3	104.68	28894.6
(0.56)	(13.97)	(2.73)	(-2.08)	(0.003)	(5.54)

Sample Period: 7/75 to 3/85
Degrees of Freedom = 101
Durbin-Watson statistic = 1.67

Adjusted R^2 = .81
SSR = 35873998300.0
SEE = 18846.431

B) Canadian Demand for Storage Stocks: CDPS

CONSTANT	CDPS(-1)	CHS	DCHP	APPST	DV2	DV3
7.9546	0.7547	0.0004	-0.0105	-6.3020	-1.1188	-2.6244
(2.24)	(12.37)	(0.23)	(-.19)	(-1.85)	(-1.94)	(-4.78)
		[0.013]	[0.011]	[0.002]		

Sample Period: 4/76 to 3/85
Degrees of Freedom = 101
Durbin-Watson statistic = 1.95

Adjusted R^2= .70
SSR = 514.32
SEE = 2.2566

Parenthesis = t-statistics.
Brackets = mean average elasticities.

A Durbin-Watson statistic of 1.70 suggests that first order serial correlation could be a problem in the equation. The statistic value is inside the indeterminate range of the test statistic despite the use of Cochrane-Orcutt estimation procedures.

An adjusted R^2 of 0.81 for the equation is lower than many values reported by quarterly models, which generally range from 0.83 to 0.89. The dummy variable SDUM used as a proxy for seasonal stocking patterns may not be sufficient to account for seasonal stock adjustments. Use of more dummies might have improved the fit of the equation.

In summary, the equation suggests that storage levels vary directly with past storage levels, seasonal storage patterns, and current slaughter volume; indirectly with the price of hogs. Estimation results do not suggest that deviations from PPP influence storage stock demand.

6.5.2 Canada

Estimation results support the hypothesis that month end cold storage pork stocks (CDPS) vary directly with slaughter level (CHS) and with the previous month's stocks ($CDPS_{t-1}$), and indirectly with deflated farm price of hogs (DECHP). However, only $CDPS_{t-1}$ and the dummies for seasonal stocks, DV2 and DV3, are significant at the five percent level.

The deflated hog price variable and the slaughter volume variable are highly insignificant in the model. The presence of multicollinearity between the PPP variable and

the price variable might account for the insignificance. Lack of significance of these variables, particularly slaughter volume, is of concern and merits further investigation. Perhaps better proxies for speculation (price) and transaction demand (slaughter level) could improve equation performance.

The hypothesis that CDPS is indirectly related to purchasing power parity deviations (APPST) is supported by the results, but only at the ten percent level. Results suggest that positive PPP deviations (Canadian pork export prices exceeds import prices) encourage excess inventory to be exported to the United States.

In summary, estimation results suggest that storage demand in Canada is largely a function of past storage levels and seasonal storage patterns. Better dummies for seasonal stock patterns might improve the coefficient of determination, which is only 0.70. Unlike the demand for consumption and supply response equations, monthly data does not provide an explanation for the relatively poor statistics in the storage equations, since stocks adjust quickly to market changes.

FOOTNOTES

1. The indeterminate range for Durbin-Watson (d.w.) test with five explanatory variables and 102 observations is: $1.57 \leq d.w. \leq 1.78$. If the d.w. statistic is below this range then the null hypothesis of no first order serial correlation is rejected.

Chapter 7

Policy Implications and Future Research

7.1 Some Policy Implications

Model results suggest that slow adjustment of prices to exchange rates or 'sticky prices' between the U.S. and Canadian markets have had an influence on the supply and demand conditions of the U.S.-Canadian hog/pork market from 1976 to 1985. There is a range of factors which can influence the speed of adjustment of hog/pork prices to exchange rates between the two countries as measured by deviations from purchasing power parity. Some of these factors include: macro-economic variables, bilateral trade laws, exchange rate policy, and agricultural policies and other public policies.

Monetary and fiscal policies, ultimately affect the relationship between bilateral exchange rates and price levels. How monetary policy can affect the level of PPP deviations is demonstrated in the pursuit of different monetary policies by the United States and Canada after 1976. For example, during the early 1980s, the U.S. Federal Reserve followed a policy of restrained money growth in order to combat inflation. While the Canadian government pursued a more accommodative monetary policy designed to encourage growth in a stagnating economy. Different monetary policies among other factors contributed to the

depreciation of the Canadian dollar relative to the U.S. dollar and, therefore, influenced the level of deviations from PPP.

Deviations from PPP occur because monetary adjustments by either country quickly influence capital markets and the value of the U.S.-Canada exchange rate. However, the adjustment of U.S.-Canadian hog/pork prices and input prices to exchange rate changes often lag for long periods of time (long-term PPP deviations).

There are a number of domestic agricultural policies which could possibly explain (some of these explanations were outlined in Chapter 2) the failure of U.S.-Canadian hog/pork prices and exchange rates to hold to their purchasing power parity equilibrium. Explanation examples include various hog producer income stabilization programs of the Canadian government. These programs are designed to assist producers or to stabilize domestic production and producer income via prices, but they tend to isolate producers' production decisions from changes in the U.S. market. Examples of such producer income stabilization programs include the Agricultural Stabilization Act of 1975 at the federal level and numerous provincial hog stabilization programs.

Other Canadian programs which assist hog producers with production costs include feed transportation assistance and credit subsidization programs. These type of programs can provide producers with a comparative advantage in trade

which is based on government assistance and not on technological or productive advantages. These Canadian policies can also isolate producers' decision sets from market signals that come to them via prices adjusted by exchange rates. If this is the case, then policies designed to stabilize production via domestic prices can be negated.

As the volume of hog/pork trade has expanded in recent years, the importance of coordinated hog/pork trade policy and agricultural trade policy between the two nations becomes more important. Currently, there is no coordination of these policies. Trade policies, which create tariffs and quotas, obviously could have a direct impact on the level of deviations from PPP found in the U.S.-Canadian hog/pork market.

The results of this study and presence of long-term deviations from purchasing power parity suggest that commodity arbitrage is not as complete as in the past. This implies that the U.S.-Canadian hog/pork market may not be as closely integrated as once thought, perhaps due to past policies. Lack of complete integration would be expected of a non-tradable commodity, good, or service. Despite some trade barriers, pork and hogs should not be considered a non-tradeable.

In conclusion, an important policy implication of the presence of PPP deviations occurring in the U.S.-Canadian hog/pork market is that consistent trade and domestic policies between the trading partners is important for

efficient market performance. If this does not occur then efficiency is not maximized and resources are misallocated. This same conclusion can be applied to other markets, to other countries, and to other goods and services as well.

7.2 Limitations and Future Research

There are several suggestions for improving this research and suggestions for future research. First, it would be valuable to know whether this paper's results are unique to the U.S.-Canadian hog/pork market or whether other agricultural commodities exhibit the same relationship. Despite beef and cattle trade being more restrictive, this similar homogeneous commodity could also be modeled to determine if deviations from PPP exhibit the same effects as reported here. Still other studies could construct models of various agricultural commodity groups to determine the relationship between PPP deviations and these broader groups.

