AN EVALUATION OF THE INFLUENCE OF EXCHANGE RATES ON THE CANADIAN RED MEAT SECTOR

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Preface

The purpose of this paper is to present quantitative evidence on the economic consequences of variations in the Canadian/United States exchange rate for the Canadian red meat industry. This project was begun in late 1983 when the exchange rate was approximately 1.30 C$/US$. Since 1983 the Canadian dollar has depreciated a further eight percent against the United States dollar. However, the further depreciation of the Canadian dollar is not the only reason why this study is of more importance now than when it was undertaken. In the intervening period agricultural trade relations with the United States have become increasingly difficult, at least partly because of the perception that the depreciating Canadian dollar has given Canadian agricultural products an unfair advantage in the United States market. For Canadian red meat producers this protectionist attitude culminated in a countervailing duty being placed on Canadian shipments of live hogs to the United States in mid-1985. While this paper does not address the question of government subsidies for red meat producers, either in Canada or the United States, it is hoped that it will shed some light on the question of the influence of exchange rate variations on the production, pricing and trade in beef and pork between Canada and the United States.

Helpful comments on an early draft of this paper were provided by Professor T.K. Warley, University of Guelph and Mr. Merritt Cluff, Agriculture Canada. Special thanks are also due to Mrs. Debbie Harkies and Mrs. Helen Martin for the careful typing of the many drafts of this paper. The authors are, however, responsible for any errors of fact or

interpretation which the paper may contain.

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K.D. Meilke
J.R. Coleman

April 1986

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CHAPTER ONE

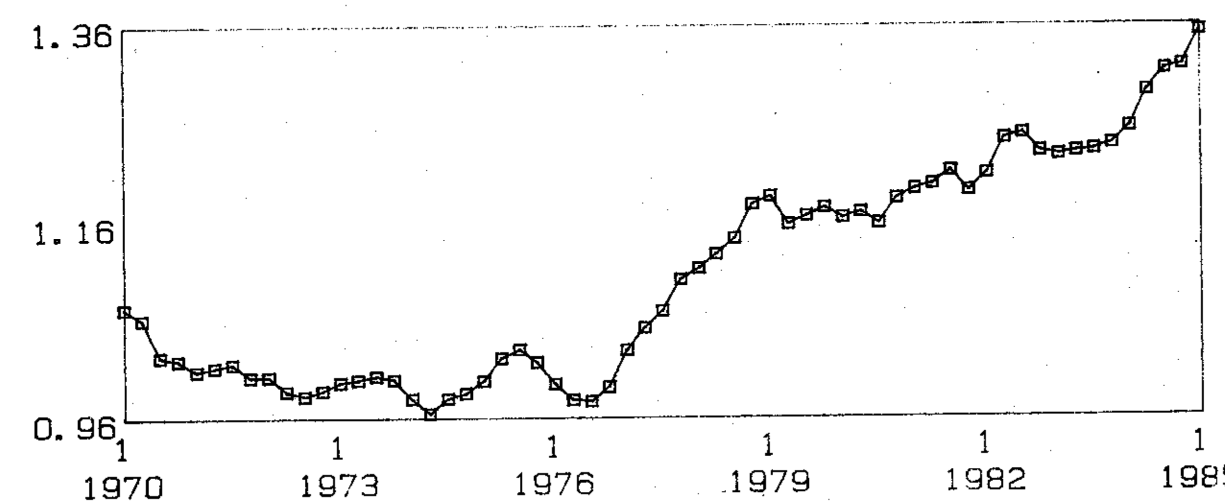
INTRODUCTION

1.1 BACKGROUND

Throughout the 1960's many industrial countries, including the United States and Canada, operated under the Bretton Woods System of fixed exchange rates. The fixing of exchange rates reduced the risk of operating within international markets and facilitated trade investment and lending. The late 1960s and early 1970s, however, saw differences in economic performance among participants who were confronted with a contrasting set of macroeconomic problems. These contrasting problems resulted in a divergent set of macroeconomic policy goals, and the fixed exchange rate proved to be a serious constraint to economic recovery and well-being in many countries. Slowly the Bretton Woods system broke down as participants opted for independent monetary and exchange rate policies. The Canadian dollar was floated in May 1970 followed by two devaluations of the U.S. dollar (April 1971 and February 1973). Finally, the German decision to float the deutschmark in 1973 signalled the end of the fixed exchange rate era.

During the early 1970's the Canadian/U.S. exchange rate was close to parity (figure 1.1).[1/] Since late 1976, however, the Canadian dollar has depreciated by more than 30 percent vis-a-vis the U.S. dollar to an unprecedented value of 1.39 $Canadian/$U.S. in early 1985.

Figure 1.1: Canadian/U.S. Exchange Rate 1970-1985



1/ Henceforth the Canadian dollar/United States dollar exchange rate will be referred to as the exchange rate.

Many reasons have been advanced as to why the market has put such a high value on the U.S. dollar relative to the Canadian dollar. Of prime importance, however was the U.S. policy to use the money supply to curb the inflation rate and the need to finance large U.S. budget deficits. This resulted in high interest rates and large capital flows into the United States. In addition, downward pressure has been exerted on the Canadian dollar by the policy to discourage foreign investment (the National Energy Programme and the Foreign Investment Review Agency), low productivity performance, and a U.S. inflation rate below that of Canada for much of the period.

The exchange rate is of prime importance to those economic agents who operate in open economies since it sets the price of goods and capital in terms of foreign currencies. In setting these prices the exchange rate is critical in determining the movement of goods and capital between countries. The Canadian agricultural sector is highly dependent on international transactions for sales of its output and purchases of its inputs, and exchange rate variations cause changes in the price levels at which these transactions occur. For example, a change in the exchange rate causes a change in the price of Canadian goods in terms of foreign currencies and a subsequent change in the demand for exports. Additionally, it causes a change in the price of foreign goods in terms of Canadian currency causing a change in the demand for imports. The well being of Canadian agriculture is influenced by the exchange rate, since it is important in determining its competitiveness both at home and abroad. Moreover, the exchange rate is particularly important in the Canadian economy where the trade sector is relatively large in relation to the domestic market.