Second, it was evident from reviewing existing PPP studies of non-agricultural goods and commodities, that further empirical studies of these markets would benefit the general body of knowledge concerning purchasing power parity. However, the presence of import quotas, tariffs, and other trade restrictions could limit the usefulness of such empirical studies. U.S.-Canadian hog and pork trade has been relatively free of these trade distortions.

Third, enhancing the value of this paper's conclusions, would be an investigation of PPP deviations found in the

markets for inputs used in hog production. It would be useful to know whether, and to what extent, the speed of adjustment of relative input prices to exchange rate adjustments is the same as the adjustment speed of pork prices. The analysis used in this paper assumes that the pork market is more integrated than input markets, especially non-tradeable inputs. Whether this is a valid assumption or not, would be valuable to this model's results and to future models.

Econometric Suggestions

Methods to improve econometric estimations are presented next. First, a full information estimation technique, such as three-stage least squares (3SLS), might have improved the estimates. 3SLS generally provides asymptotically more efficient estimations than the two-stage least squares (2SLS) technique. Computer software constraints prohibited using the 3SLS technique here.

Second, a quarterly model might alleviate serial correlation problems and provide more efficient estimates than the monthly model used here. Quarterly data would also: reduce data tabulation problems, eliminate most assumptions required in compiling the data, and diminish data reporting discrepancies. However, quarterly data limits the degrees of freedom and it might not fully capture the price-exchange rate relationship.

Third, although more costly, treating the "rest of the World" as endogenous could increase the model's value for

certain applications. This could effectively be accomplished by including Japan, Denmark, and perhaps another major pork trading country or region.

Fourth, estimation statistics for the United States supply response equation were generally poor and could be improved. One explanation for these results might be the use of monthly data, which has more noise and random disturbances than quarterly data. Also, the U.S. supply response and the Canadian supply response equations might be improved if a shorter distributive lag length was selected, perhaps a length of 24 or 26 months. Finally, a single supply response equation may not adequately capture the dynamics of the U.S. hog/pork market.

Fifth, a better proxy for speculation demand and the transaction component is needed in the demand for storage equations, particularly the Canadian equation. Other studies have tried different approaches to represent speculation demand, results of these studies are not always consistent. Including variables for export and import volume as regressors in the equation might also improve these equations.

Sixth, a poultry price index was dropped from both demand for consumption equations for econometric reasons. Whether this was correct or not is debatable, but further analysis of its relevance in pork demand for consumption equations would be valuable.

Finally, running simulations of the estimations would have tested the model's historical validity. Moreover, simulations would have provided comparisons of actual versus estimated results.

Chapter 8

Summary

From 1977 through 1985, Canadian hog/pork exports to the United States expanded by 1800 percent, while United States exports to Canada declined rapidly to insignificant levels. The expansion and shift in trade volume occurred while diverging supply and demand conditions between the U.S. and Canadian markets were taking place. Prior to the early 1970s, these conditions had traditionally been very similar and only diverged after the Canadian and U.S. dollars were allowed to float in 1973. Under the floating exchange rate system, the Canadian dollar depreciated against the U.S. dollar from 1977 to 1985--losing over 30 percent of its value during this period.

This paper has attempted to answer questions regarding the influence of exchange rate adjustments on the North American hog/pork market. More specifically, it tries to explain whether adjustment lags of hog prices ('sticky prices') to currency exchange rate changes have affected the relative supply and demand functions in both countries, and hence influenced U.S.-Canadian hog/pork trade volume since 1976.

To represent the relationship between price and currency exchange rate adjustment, aspects of purchasing power parity (PPP) theory are utilized in this research.

More specifically, the concept of deviations from PPP (an equilibrium condition) is used to quantify the influence, if any, which lags in the speed of adjustment of prices to exchange rates have had on the U.S.-Canadian hog/pork market.

To quantify the influence of these adjustment lags, a structural econometric model of the North American hog/pork market was constructed. The theoretical framework for the model is based on concepts found in supply-demand trade models and spatial equilibrium models. The model consists of seven behavioral equations (three supply response, two demand for consumption, two demand for storage) and eight identities, and is estimated from March 1976 to March 1985--a period of relatively few tariffs and a floating exchange rate. A two-stage least squares (2SLS) estimation procedure was used to estimate the model since hog price and the quantity of pork demanded is simultaneously determined.

The model's system of seven behavioral equations is unique from past models of the U.S.-Canadian hog/pork market for three primary reasons. First, the model accounts for the relationship between prices and exchange rates by including a variable which measures deviations from PPP. Second, the model is estimated using monthly instead of quarterly or annual data. Finally, all price series used in the model are deflated. Previous hog/pork supply-demand estimations have used nominal price series.

In general, estimation results are consistent with hypothesized expectations. Results support the hypothesis that deviations from purchasing power parity have influenced supply conditions in the U.S.-Canada hog/pork market since 1977. Specifically, estimations indicate that PPP deviations increased Canadian production and hence expanded Canadian exports to the U.S.

Elasticities estimates for the Canadian supply response equations indicate that deviations from PPP have a greater influence on Western Canada production than Eastern Canada production. The purchasing power parity variables are inelastic in both Canadian supply response equations, with an elasticity of 0.18 reported for the Western Canada equation.

The coefficient on the PPP variable in the Western Canada equation indicates that a 0.1 increase in positive deviation will increase hog production by 7,598 head or 1.6 million pounds per month (other things being equal). For Eastern Canada, the response is 5,202 head or 1.1 million pounds per month. In 1985, these increases would represent roughly 2.5 percent of monthly Western production or 12 percent of Western monthly U.S. exports and roughly 1.0 percent of Eastern monthly production or 3.5 percent of Eastern exports to the U.S. Furthermore, the same 0.1 increase in PPP deviation would increase supply response by an amount equal to 6 percent of the change in Canadian exports that occurred during the estimation period.

Model results support the hypothesis that since Canada is a small country relative to the United States, that its production will be affected by PPP deviations more than the United States. The PPP variable in all the United States equations and the two Canadian demand equations was insignificant at the five percent level.

There are some other estimation results which are important and could indicate that structural changes are occurring in the two markets. First, the coefficient estimates for the hog price variables in the demand for consumption equations in both countries are more inelastic than previous studies have reported. This suggests that price has a smaller influence on the amount of pork consumers demand.

Second, the hog price variables in the Eastern Canada and the U.S. supply response equations are more inelastic than previous studies have reported. However, a higher elasticity was reported for the Western Canada supply response equation, which was comparable to past studies. The higher elasticity for the Western equation was anticipated since production there tends to be on smaller more diversified farms. Third, elasticities of the other variables used in the model were generally more inelastic than many previous studies have reported.

Finally, the presence of PPP deviations and their affect on supply and demand conditions and trade has implications toward trade policy, agricultural policy, and

macro-economic policy. If such policies cause prices to adjust slowly to exchange rate changes, markets will perform less efficiently.

APPENDICES

APPENDIX A

World Dressed Pork Trade

Dressed pork trade with countries outside of North America is significant for both the United States and Canada. Canadian exports go primarily to Japanese markets. Dressed pork trade of the U.S. is primarily with Japan and European nations.

Specific aggregate world trade is discussed in the following two sections. The discussion is limited to dressed pork trade because slaughter hog trade occurs only between the U.S. and Canada.

United States

Traditionally, the United States has been a net importer of dressed pork with countries other than the Canada (Figure 23). During the 1970s pork imports remained relatively flat, while exports expanded. By 1981, U.S. pork exports peaked at 412 million pounds, exceeding imports by 45 million pounds. After peaking, annual exports declinned by 170 million pounds in the following years.

Much of the decline occurred from reduced sales to the large Japanese market, but declines in smaller markets, such as Mexico, were also significant. Reduced export volume may have been influenced by U.S. dollar appreciation against world currencies and the World economic recession of the

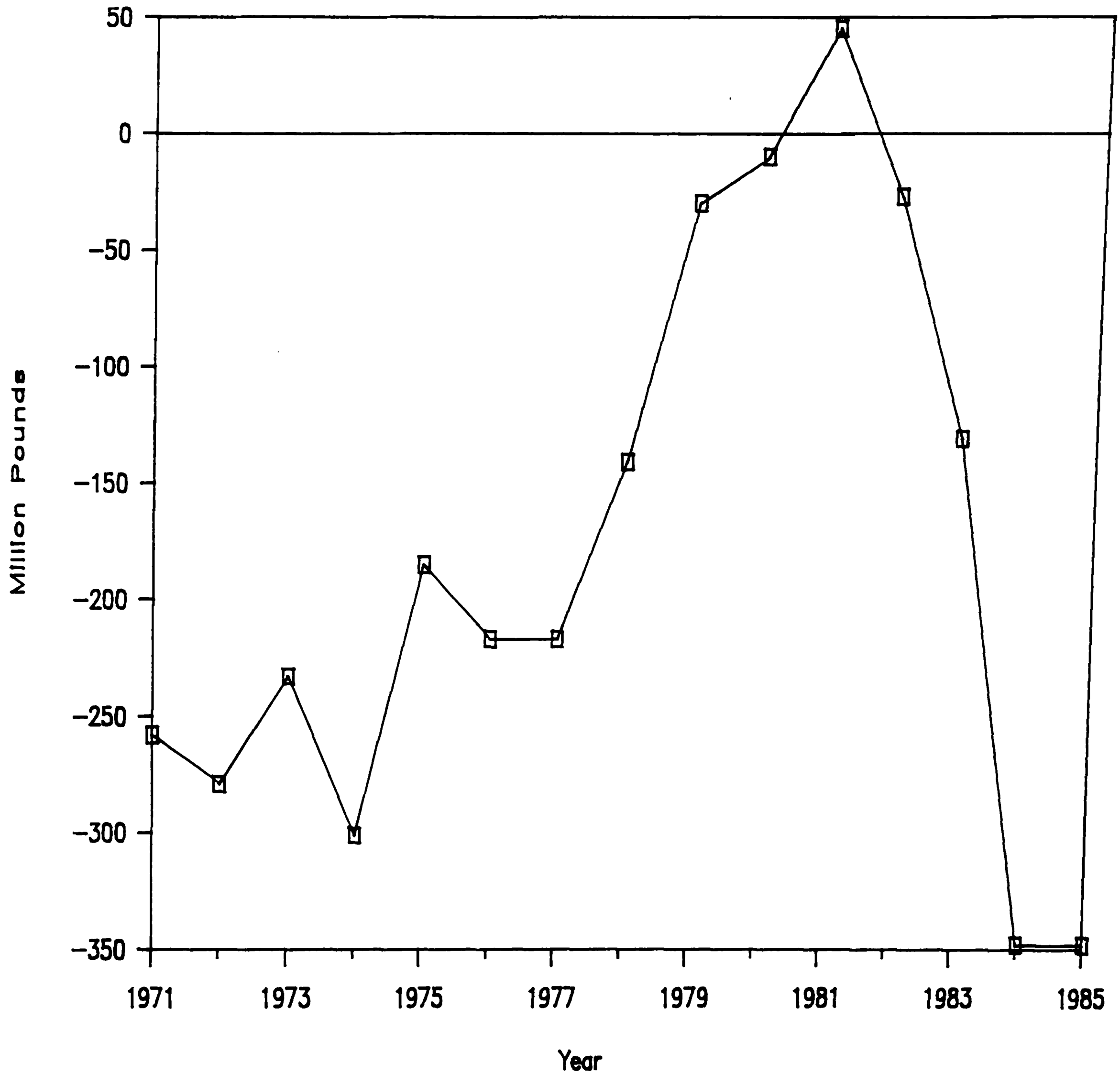


Figure 23. U.S. Net Pork Exports (Excludes Canada), 1971-85

early 1980s. Exports remain a relatively small portion of domestic production volume, ranging from one percent to three percent (Table 4).

Imports increased by 230 million pounds or 65 percent in the four years following 1981. The increase in imports came primarily from Poland, the Netherlands, and particularly from Denmark. Dressed pork imports from these and other countries are usually processed products, often carrying brand names. In the 1980s, Denmark has shipped relatively large quantities of frozen pork carcasses and sides.

Increasing imports from Denmark gained the attention of the same groups that requested the countervailing duty investigation of the Canadian pork industry. An investigation of the Denmark industry was, however, not initiated. Total dressed pork imports as a percent of total consumption was stable for most of the period, with increases beginning only after 1981 (Table 4).

Canada

Traditionally, Canada has been a net exporter of dressed pork with markets other than the United States (Figure 24). Pork imports are insignificant, exceeding 10 million pounds in only four years since 1971. World exports have been more a important component of total Canadian pork trade, ranging 42 to 111 million pounds since 1971. Most exports go to Japan.