During the Bretton Woods era changes in trade and international lending were attributed to factors other than the exchange rate which was held constant. The floating of exchange rates in the early 1970's, however, meant that they could no longer be ignored. Nevertheless, it was only after Schuh's article suggesting that the exchange rate was an important and under-emphasized variable within agricultural commodity markets that the exchange rate was recognized as a factor contributing to the economic performance of the agricultural sector.

Following Schuh's article academic work by agricultural economists on the subject has been centered in three broad areas. Work in the first area has focused on the treatment of exchange rates at a theoretical level and how they should be incorporated into agricultural commodity models. The relative impact of an exchange rate change on price has been given particular attention (Bredahl and Gallagher (1977); Kost (1976); Chambers and Just (1979)). Work in the second area deals with the measurement of the impact of U.S. exchange rate movements on grain exports (Greenshields (1974); Meilke and de Gorter (1978); Martin and Meilke (1980); Johnson, Grennes and Thursby (1977); Meyers, Gerber and Bredahl (1980); Collins, Meyers and Bredahl (1980)), while the third body of work analyzes the effects of monetary and exchange rate policy on agricultural commodity markets (Chambers and Just (1981, 1982)).

With the exception of Zenko (1981) analysis of the effects of exchange rate changes on Canadian agriculture is missing from the academic literature. Thus there is a serious lack of information on the precise link between the exchange rate and Canadian agriculture, especially in view of the persistent depreciation described above.

1.2 THE ECONOMIC PROBLEM

The impact of exchange rate changes are the most pronounced in those sectors which are strongly interrelated with world markets. Trade in United States and Canadian livestock and meat is substantial and is subject to only modest trade restrictions. Therefore, the depreciation of the Canadian dollar must have had an effect on the livestock industry and more specifically on the red meat sector.

Price formation in the Canadian red meat industry is dominated by that of the U.S. which is almost ten times as large. This, combined with the minor trade restrictions, means that livestock prices are largely determined by supply and demand conditions in the U.S., while the Canadian price is the U.S. price times the exchange rate ($C/$US) adjusted for transportation costs. Thus the depreciation of the Canadian dollar has increased the price of livestock to Canadian producers. The depreciation therefore, has been hailed by some as of great benefit to Canadian producers who now receive a higher price for their output. However, Canadian feed grains and protein meals are also priced on world markets and given the size of Canadian production relative to U.S. production here again, the Canadian prices tend to equal the U.S. prices adjusted for exchange rates and transportation costs. Thus the depreciation has also made these major inputs to livestock production more expensive.

Canadian exchange rate fluctuations also influence the macroeconomic performance of the Canadian economy. It is generally assumed that a ten percent depreciation of the Canadian dollar will lead to a two percent increase in the consumer price index because of the increased cost of imported goods (Economic Council of Canada (1982)). In addition, the Bank of Canada has actively intervened in the capital market, by adjusting interest rates, in attempts to stabilize the value of the Canadian dollar. These macroeconomic variables also influence the agricultural sector and complicate the evaluation of the impact of exchange rate variations on agriculture.

Consequently, the economic problem is to estimate the true benefits if any, of the Canadian devaluation on the Canadian red meat sector. If indeed the exchange rate does affect the agricultural industry, it is also necessary to consider its relative importance. For example, are changes in the exchange rate more important to producer incomes than say a change in the price of corn?

As the exchange rate continues to fluctuate it will be important to fully understand the implications for the agricultural industry.

Government's use of economic policies that impact on the exchange rate must be tempered by the effect it will have in the agricultural sector, and producer groups must be able to quantify the true effects of exchange rate changes on their incomes if they deem such changes as a source of instability or economic hardship.

1.3 SCOPE OF STUDY

This study is focused on the North American red meat industry. Meat trade with countries other than the United States, such as imports from Australia and New Zealand and exports to Japan are treated exogenously. This omission facilitates analysis of Canadian/U.S. exchange rates without the unnecessary complexity of third countries. In addition, only pork and beef are considered in the study. This represents only a minor limitation since trade in other livestock products is insignificant. The effects of exchange rate variations will be traced over a period of time so that both the initial impacts and dynamics of the adjustment process can be analyzed. It is hoped that these estimates will provide valuable information to policy makers and producer groups in an area that has been sadly neglected by agricultural research.

1.4 OBJECTIVES

The objectives of this research are to quantify and analyze both the absolute and relative impact of Canadian exchange rate changes vis-a-vis the U.S. on the Canadian beef and pork sectors. The study accounts for changes that occur in both the factor and product markets, as well as macroeconomic effects, to determine the true benefits or costs associated with exchange rate fluctuations.

1.5 OUTLINE OF THE STUDY

The study is divided into six chapters. In Chapter 2 an appropriate model is formulated and a brief review of the exchange rate literature is given. In Chapter 3 the individual equations which make up the model are presented. In Chapter 4 the model validation is reported and in Chapter 5 the policy analysis is presented. In Chapter 6 the summary and conclusions of the study are detailed.

CHAPTER TWO

RESEARCH METHODS

2.1 INTRODUCTION

In order to develop an appropriate model specification and structure there are certain requirements that must be satisfied. The first is that the model should be designed to answer the question posed. This is perhaps obvious but nevertheless worth stressing. In order to evaluate the effect of the depreciating dollar on the red meat sector the model must incorporate the Canadian/U.S. dollar exchange rate. The exchange rate must be determined outside the model so that exogenous shocks can be applied to it. The effects of these shocks must then be observable in changes in demand and supply conditions as well as in trading patterns and price levels. The second requirement is that the model incorporate the essential characteristics of the red meat industry. Consequently, it is necessary that the model: (1) capture the supply and demand forces in the red meat market, including the recursive nature of livestock production; (2) acknowledge the spatial characteristics of the North American beef and pork industry and link the separate regions appropriately; (3) incorporate the reactions of macroeconomic variables resulting from exchange rate variations; and (4) include enterprise budgets so that changes in producers' income positions can be identified following a shock to the exchange rate.

These requirements largely determine the most appropriate model structure and specification to employ. A complete discussion of these is provided below.

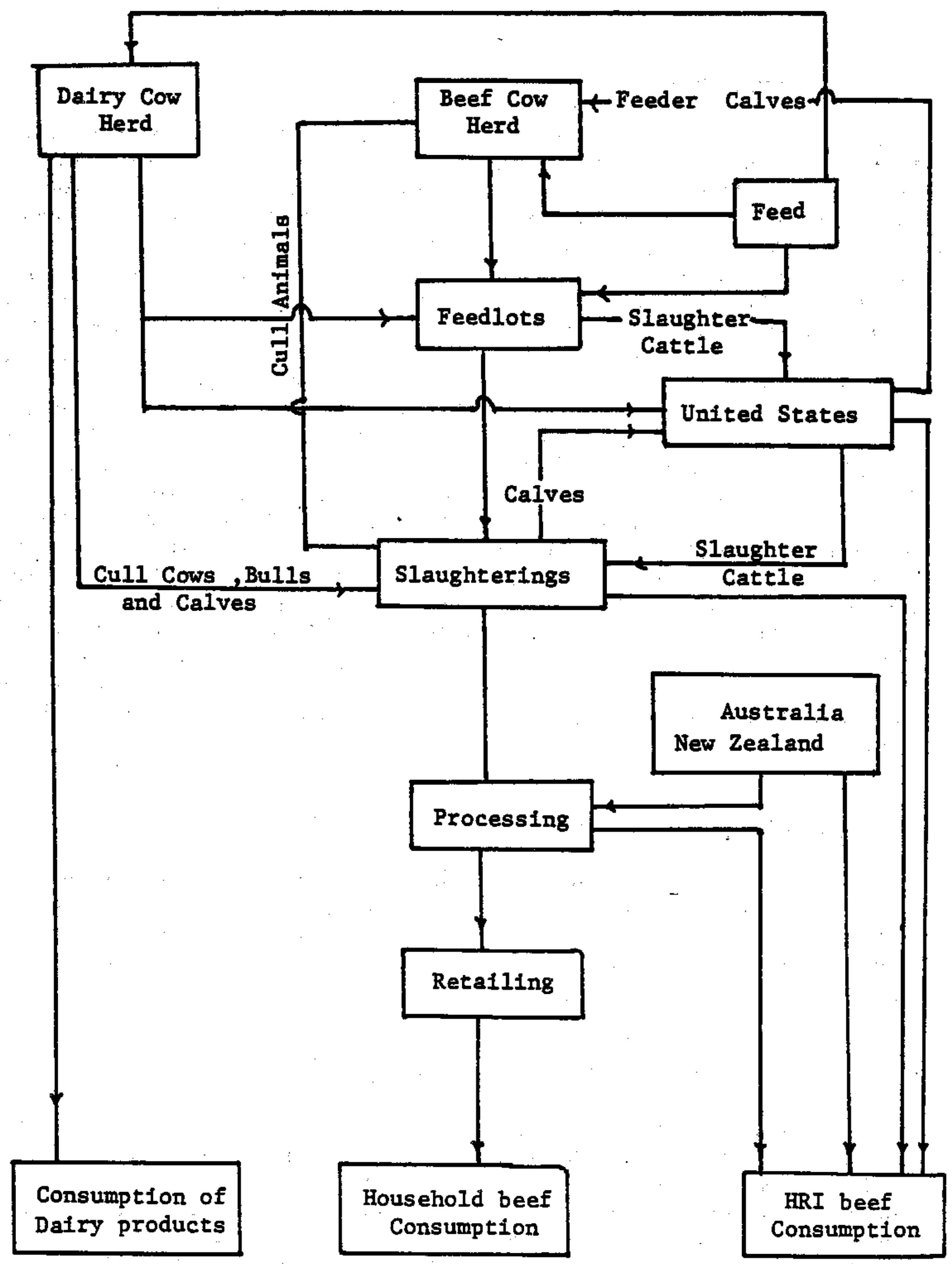
2.2 CHARACTERISTICS OF THE RED MEAT INDUSTRY

To meet the requirements of the model the major components of the market must be incorporated. These include the production process, the demand for meat by both consumers and the meat processing sector, and trade flows. By way of introduction it is useful to briefly review the importance of the red meat sector to the agricultural system in Canada.

2.2.1 The Canadian Beef and Pork Sector

The beef market represents a major component of the agricultural system in Canada, contributing 18.3 percent of total farm cash receipts in 1983. Meat packing, of which beef is the most important part, is Canada's largest food processing industry and the fourth largest manufacturing sector. A flow chart of the beef sector is provided in figure 2.1. The system can be divided into three broad production processes. The first entails the breeding of stock and subsequent

Figure 2.1 Canadian Beef Industry Flowchart.



Source: Agricultural Research Council of Canada.

weaning of calves. These cow-calf operators are situated mainly on range land in the West (Alberta and Saskatchewan), although such operations are also found on less productive land in Eastern Canada. After weaning, the calves weigh between 400 and 500 pounds and move on to the second stage in which they are backgrounded to weights ranging between 750 and 850 pounds. This process often takes place on the cow-calf units although many are moved to specialized backgrounding operations. Once the backgrounding is complete, the cattle are fed and fattened to slaughter weight (1000 to 1200 pounds) in feedlot operations.

The distribution of cattle in Canada shows marked regional specialization. The Prairie Provinces and Ontario contain most of the production and marketing of beef. Western Canada contains 80 percent of the beef cow herd while the East contains 80 percent of the dairy herd. About 300,000 to 500,000 head of feeder cattle are transfered annually from West to East. Large numbers of live cattle and calves also move between Canada and the United States. Trade continues in an environment of modest trade restrictions in which both nations impose a tariff of 1.0 cent/lb. on live cattle and calves. Most animals are traded for slaughter, although a significant number are sent for fattening and breeding purposes. Western Canada is a net exporter to the U.S., while the East is a net importer.

Of the total production of meat, about 30 percent is consumed by the hotel, restaurant and institutional sector while the remainder is sold through retail chains. Trade in beef meat is an important component of the sector and is dealt with in section 2.2.5.