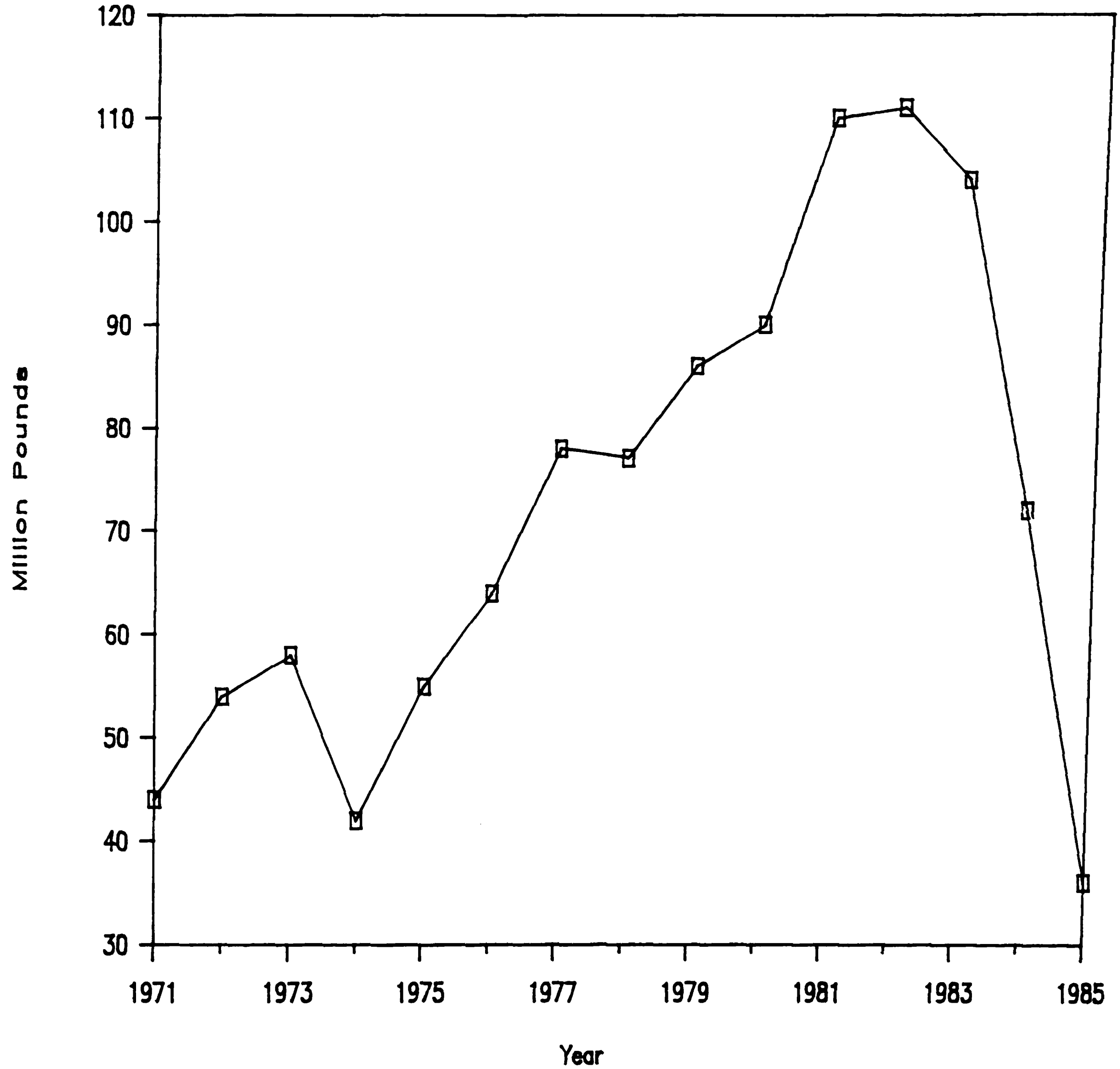


Figure 24. Canadian Net Pork Exports (Excludes the U.S.), 1971-85

Canadian dressed pork exports trended up during the 1970s, peaking at 111 million pounds in 1982. After peaking, exports dropped until by 1985 they were nearly 50 percent below the peak. A decline in Japanese exports accounts for most of the drop.

Canadian dressed pork shipments to Japan are mostly fresh or frozen classifications. Japanese export volume has ranged from 29 million pounds to 96 million pounds or from roughly two and five percent of production (Figure 10). From 1975 through 1978, export volume to Japan exceeded export volume to the United States. The Japanese and the U.S. pork markets account for over 90 percent of annual Canadian dressed pork export volume.

Usually more than 90 percent of Canadian dressed pork imports come from the United States. Therefore, trends in total pork imports closely resembles the pattern of pork imports from the U.S. Imports from countries other than the U.S. are mainly branded or specialty pork products. European countries supply most of this trade.

APPENDIX B

Model Definitions

Endogenous Variables

CCON = Canadian per capita pork consumption. Derived from monthly balance sheet figures (CDPP + the change in CDPS + NCDEW + NPTCU) / CPOP. Carcass weight pounds per capita. Agriculture Canada, Livestock Market Review and Livestock and Meat Trade Report. Statistics Canada, Livestock and Animal Products Statistics, Estimates of Population of Canada by Provinces by Quarterly Periods, Trade of Canada, Exports by Commodities, and Trade of Canada, Imports by Commodities.

CDPS = Canadian month end cold storage pork stocks. Thousand carcass weight pounds. Agriculture Canada, Market Commentary and Statistics Canada, Livestock and Animal Products Statistics.

$DECHP_t$ = Deflated Eastern Canada hog price in the current period t. Toronto Index 100 average hog price. Dollars per dressed hundred weight, deflated by the Canadian Consumer Price Index, CPI-All Items, base 100 = June 1972. Agriculture Canada, Livestock Market Review. Statistics Canada, The Consumer Price Index.

$DUHP_t$ = Deflated United States hog price in the current period t. Weighted average live price of all weight classes of barrows and gilts at seven central U.S. markets. Dollars per hundred carcass weight, deflated by the U.S. Consumer Price Index, CPI-W after 1978, CPI-U before 1978, base 100 = June 1972. U.S. Department of Agriculture (USDA), Livestock and Meat Statistics, 1983, and Livestock and Poultry Outlook and Situation Report. U.S. Department of Commerce, Survey of Current Business.

$DWCHP_t$ = Deflated Western Canada hog price in the current period t. Winnipeg Index 100 average hog price. Dollars per dressed hundred weight, deflated by the Canadian Consumer Price Index, CPI-All Items, base 100 = June 1972. Agriculture Canada, Livestock Market Review. Statistics Canada, The Consumer Price Index.

ECHS = Eastern Canada commercial hog supply response. Commercial inspected hog slaughter in Eastern provinces plus hog exports to the United States. Thousand head.

Agriculture Canada, Livestock Market Review and Livestock and Meat Trade Report. Statistics Canada, Livestock and Animal Products Statistics.

NUHS = Net United States commercial hog supply response. U.S. commercial inspected hog slaughter less hogs imported from Canada. Thousand head. USDA, Livestock and Meat Statistics,1983 and Livestock and Poultry Outlook and Situation Report.

UCON = United States per capita pork consumption. USDA derived balance sheet quarterly figures. Carcass weight pounds per capita. USDA, Livestock and Meat Statistics,1983 and Livestock and Poultry Outlook and Situation Report.

USPS = United States end of month cold storage pork stocks. Thousand carcass weight pounds. USDA, Livestock and Meat Statistics, 1983 and Livestock and Poultry Outlook and Situation Report.

WCHS = Western Canada commercial hog supply response. Commercial inspected hog slaughter in Western provinces plus hog exports to the United States. Thousand head. Agriculture Canada, Livestock Market Review and Livestock and Meat Trade Report. Statistics Canada, Livestock and Animal Products Statistics.

Exogenous and Predetermined Variables

APPST = Absolute purchasing power parity measure of UHP and ECHP. Equation: UHP/ECHP - exchange rate (U.S. dollars per Canadian dollar). UHP and ECHP are undeflated values of DUHP and DECHP. U.S. live weight price converted to dressed carcass weight price by a conversion factor of 1.23. Exchange rates from the U.S. Federal Reserve Board, Federal Reserve Bulletin.

APPSW = Absolute purchasing power parity measure of UHP and WCHP. Equation: UHP/WCHP - exchange rate (U.S. dollars per Canadian dollar). UHP and WCHP are undeflated values of DUHP and DWCHP. U.S. live weight price converted to dressed carcass weight price by a conversion factor of 1.23. Exchange rates from the U.S. Federal Reserve Board, Federal Reserve Bulletin.

CASW = Canadian average hog slaughter weight. Federal slaughter weights are used because commercial slaughter weights were unavailable. Warm weight adjusted to cold weight by a three percent shrink factor. Dressed carcass weight pounds per slaughter head. Agriculture Canada, Livestock Market Review.

CDUM = Canada dummy variable. One for the months of March, June, September, and December; zero for the other months. See Chapter 6 for a detailed explanation.