The Canadian pork sector contributed 9.1 percent of total farm cash receipts in 1983 as well as providing a major segment of meat processing and packing. As with the beef sector, pork production is served by three major types of enterprise. The specialist weaner operator breeds sows and raises weaner pigs while the specialist feeder enterprise feeds and fattens weaners to slaughter. The farrow-to-finish operator combines these two activities in one enterprise. Approximately one-third of hog production occurs in Western Canada (with Alberta having the largest share). The remaining two-thirds of Canadian hog production is shared evenly between Ontario and Quebec.

The production of hogs has benefited from significant economies of scale and this has been reflected in a substantial movement to larger enterprises and greater specialization. Other recent trends include increased vertical integration by feed companies and cooperatives into hog production. This has occurred principally in Quebec and has resulted in more stable production patterns than in other areas of the country.

As with beef, the Canadian hog industry is closely associated with the United States market and relies heavily on foreign markets to sell its output. Trade in pork is considered below (section 2.2.5).

2.2.2 Beef and Pork Production Systems

2.2.2.1 Beef Production

The beef production process begins with the decision to breed a cow. This typically occurs in the third calendar quarter and after a nine month gestation period a calf is born in the spring. Weaning occurs within six months at which time the animal is either slaughtered or passed on for fattening. The decision to breed therefore depends on the expected price of feeder calves which is determined by the supply and demand for calves. The strength of this demand is derived from the expected prices of steers and feed costs. Those animals entering feedlots will be fed a high energy ration over a period of 7 to 11 months. Others, which are backgrounded, feed on range land or pasture and low energy supplements. These animals either remain on farms longer or are slaughtered at lower weights. Consequently, the production process is both long and complex, with total beef production constrained, to some extent, by the breeding inventory two or three years earlier. However, the current supply of beef also depends on beef and feed prices as they regulate the flow of animals to market. The system is further complicated by the culling of cows and bulls from the breeding herd, variations in slaughter weights and by the impact of the dairy sector on beef supplies.

2.2.2.2 Pork Production

The pork production process begins with the decision to breed a sow. The gestation period is four months and the offspring are weaned three to five weeks later. A recent trend towards weaning at earlier ages has increased sow productivity by raising the average annual number of litters produced. After a ration of creep and starter feeds the weaner pig (at 40 lbs.) is moved from the farrowing unit for fattening. The production process for pork is less seasonal than for beef, chiefly due to the shorter reproductive cycle of pigs, and the type of husbandry and housing which keeps much stricter control over their environment. A sow will typically produce sixteen weaned pigs every year coming from two litters of eight. Some will be held back in the breeding herd for replacement. Unlike the beef sector, the culling of the breeding herd has little effect on supplies and contributes less than four percent of total production. Production is determined principally by hog and feed prices. The cost of feed is estimated to account for between 65 percent and 70 percent of all variable inputs in pork production.

2.2.2.3 The Cattle and Hog Cycles

The beef and pork markets are characterized by production and price cycles resulting from the atomistic organization of the industry and the time lag between producers decisions to produce and the realization of those decisions. The beef cycle is long, lasting eight to twelve years, and results from the inability of cow-calf producers to react quickly to

changes in the economic environment and price expectations. From figure 2.2 we see that the production process lasts a minimum of two years and once the process has been set in motion little can be done to change it in the short run. Say, for example, the price of steers were to increase enhancing profit margins in the feeding sector. This would be reflected in an increased demand for feeder calves and a subsequent increase in their price. Higher feeder calf prices would prompt cow-calf operators to hold back inventory by reducing culling rates and holding back heifers from the market. The decline in supply intensifies the upward pressure on steer and feeder calf prices. Within two or three years the hold-back of heifers is reflected in increased supplies and downward pressure on steer prices. This in turn reduces feeder calf prices and the cycle begins a downward trend. The cattle cycle in Canada is driven by that of U.S. whose cattle population is about ten times larger (figure 2.3).

The pork production cycle is generated in a similar way to the beef cycle. The pork cycle, however, is much shorter than that of beef lasting between three and four years. This is due to the shorter gestation and weaning period and the lower weight at which hogs are marketed, thereby allowing operators to adjust more quickly to meet changing conditions.

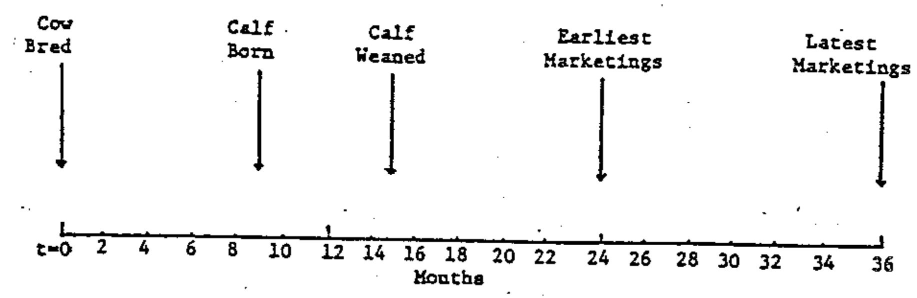
2.2.3 Consumption of Red Meats

Canadian consumption of government inspected beef increased over 30 percent during the late sixties and seventies from 73 pounds per capita, in 1966, to 96 pounds per capita in 1976. However, beef consumption has declined since its peak in 1976 and by 1984 had dropped to 75.5 pounds per capita. Pork consumption was 51 pounds per capita in 1966 and remained fairly stable during the seventies. Consumption rose in the late 1970's to a peak of 65 pounds per capita in 1980, but has declined moderately since averaging about 60 pounds per capita between 1982 and 1984 (figure 2.4). The increases during the seventies resulted directly from increases in per capita income throughout the period. The decline in the eighties may reflect a structural change away from red meats spurred by evidence that large quantities may be damaging to human health, however the results of Moschini and Meilke (1984) show that most of the decline can be explained by economic forces. Nevertheless, meats still comprise a large proportion of consumer expenditure on food. For example, in 1982, 8.5 percent of total food expenditure was spent on beef (representing 1.71 percent of total expenditure) while expenditures on pork amounted to 4.2 percent of the food budget, or 0.85 percent of total expenditure.

2.2.4 Storage of Red Meats

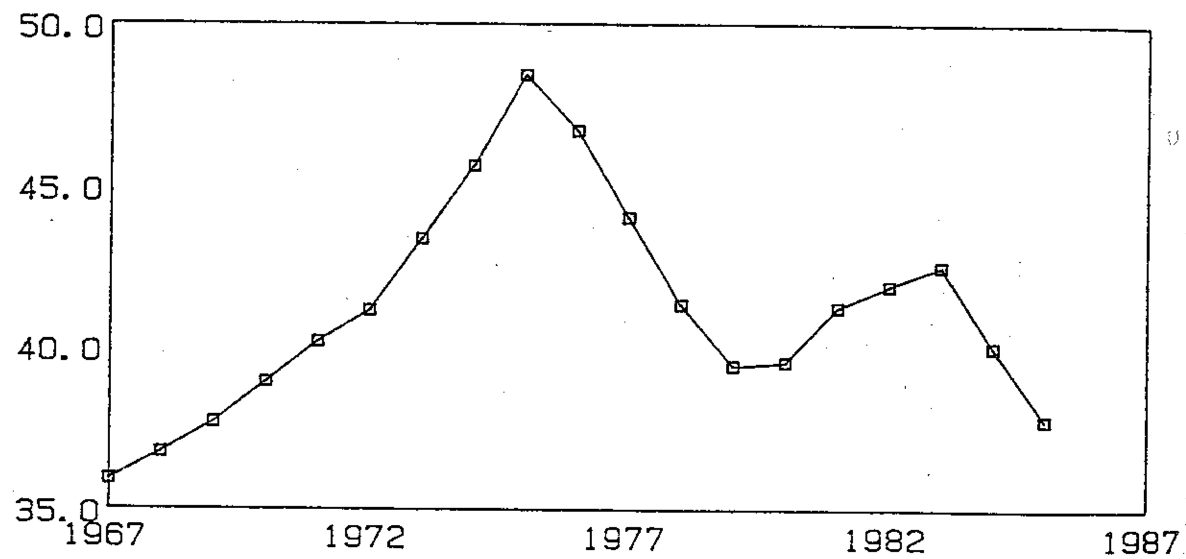
Not all the meat that is produced goes for immediate consumption or export, since a small proportion is held in inventories. The demand for inventories comes from the processing and retail sectors and evolves

Figure 2.2: Time Line Showing Stages in the Production Process



Source: Haack (1978).

Figure 2.3: U.S. Beef Cow and Bull Inventory, January 1, 1967-1985, Million Head



Canada Beef Cow and Bull Inventory, January 1, 1967-1985, Million Head

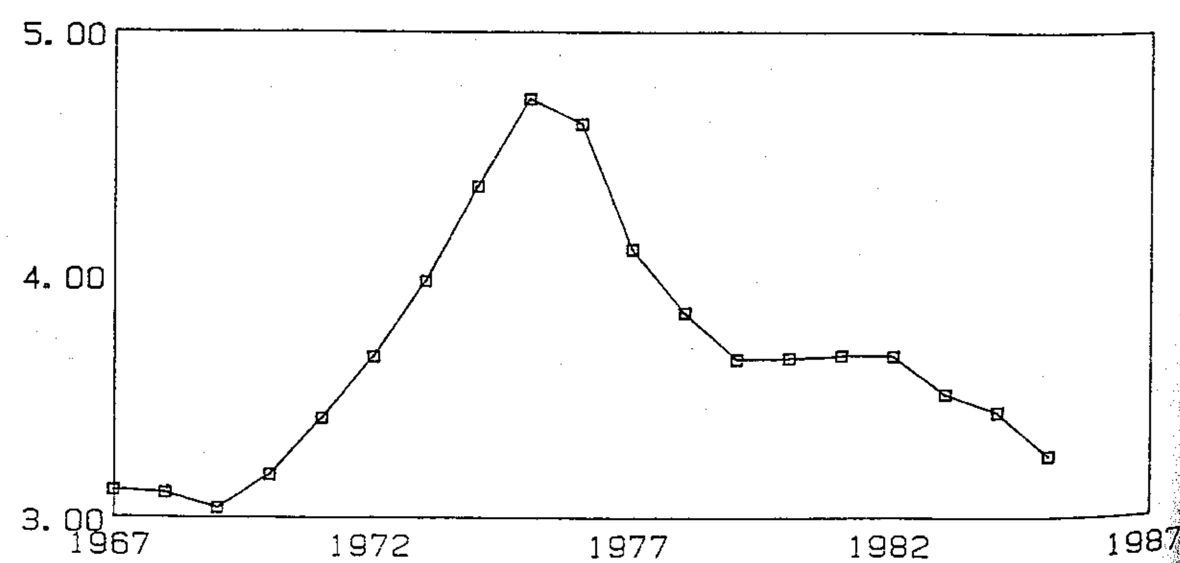
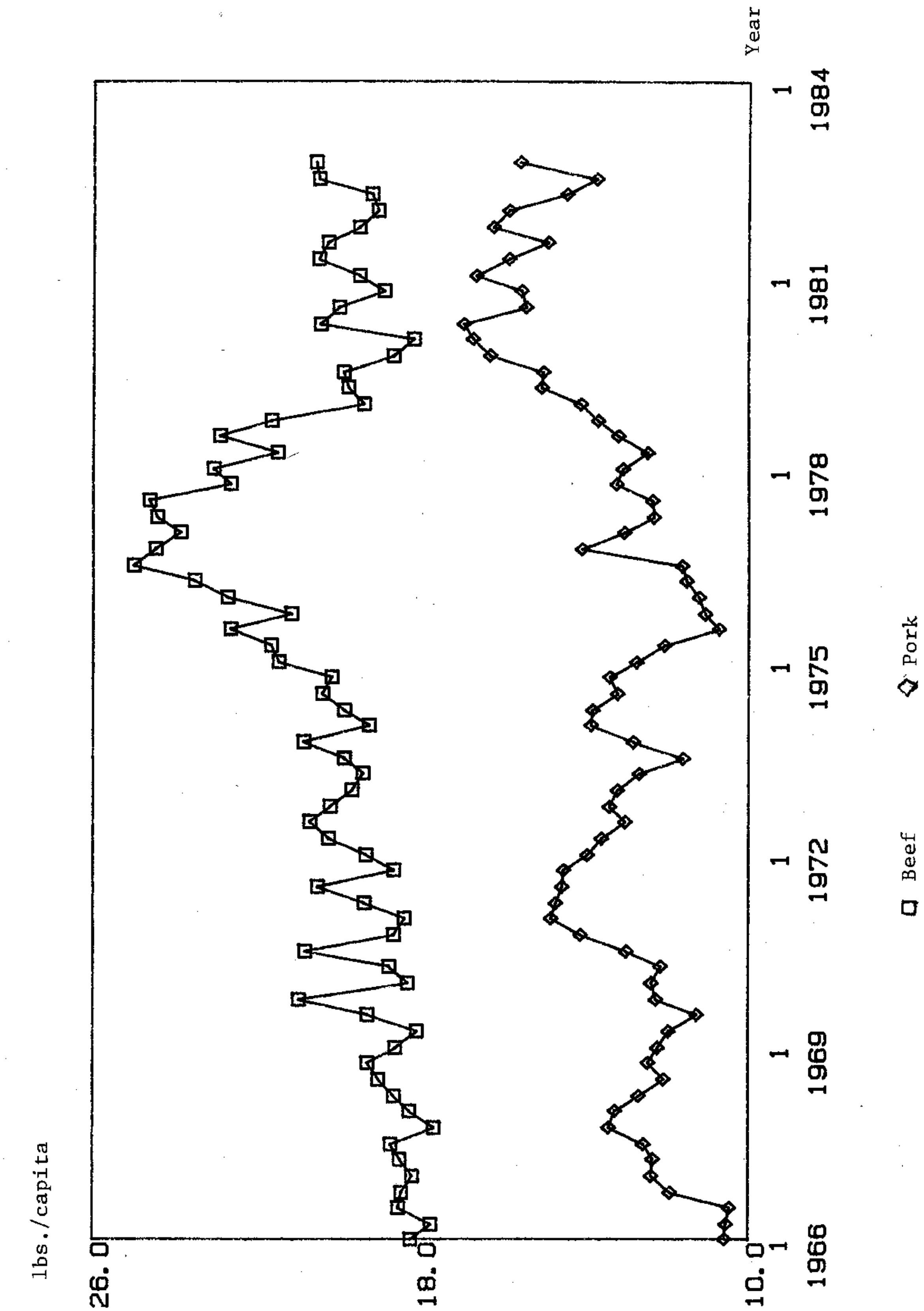