CORNPR = Eastern Canada corn production. Annual corn production in Ontario (Ontario accounts for nearly all corn production) for the marketing year beginning September 1st. Million bushels. Agriculture Canada, Market Commentary.

CPOP = Canadian Population. Quarterly data are used (monthly figures were unavailable). Thousands. Statistics Canada, Estimates of Population of Canada by Provinces, by Quarterly Periods.

DCBI = Deflated Canadian retail beef price index. Deflated by the Consumer Price Index, CPI-All Items, base 100 = June 1972. Statistics Canada, Consumer Prices and Price Indexes.

DECFI = Deflated Eastern Canada feed index. Quarterly index deflated by the Farm Input Price Index for Eastern Canada, base 100 = 1972. Statistics Canada, Farm Input Prices and Price Indexes.

DCFM = Deflated net cattle feeding margin in Western Canada. A1, A2 steer price at Calgary times 11 minus 4.5 times graded feeder steer price at Calgary. Dollars per hundred weight deflated by the Farm Price Input Index, base 100 = 1972. Agriculture Canada, Livestock Market Review. Statistics Canada, Farm Input Prices and Price Indexes.

DECHP = Deflated Eastern Canada hog price. Toronto Index 100 price. Dollars per dressed hundred carcass weight. Deflated by the Farm Price Input Index, base 100 = 1972. Agriculture Canada, Livestock Market Review. Statistics Canada, Farm Input Prices and Price Indexes.

DUBI = Deflated United States retail beef index. Bureau of Labor Statistics, Retail Index of Beef and Veal, base 100 = June, 1972. Deflated by the U.S. Consumer Price Index, CPI-W after 1978, CPI-U before 1978, base 100 = June 1972. USDA, Livestock and Poultry Outlook and Situation Report, U.S. Bureau of Labor Statistics, CPI Detailed Report.

DUCPO = Deflated United States corn price at Omaha. Number two corn price at Omaha, Nebraska. Cents per bushel. Deflated by Prices Paid by Farmers Index, base 100 = June 1972. Survey of Current Business. USDA, Feed Outlook and Situation Report.

DUHP = Deflated United States hog price. Weighted average live price of all weight classes of barrows and gilts at seven central U.S. markets. Deflated by the Prices Paid by Farmers Index, base 100 = June 1972. Dollars per hundred

weight. USDA, Livestock and Meat Statistics, 1983 and Livestock and Poultry Outlook and Situation Report. U.S. Department of Commerce, Survey of Current Business.

DV1, DV2, DV3, DV4, = Dummy variables used as seasonal shifters. One placed in the three months of each quarter and zero in the months of the remaining quarters.

DWCHP = Deflated Western Canada hog price. Winnipeg Index 100 price. Dollars per hundred dressed carcass weight. Deflated by the Farm Price Input Index, base 100 = 1972. Agriculture Canada, Livestock Market Review. Statistics Canada, Farm Input Prices and Price Indexes.

HDUM = Holiday demand dummy variable. One for the months of October, November, and December; zero for the other months.

LCDY = Natural log of deflated Canadian per capita disposable personal income. Quarterly series used. Seasonally adjusted annual rates in 1972 dollars. Statistics Canada, Canadian Statistical Review.

LUSY = Natural log of deflated United States per capita disposable personal income. Quarterly series used. Seasonally adjusted annual rates in 1972 dollars. USDA, Working Data for Demand Analysis.

NCDEW = Net Canadian pork exports with the World, excluding the United States. Million pounds. Statistics Canada, Trade of Canada, Exports by Commodities and Trade of Canada, Imports by Commodities.

NUSEW = Net United States pork exports with the World, excluding Canada. Million pounds. U.S. Bureau of Census, Exports by Commodities and Imports by Commodities.

PDUM = Seasonal hog production dummy variable. Zero for the months of June, July, August, and September; one for the remaining months.

PGRAIN = Prairie province on farm grain stocks. August 1st on farm storage stocks of wheat, oats, and barley. August 1st figures are used for the preceding 12 month time period. Thousand metric tons. Statistics Canada, Cereals and Oilseed Review and Coarse Grains and Oilseed Review. Agriculture Canada, Market Commentary.

SDUM = Dummy variable for seasonal cold storage stocks of pork. One for March, April, May; zero for the remaining months.

USASW = United States average slaughter weight. Federal slaughter weights are used since commercial weights were unavailable. Carcass weight pounds per slaughter head. USDA, Livestock and Meat Statistics, 1983 and Livestock and Poultry Outlook and Situation Report.

USPOP = United States population. Quarterly data are used (monthly data was unavailable). Millions. USDA, Working Data for Demand Analysis.

Identities

CHS = Canadian hog slaughter under commercial inspection. Western Canada commercial hog slaughter (WCHS) plus Eastern Canada commercial hog slaughter (ECHS). Thousand head.

CDPC = Canadian pork consumption. Canadian per capita pork consumption (CCON) multiplied by Canadian population (CPOP). Thousand pounds, carcass weight basis.

CDPP = Canadian pork production. Canadian hog slaughter (CHS) multiplied by the average slaughter weight (CDASW). Million pounds, carcass weight basis.

USPC = United States pork consumption. United States per capita pork consumption (UCON) multiplied by the United States population (USPOP). Million pounds, carcass weight basis.

USPP = United States Pork Production. Net United States hog slaughter under commercial inspection (NUHS) multiplied by the average slaughter weight (USASW). Million pounds, carcass weight basis.

NPTUC = Net pork trade from the United States to Canada. USPP - change in USPS - NUSEW - USPC. Million pounds, carcass weight basis.

NPTCU = Net pork trade from Canada to the United States. CDPP - change in CDPS - NCDEW - CDPC. Million pounds, carcass weight basis.

At equilibrium: $|NPTCU| = |NPTUC|$

APPENDIX C

Computer Statistics

Table 14. First Stage 2SLS Variables

```
EXOGENOUS VARIABLES IN FIRST STAGE REGRESSIONS
FROM    76- 3 UNTIL   85- 3
VAR     0      CONSTANT
VAR     1      DUM1 = PDUM
VAR     2      APST = APPST
VAR     3      DCBI
VAR     4      DUBI
VAR     5      CHS
VAR     9      NUHS
VAR    10      PG = PGRAIN Lags 1 to 30
VAR    11      PP1 = APPSW Lags 1 to 30
VAR    12      APST1 = APPST Lags 1 to 30
VAR    13      CP = CORNPR Lags 1 to 30
VAR    14      LUSY
VAR    15      CDPS        LAGS   1 TO   1
VAR    16      USPS        LAGS   1 TO   1
VAR    17      DV4
VAR    18      DV3
VAR    19      DV2
VAR    20      SDUM
VAR    21      CDUM
VAR    36      LCDY
VAR    29      USAPST
VAR    30      CFM2 = DCFM Lags 1 to 30
VAR    31      CPO2 = DUCPO Lags 1 to 30
VAR    32      EHP2 = DECHP Lags 1 to 30
VAR    33      FD2 = DCFI Lags 1 to 30
VAR    34      LHP2 = DUHP Lags 1 to 30
VAR    35      WHP2 = DWCP Lags 1 to 30
```