Figure 2.4: Per Capita Disappearance of Beef and Pork, Canada, 1966(1) to 1982(4)



from two motives for holding stocks. The first comes from a transactions demand in which processors keep back a certain quantity to ensure that unanticipated changes in consumer demand can be met. The second is derived from a speculative demand. Here processors hold back stocks if they believe prices will rise in the future, providing the potential for profits. Quarterly closing stocks of beef averaged 10.9 percent of total production between 1966 and 1982 and reached a maximum of 19.2 percent in 1976. Meanwhile, quarterly closing stocks of pork averaged 7.9 percent during the same period and peaked at 16.9 percent in 1971. Stocks, therefore, are important in determining the quantity of meat that is available for consumption and may also have an impact on price levels and trade.

2.2.5 Trade in Red Meats

The Canadian red meat sector is greatly affected by international trade in beef and pork. The United States is the major trading partner for beef although trade in manufacturing quality beef with Oceania (Australia and New Zealand) is substantial. Barriers to trade have been modest and have not inhibited trade significantly. A tariff of 1.0 cent/lb. on live imports and 2 cent/lb. on dressed beef are imposed. Non-tariff barriers include quotas, health regulations and strict processing and packaging specifications on trade in dressed meats. The U.S. imposes reciprocal barriers (ie. 1.0 cent/lb. on live imports and 2 cent/lb. on dressed beef) on Canadian beef but these too provide little disincentive to trade.

Canada has been a consistent net importer of beef from the rest of the world (ROW), excluding the United States. This trade, originating primarily from Oceania, is typically of low quality and is generally used for hamburger. Canadian exports of beef to the rest of the world, excluding the Unied States, are minimal. Meanwhile, Canada has been a consistent net exporter of beef to the U.S. despite substantial imports of beef that have moved North across the border (table 2.1). This two way trade can perhaps be explained by the differences in types and qualities of beef that are traded indicating that beef in two different countries may not be perfectly substitutable (Goddard (1984)).

Canada is a consistent net exporter of pork to the rest of the world with exports increasing in the late 1970's with the expansion of the Japanese market (Pieri, Meilke and MacAulay (1977)). Imports of pork from the ROW are minimal. Trade in pork between the U.S. and Canada has switched during the 1970s, as demonstrated in table 2.2. Net exports have risen considerably due to favourable hog/feed price ratios and increased production in Quebec. Reciprocal tariffs, on pork meat and live hogs, between Canada and the United States were zero until a countervailing duty was placed on Canadian hog exports to the U.S. in early 1985.

Table 2.1: Canadian Trade in Beef with the Rest of the World and the U.S., million pounds, (1972-1984)

Year	Imports from ROW	Exports to ROW	Net Imports from ROW	Imports from U.S.	Exports to U.S.	Net Exports to U.S.
1972	159.9	11.5	148.4	45.2	75.8	30.6
1973	171.8	12.0	159.8	51.0	82.7	31.7
1974	154.1	7.7	146.4	25.0	58.9	33.9
1975	180.6	11.7	168.9	14.0	39.3	25.3
1976	281.6	16.1	265.5	30.9	113.4	82.5
1977	176.4	13.1	163.3	15.8	99.2	83.4
1978	198.1	16.7	181.4	16.9	81.7	64.8
1979	173.9	15.8	158.1	9.6	98.9	89.3
1980	158.3	20.0	138.3	14.3	123.4	109.2
1981	149.0	21.8	127.2	25.4	153.7	128.3
1982	165.5	20.9	144.6	25.8	162.6	136.8
1983	169.6	18.5	151.1	31.1	164.0	132.9
1984	197.5	20.0	177.5	56.9	214.2	157.4

Source: Statistics Canada. Trade of Canada, Exports by Commodity and Trade of Canada, Imports by Commodity.