Table 15. Instrumental Variable - DECHP

```
DEPENDENT VARIABLE     7      DCHPT = DECHP
FROM    76- 3 UNTIL    85- 3
OBSERVATIONS             109      DEGREES OF FREEDOM      82
R**2              .92709327       RBAR**2             .90397650
SSR          369.50703            SEE            2.1227773
DURBIN-WATSON  1.12957627
Q(  30)=     84.2560          SIGNIFICANCE LEVEL   .474378E-06
```

NO.	LABEL	VAR	LAG	COEFFICIENT	STAND. ERROR	T-STATISTIC
***	*******	***	***	***********	***********	***********
1	CONSTANT	0	0	518.3655	375.9883	1.378675
2	DUM1	1	0	-.1099499	1.987119	-.5533129E-01
3	APST	2	0	-8.662544	6.156923	-1.406960
4	DCBI	3	0	.1810507E-01	.7742065E-01	.2338532
5	DUBI	4	0	.9024673E-01	.1681320	.5367610
6	CHS	5	0	-.9317034E-02	.5949172E-02	-1.566106
7	NUHS	9	0	-.2930221E-02	.6633734E-03	-4.417152
8	PG	10	0	-.2502601E-05	.9719015E-05	-.2574953
9	PP1	11	0	3.616747	.8883000	4.071538
10	APST1	12	0	-2.231041	.8747931	-2.550364
11	CP	13	0	-.2481718E-02	.1317433E-02	-1.883752
12	LUSY	14	0	42.43003	31.11213	1.363777
13	CDPS	15	1	.9611808E-02	.1091330	.8807428E-01
14	USPS	16	1	-.1505179E-04	.9992304E-05	-1.506338
15	DV4	17	0	.2978220	.8568441	.3475801
16	DV3	18	0	-.9883736	1.931387	-.5117428
17	DV2	19	0	-.4189436	1.129954	-.3707617
18	SDUM	20	0	.2724457	1.451627	.1876830
19	CDUM	21	0	2.478940	1.352957	1.832239
20	LCDY	36	0	-61.05764	26.41157	-2.311776
21	USAPST	29	0	-1.783541	.9359514	-1.905592
22	CFM2	30	0	.2047994E-02	.9420647E-03	2.173942
23	CPO2	31	0	-.8686387E-03	.1012795E-02	-.8576649
24	EHP2	32	0	-.3368791E-01	.5135874E-01	-.6559334
25	FD2	33	0	-.1045944E-01	.4413478E-02	-2.369886
26	LHP2	34	0	.1254227	.6427591E-01	1.951317
27	WHP2	35	0	-.8136056E-01	.4111711E-01	-1.978752

Table 16. Instrumental Variable - DUHP

DEPENDENT VARIABLE 6 DUHP
FROM 76- 3 UNTIL 85- 3
OBSERVATIONS 109 DEGREES OF FREEDOM 82
R**2 .94315988 RBAR**2 .92513740
SSR 170.07717 SEE 1.4401777
DURBIN-WATSON 1.20194501
Q(30)= 81.3111 SIGNIFICANCE LEVEL .127775E-05

NO.	LABEL	VAR	LAG	COEFFICIENT	STAND. ERROR	T-STATISTIC
***	*******	***	***	***********	***********	***********
1	CONSTANT	0	0	304.8667	255.0856	1.195155
2	DUM1	1	0	-.2027581	1.348142	-.1503982
3	APST	2	0	18.49181	4.177105	4.426944
4	DCBI	3	0	-.1198092E-02	.5252529E-01	-.2280981E-01
5	DUBI	4	0	.1106327	.1140676	.9698874
6	CHS	5	0	-.7147666E-02	.4036158E-02	-1.770908
7	NUHS	9	0	-.2201368E-02	.4500592E-03	-4.891284
8	PG	10	0	-.8135716E-05	.6593772E-05	-1.233849
9	PP1	11	0	2.131309	.6026586	3.536512
10	APST1	12	0	-1.533634	.5934949	-2.584074
11	CP	13	0	-.2122250E-02	.8937999E-03	-2.374413
12	LUSY	14	0	36.55601	21.10773	1.731878
13	CDPS	15	1	-.1604151E-01	.7404021E-01	-.2166594
14	USPS	16	1	-.1064173E-04	.6779182E-05	-1.569767
15	DV4	17	0	.1888086	.5813176	.3247942
16	DV3	18	0	-1.007304	1.310331	-.7687404
17	DV2	19	0	-.3489515	.7666062	-.4551901
18	SDUM	20	0	.3856068	.9848421	.3915417
19	CDUM	21	0	1.789147	.9179004	1.949173
20	LCDY	36	0	-35.89330	17.91867	-2.003123
21	USAPST	29	0	-.9005351	.6349871	-1.418194
22	CFM2	30	0	.2105571E-02	.6391347E-03	3.294409
23	CPO2	31	0	.7674215E-03	.6871210E-03	1.116865
24	EHP2	32	0	-.5407720E-02	.3484384E-01	-.1551988
25	FD2	33	0	-.1110037E-01	.2994282E-02	-3.707191
26	LHP2	34	0	.7449647E-01	.4360737E-01	1.708346
27	WHP2	35	0	-.6721882E-01	.2789550E-01	-2.409665

Table 17. Endogenous Variable - NUHS

SMPL 1976.03 - 1985.03
109 Observations
LS // Dependent Variable is NUHS
Convergence achieved after 2 iterations

	COEFFICIENT	STANDARD ERROR	T-STATISTIC
C	6981.0942	897.39708	7.7792700
DUCPO	-0.0770820	0.0396963	-1.9417915
DUHP	0.3701588	0.2393518	1.5465055
APPST	29.840672	20.682159	1.4428219
PDUM	422.04725	158.64110	2.6603903
DV4	353.44874	168.19365	2.1014392
AR(1)	0.4330332	0.0915679	4.7290961

R-squared	0.552287	Mean of dependent var	7034.031
Adjusted R-squared	0.525951	S.D. of dependent var	808.4770
S.E. of regression	556.6460	Sum of squared resid	3.16D+07
Durbin-Watson stat	2.142423	F-statistic	20.97079
Log likelihood	-840.1372		

Covariance Matrix

C,C	805321.515	C,DUCPO	-16.4403770
C,DUHP	-122.093260	C,APPST	-15215.0960
C,PDUM	-14122.0563	C,DV4	4093.74846
C,AR(1)	-7.85938453	DUCPO,DUCPO	0.00157580
DUCPO,DUHP	-0.00432141	DUCPO,APPST	0.41564511
DUCPO,PDUM	-0.01729996	DUCPO,DV4	0.05487258
DUCPO,AR(1)	0.00014236	DUHP,DUHP	0.05728928
DUHP,APPST	1.89219897	DUHP,PDUM	0.10622467
DUHP,DV4	-1.21634457	DUHP,AR(1)	0.00168910
APPST,APPST	427.751691	APPST,PDUM	-44.2263046
APPST,DV4	-47.9445362	APPST,AR(1)	0.15942090
PDUM,PDUM	25166.9989	PDUM,DV4	-11596.9213
PDUM,AR(1)	-0.71287450	DV4,DV4	28289.1044
DV4,AR(1)	-2.97223854	AR(1),AR(1)	0.00838467