Table 2.2: Canadian Net Trade in Pork with the U.S. and the Rest of the World, million pounds, 1972-1984

Year	Net Exports to the U.S.	Net Exports to the ROW
1972	27.7	43.1
1973	25.6	46.1
1974	-14.7	37.8
1975	-62.7	55.4
1976	-169.7	60.3
1977	-176.0	75.7
1978	-67.0	72.0
1979	20.8	81.0
1980	133.4	88.1
1981	135.0	105.8
1982	219.9	108.5
1983	210.0	94.7
1984	295.7	58.3

Source: Statistics Canada. Trade of Canada, Exports by Commodity.

2.3 THE IMPACT OF EXCHANGE RATE CHANGES ON PRICES, QUANTITIES AND TRADE

Section 2.2 described the major components of the red meat market. In modeling the red meat sector it is essential to capture the major determinants of prices, quantities and trade flows. Moreover, it is changes in these variables following a change in the exchange rate, that can be used to measure its effects on the agricultural sector. It is important therefore to present a framework within which the effects of the exchange rate on prices, quantities and trade can be dealt with at a theoretical level. In doing so not only is a theoretical justification for the model specification provided, but also a basis for forming *a priori* expectations of market adjustments following a change in the exchange rate.

The treatment of exchange rates from a theoretical level has centered on the relative changes in price and trade flows for a given change in the exchange rate. Kost (1976) provides a theoretical framework that enables assessment of exchange rate changes on prices and quantities traded in a simple one-commodity, two-country model. The model is simplified by assuming perfect markets in both countries and no barriers to trade or transportation costs. It can be represented mathematically using equations 2.1 through 2.4, where ES is the exporting country's excess supply curve, ED the importing country's excess demand curve, P_e and P_i prices in the exporting and importing countries, and r the rate of exchange between the importers' and exporters' currency.

2.1 $$ES = ES(P_e) \quad , \quad \partial ES/\partial P_e > 0 \quad ;$$

2.2 $$ED = ED(P_i) \quad , \quad \partial ED/\partial P_i < 0 \quad ;$$

2.3 $$P_i = r\,P_e$$

2.4 $$ES = ED$$

Totally differentiating equations 2.1 through 2.4 and substituting the results from 2.1 through 2.3 into 2.4 gives,

2.5 $$\frac{\partial ES}{\partial P_e} dP_e = \frac{\partial ED}{\partial P_i} dP_e r = \frac{\partial ED}{\partial P_i} drP_e .$$

Solving equation 2.5 for the elasticity of the exporter's price with respect to a change in the exchange rate (E_{P_e},r) gives,

2.6 $$E_{P_e},r = \frac{dP_e}{dr}\ \frac{r}{P_e} = \frac{E_{ed}}{E_{es} - E_{ed}}$$

where, E_{ed} and E_{es} are the price elasticities of excess demand and excess supply, respectively.

Clearly, if the excess supply curve is perfectly inelastic (E_{es} = 0) then the price elasticity with respect to the exchange rate is minus one, whereas if excess supply is perfectly elastic (E_{es} = 00) the elasticity is zero. Consequently, in this simple model the percentage change in the equilibrium price is bounded by zero and minus one, and the percentage change in the equilibrium price will be at most equal to the percentage change in the exchange rate (Bredahl and Gallagher (1977)).

The excess supply curve measured in the exporter's currency does not shift with variations in the exchange rate, and the elasticity of the equilibrium quantity traded with respect to the exchange rate is

2.7 $$E_{es},r = E_{P_e},r \ * \ E_{es} \ ,$$

$$= \frac{E_{ed} \ * \ E_{es}}{E_{es} - E_{ed}}$$

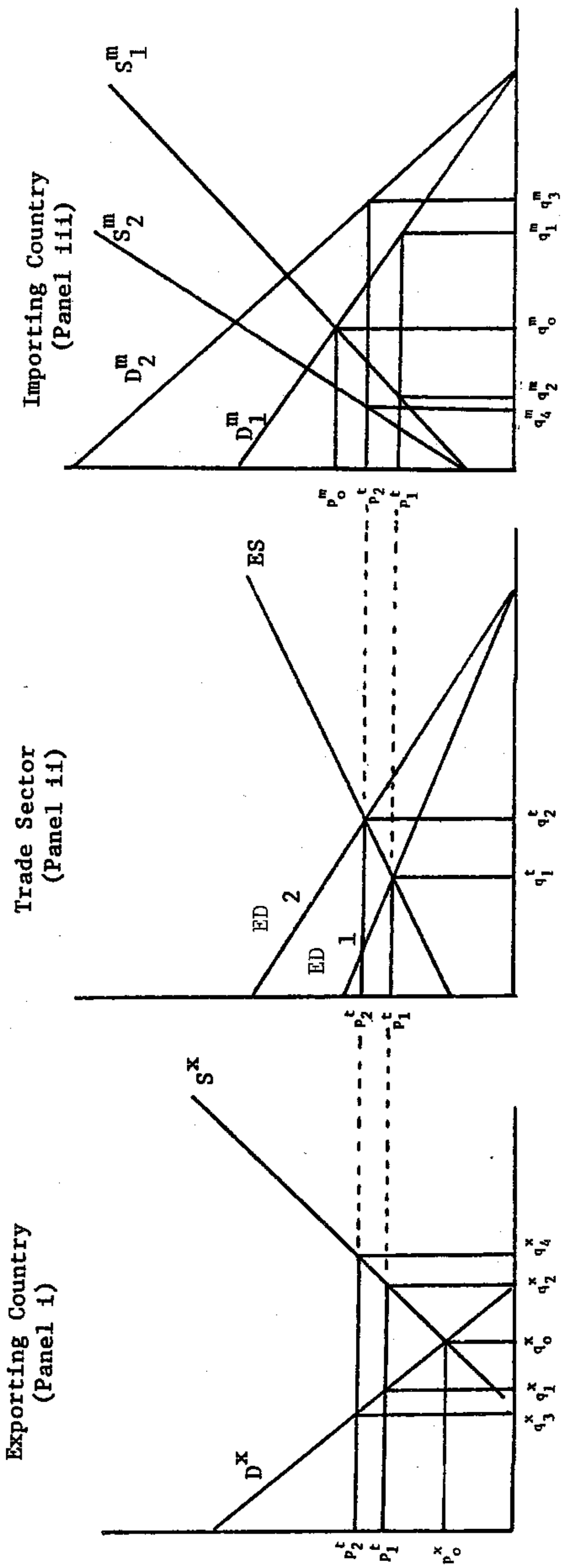
This elasticity, which is negative, is bounded on the upper end by zero but has no lower bound (Bredahl and Gallagher (1977)).