Table 18. Endogenous Variable - ECHS

SMPL 1976.03 - 1985.03
109 Observations
LS // Dependent Variable is ECHS
Convergence achieved after 2 iterations

	COEFFICIENT	STANDARD ERROR	T-STATISTIC
C	1563.6880	199.83403	7.8249338
DECFI	-0.0097862	0.0033244	-2.9437797
DECHP	0.1292213	0.0220080	5.8715740
APPST	5.2022293	1.6845890	3.0881298
CORNPR	0.0061699	0.0027996	2.2038745
PDUM	35.578188	14.833889	2.3984396
CDUM	150.22786	10.391000	14.457498
AR(1)	0.3108282	0.0964448	3.2228614

R-squared	0.914652	Mean of dependent var	681.7064
Adjusted R-squared	0.908736	S.D. of dependent var	186.2523
S.E. of regression	56.26658	Sum of squared resid	319758.8
Durbin-Watson stat	2.064704	F-statistic	154.6264
Log likelihood	-589.7909		

Covariance Matrix

C,C	39933.6389	C,DECFI	-0.47828628
C,DECHP	-3.96155672	C,APPST	-104.469813
C,CORNPR	0.13373356	C,PDUM	-122.525200
C,CDUM	-47.2981015	C,AR(1)	-0.13569934
DECFI,DECFI	1.1051D-05	DECFI,DECHP	3.9240D-05
DECFI,APPST	0.00191944	DECFI,CORNPR	-7.4262D-06
DECFI,PDUM	-0.00091338	DECFI,CDUM	-0.00078058
DECFI,AR(1)	1.7182D-05	DECHP,DECHP	0.00048435
DECHP,APPST	0.02190678	DECHP,CORNPR	-1.2734D-05
DECHP,PDUM	-0.00487213	DECHP,CDUM	-0.00330619
DECHP,AR(1)	3.2549D-05	APPST,APPST	2.83783998
APPST,CORNPR	-0.00246894	APPST,PDUM	-0.62509297
APPST,CDUM	-0.42924220	APPST,AR(1)	0.00315977
CORNPR,CORNPR	7.8377D-06	CORNPR,PDUM	0.00064849
CORNPR,CDUM	0.00071263	CORNPR,AR(1)	-1.6122D-05
PDUM,PDUM	220.044274	PDUM,CDUM	56.5650032
PDUM,AR(1)	-0.29685655	CDUM,CDUM	107.972873
CDUM,AR(1)	-0.18321326	AR(1),AR(1)	0.00930160

Table 19. Endogenous Variable - WCHS

SMPL 1976.03 - 1985.03
109 Observations
LS // Dependent Variable is WCHS
Convergence achieved after 2 iterations

	COEFFICIENT	STANDARD ERROR	T-STATISTIC
C	435.89667	57.172392	7.6242512
DWCHP	0.0061886	0.0056091	1.1033143
PGRAIN	0.0001025	1.900D-05	5.3947241
APPSW	7.5980448	0.7185066	10.574774
DCFM	-0.0137549	0.0028779	-4.7795056
PDUM	10.392873	4.8853572	2.1273517
CDUM	62.655856	3.0889503	20.283867
AR(1)	0.4182884	0.0931461	4.4906723

R-squared	0.918270	Mean of dependent var	307.7339
Adjusted R-squared	0.912605	S.D. of dependent var	60.13544
S.E. of regression	17.77759	Sum of squared resid	31920.31
Durbin-Watson stat	2.108419	F-statistic	162.1106
Log likelihood	-464.2052		

Covariance Matrix

C,C	3268.68238	C,DWCHP	-0.10152208
C,PGRAIN	0.00071811	C,APPSW	-8.03642527
C,DCFM	-0.13442380	C,PDUM	-29.6094964
C,CDUM	-9.28295858	C,AR(1)	-0.32642434
DWCHP,DWCHP	3.1462D-05	DWCHP,PGRAIN	2.2897D-08
DWCHP,APPSW	0.00316550	DWCHP,DCFM	-3.7328D-06
DWCHP,PDUM	-0.00044084	DWCHP,CDUM	-0.00028973
DWCHP,AR(1)	3.6891D-05	PGRAIN,PGRAIN	3.6114D-10
PGRAIN,APPSW	5.8790D-06	PGRAIN,DCFM	-5.0382D-08
PGRAIN,PDUM	-4.3651D-06	PGRAIN,CDUM	-1.5158D-06
PGRAIN,AR(1)	-2.1092D-08	APPSW,APPSW	0.51625174
APPSW,DCFM	-0.00069050	APPSW,PDUM	-0.12953897
APPSW,CDUM	-0.06914342	APPSW,AR(1)	0.00589370
DCFM,DCFM	8.2823D-06	DCFM,PDUM	0.00075357
DCFM,CDUM	0.00022229	DCFM,AR(1)	4.2942D-06
PDUM,PDUM	23.8667153	PDUM,CDUM	5.79882414
PDUM,AR(1)	0.04102859	CDUM,CDUM	9.54161398
CDUM,AR(1)	0.01296823	AR(1),AR(1)	0.00867619

Table 20. Endogenous Variable - UCON

```
DEPENDENT VARIABLE   39      UCON
FROM   76- 4 UNTIL   85- 3
OBSERVATIONS          108     DEGREES OF FREEDOM    102
R**2           .84016791     RBAR**2         .83233301
SSR       13.914617          SEE         .36934782
DURBIN-WATSON  1.59958080
Q(  30)=    66.3015        SIGNIFICANCE LEVEL  .149127E-03
```

NO.	LABEL	VAR	LAG	COEFFICIENT	STAND. ERROR	T-STATISTIC
***	*******	***	***	************	************	************
1	CONSTANT	0	0	35.26913	9.647976	3.655598
2	DUHP	40	0	-.2245842	.1598671E-01	-14.04818
3	DUBI	41	0	.6126486E-01	.7587724E-02	8.074208
4	LUSY	42	0	-5.875976	2.067519	-2.842042
5	APST	43	0	1.541409	.8216508	1.875990
6	DV4	44	0	1.216957	.1009465	12.05546

VARIANCE-COVARIANCE MATRIX OF COEFFICIENTS

VARIABLE	SERIES	LAG	CONSTANT 0 0	FDUHP 40 0	FDUBI 41 0	FLUSY 42 0
CONSTANT	0	0	93.083	-.10229	-.26049E-01	-19.932
DUHP	40	0	-.10229	.25558E-03	.19560E-04	.21586E-01
DUBI	41	0	-.26049E-01	.19560E-04	.57574E-04	.50550E-02
LUSY	42	0	-19.932	.21586E-01	.50550E-02	4.2746
APST	43	0	4.1230	-.34286E-02	-.82098E-03	-.89068
DV4	44	0	-.45739E-01	.23332E-03	.77669E-04	.82453E-02

VARIABLE	SERIES	LAG	FAPST 43 0	FDV4 44 0
CONSTANT	0	0	4.1230	-.45739E-01
DUHP	40	0	-.34286E-02	.23332E-03
DUBI	41	0	-.82098E-03	.77669E-04
LUSY	42	0	-.89068	.82453E-02
APST	43	0	.67511	.99331E-02
DV4	44	0	.99331E-02	.10190E-01

Table 21. Endogenous Variable - CCON

```
DEPENDENT VARIABLE     24        CCON
FROM   76- 3 UNTIL     85- 3
OBSERVATIONS             109      DEGREES OF FREEDOM     102
R**2              .78248912       RBAR**2          .76969437
SSR          22.926015            SEE          .47409372
DURBIN-WATSON  2.06675817
Q(  30)=     20.6982         SIGNIFICANCE LEVEL   .897086
```

NO.	LABEL	VAR	LAG	COEFFICIENT	STAND. ERROR	T-STATISTIC
***	*******	***	***	***********	***********	***********
1	CONSTANT	0	0	28.65074	19.98481	1.433626
2	DCHPT	7	0	-.7600087E-01	.1067598E-01	-7.118869
3	DCBI	3	0	.1601009E-01	.2558330E-02	6.258025
4	LCDY	36	0	-2.760340	2.384321	-1.157705
5	AFST	2	0	-1.398480	.7631675	-1.832467
6	DV4	17	0	.2671496	.1082361	2.468211
7	CDUM	21	0	1.413650	.9613952E-01	14.70415

VARIANCE-COVARIANCE MATRIX OF COEFFICIENTS

VARIABLE	SERIES	LAG	CONSTANT 0 0	DCHPT 7 0	DCBI 3 0	LCDY 36 0
CONSTANT	0	0	399.39	-.12802	-.10478E-02	-47.638
DCHPT	7	0	-.12802	.11398E-03	.39934E-05	.14915E-01
DCBI	3	0	-.10478E-02	.39934E-05	.65451E-05	.18686E-04
LCDY	36	0	-47.638	.14915E-01	.18686E-04	5.6850
AFST	2	0	4.9935	.16658E-02	-.36480E-03	-.60501
DV4	17	0	.15580	.12082E-03	.17237E-05	-.19673E-01
CDUM	21	0	.45127E-01	-.27536E-04	-.63948E-05	-.56268E-02

VARIABLE	SERIES	LAG	AFST 2 0	DV4 17 0	CDUM 21 0
CONSTANT	0	0	4.9935	.15580	.45127E-01
DCHPT	7	0	.16658E-02	.12082E-03	-.27536E-04
DCBI	3	0	-.36480E-03	.17237E-05	-.63948E-05
LCDY	36	0	-.60501	-.19673E-01	-.56268E-02
AFST	2	0	.58242	.17822E-01	.38305E-02
DV4	17	0	.17822E-01	.11715E-01	.14734E-03
CDUM	21	0	.38305E-02	.14734E-03	.92428E-02

Table 22. Endogenous Variable - USPS

```
DEPENDENT VARIABLE    39       USPS
FROM    76- 5 UNTIL   85- 3
OBSERVATIONS           107      DEGREES OF FREEDOM     101
R**2             .81497210      RBAR**2           .80581230
SSR          .35873983E+11      SEE           18846.431
DURBIN-WATSON  1.66904851
Q(   30)=    75.6460       SIGNIFICANCE LEVEL  .818784E-05
```

NO.	LABEL	VAR	LAG	COEFFICIENT	STAND. ERROR	T-STATISTIC
***	*******	***	***	***********	***********	***********
1	CONSTANT	0	0	17880.31	31977.19	.5591583
2	USPS	39	1	.7239741	.5182003E-01	13.97093
3	NUHS	40	0	10.84509	3.976428	2.727343
4	DUHP	41	0	-1693.346	814.6427	-2.078636
5	AFST	42	0	104.6824	34663.23	.3019985E-02
6	SDUM	43	0	28894.59	5218.508	5.536944

VARIANCE-COVARIANCE MATRIX OF COEFFICIENTS

VARIABLE	SERIES	LAG	CONSTANT 0 0	FUSPS 39 1	FNUHS 40 0	FDUHP 41 0
CONSTANT	0	0	.10225E+10	-991.75	-.11390E+06	-.23089E+08
USPS	39	1	-991.75	.26853E-02	.61021E-01	19.111
NUHS	40	0	-.11390E+06	.61021E-01	15.812	2213.0
DUHP	41	0	-.23089E+08	19.111	2213.0	.66364E+06
AFST	42	0	-.89380E+08	-436.38	21167.	.37018E+07
SDUM	43	0	.37217E+08	-45.170	-5775.0	-.53416E+06

VARIABLE	SERIES	LAG	FAFST 42 0	FSDUM 43 0
CONSTANT	0	0	-.89380E+08	.37217E+08
USPS	39	1	-436.38	-45.170
NUHS	40	0	21167.	-5775.0
DUHP	41	0	.37018E+07	-.53416E+06
AFST	42	0	.12015E+10	-.72338E+06
SDUM	43	0	-.72338E+06	.27233E+08

Table 23. Endogenous Variable - CDPS

```
DEPENDENT VARIABLE    14      CDPS
FROM   76- 4 UNTIL    85- 3
OBSERVATIONS            108      DEGREES OF FREEDOM    101
R**2             .71881067       RBAR**2           .70210635
SSR         514.31632            SEE          2.2565995
DURBIN-WATSON   1.95414499
Q(  30)=    20.8919         SIGNIFICANCE LEVEL   .891237
```

NO.	LABEL	VAR	LAG	COEFFICIENT	STAND. ERROR	T-STATISTIC
***	*******	***	***	***********	***********	***********
1	CONSTANT	0	0	7.954600	3.550713	2.240283
2	CDPS	14	1	.7547591	.6099527E-01	12.37406
3	CHS	5	0	.3810875E-03	.1619481E-02	.2353146
4	DCHPT	7	0	-.1050976E-01	.5546174E-01	-.1894956
5	APST	2	0	-6.302858	3.411071	-1.847765
6	DV2	18	0	-1.118829	.5757611	-1.943218
7	DV3	17	0	-2.624495	.5480525	-4.788766

VARIANCE-COVARIANCE MATRIX OF COEFFICIENTS

VARIABLE	SERIES	LAG	CONSTANT 0 0	CDPS 14 1	CHS 5 0	DCHPT 7 0
CONSTANT	0	0	12.608	-.10324	-.44957E-02	-.15981
CDPS	14	1	-.10324	.37204E-02	-.13874E-05	-.47796E-05
CHS	5	0	-.44957E-02	-.13874E-05	.26227E-05	.60767E-04
DCHPT	7	0	-.15981	-.47796E-05	.60767E-04	.30760E-02
APST	2	0	-2.2314	.53785E-01	-.98828E-03	.46743E-01
DV2	18	0	.25504	-.12902E-01	.41244E-04	-.84882E-03
DV3	17	0	-.12215	.45365E-02	.17419E-04	-.36131E-02

VARIABLE	SERIES	LAG	APST 2 0	DV2 18 0	DV3 17 0
CONSTANT	0	0	-2.2314	.25504	-.12215
CDPS	14	1	.53785E-01	-.12902E-01	.45365E-02
CHS	5	0	-.98828E-03	.41244E-04	.17419E-04
DCHPT	7	0	.46743E-01	-.84882E-03	-.36131E-02
APST	2	0	11.635	-.16066	.12415E-01
DV2	18	0	-.16066	.33150	.84751E-01
DV3	17	0	.12415E-01	.84751E-01	.30036

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