Consequently, a devaluation of the exporter's currency, which would be represented by a decline in r, will result in an increase in the exporting country's price ranging between zero and the percentage change in the exchange rate, and an increase in the quantity traded unless the elasticity of excess supply or excess demand is zero.

The model derived above is represented graphically in figure 2.5 and describes the impact of a devaluation by an exporting country. Figure 2.5 shows a simple two-country, one-commodity trade model. In the no trade situation the exporting country (panel i) produces q_o^x at a price p_o^x as shown by the intersection of its domestic supply and demand curves, S^x and D^x. The importing country (panel iii) produces q_o^m at price p_o^m as given by the intersection of its domestic supply and demand curves, S_1^m and D_1^m. In this situation the prices in each country are not the same (ignoring exchange rates and transportation costs), and provides the possibility of trade.

The trade relationships are summarized in panel ii. The excess supply curve (ES) shows the various quantities of the commodity that will be supplied to the importing country by the exporting country at different price levels. Only when the trading price rises above the domestic equilibrium price (P_o^x) will there be any of the commodity available for export. The excess demand curve (ED) shows the various quantities of a commodity that will be demanded from the exporting

Figure 2.5 One-Commodity Two Region Trade Model.



1. No trade situation.		
Exporting Country:	Production	q_o^x
	Consumption	q_o^x
	Price	p_o^x
Importing Country:	Production	q_o^m
	Consumption	q_o^m
	Price	p_o^m
2. With trade before devaluation.		
Exporting Country:	Production	q_2^x
	Consumption	q_1^x
	Price	p_1^t
Importing Country:	Production	q_2^m
	Consumption	q_1^m
	Price	p_1^t
Trade:		q_1^t
3. With trade after devaluation.		
Exporting Country:	Production	q_4^x
	Consumption	q_3^x
	Price	p_2^t
Importing Country:	Production	q_4^m
	Consumption	q_3^m
	Price	p_2^t
Trade:		q_2^t

country by the importing country at different price levels. Only when the trading price falls below the domestic price will there be demand that can not be satisfied from the domestic supply. At any price below the domestic price, the amount the importing country desires to import will equal the difference between quantity demanded and quantity supplied.

Trade equilibrium is reached at the intersection of the excess supply and excess demand curves, ES and ED_1, where quantity q_1^t is traded at price p_1^t. Note that q_1^t equals the difference between quantity supplied and quantity demanded in the exporting $(q_2^x - q_1^x)$ and the importing $(q_1^m - q_2^m)$ countries.

In figure 2.5, the effect of a devaluation in the exporting country is to shift the importing country's domestic demand curve from D_1^m to D_2^m and domestic supply curve from S_1^m to S_2^m. This in turn causes the import demand curve to shift from ED_1 to ED_2 (panel ii), to give a new trade equilibrium at q_2^t and P_2^t. Note q_2^t equals $(q_4^x - q_3^x)$ and $(q_3^m - q_4^m)$ and the price in both countries increases from P_1^t to P_2^t.

The model shows that for a given change in the exchange rate, there is an impact on both price and quantity traded. It is possible to calculate elasticities for both the price and quantity with repect to the exchange rate and this was done in the mathematical model presented earlier.

The model presented above is the standard textbook example of the impact of exchange rates on prices and quantities traded. However, it is somewhat misleading in that supply and demand are functions of only a single price. In reality supply and demand are functions of many prices, most, if not all of which, will be influenced by variations in the exchange rate. In considering red meat trade between Canada and the United States one of the most important variables falling into this class is the price of purchased feed grains. Because of the size of the U.S. feed grain market relative to Canada's demand, the small country assumption is appropriate for Canada in this market. Following from this a slightly more complicated trading model is formulated in equations 2.8 through 2.12.

2.8 $ES = ES(P_e, W_e)$, where $\partial ES/\partial P_e > 0$ and $ES/\partial W_e < 0$.

2.9 $ED = ED(P_i, \bar{W}_i)$, where $\partial ED/\partial P_i < 0$ and $\partial ED/\partial W_i > 0$.

2.10 $P_i = r P_e$

2.11 $\bar{W}_i = r W_e$

2.12 $ES = ED$

The only modification to the previous model is the inclusion of another price in the excess supply (W_e) and excess demand (W_i) curves. This price may represent the price of a substitute, on the demand side, or of an input on the supply side. Further, the exporting country is assumed to be a small country with respect to the second good. Consequently its price (W_e) is calculated by multiplying the fixed price in the importing country (W_i) by the inverse of the exchange rate.

Proceeding as before by totally differentiating equations 2.8 through 2.12 and solving for the elasticity of the export price with repect to the exchange rate gives (2.13).

$$2.13 \qquad E_{P_e,r} = \frac{E_{ed} + E_{es,w}}{E_{es} - E_{ed}}$$

where, $E_{es,w}$ is the elasticity of the excess supply curve with respect to the input price.

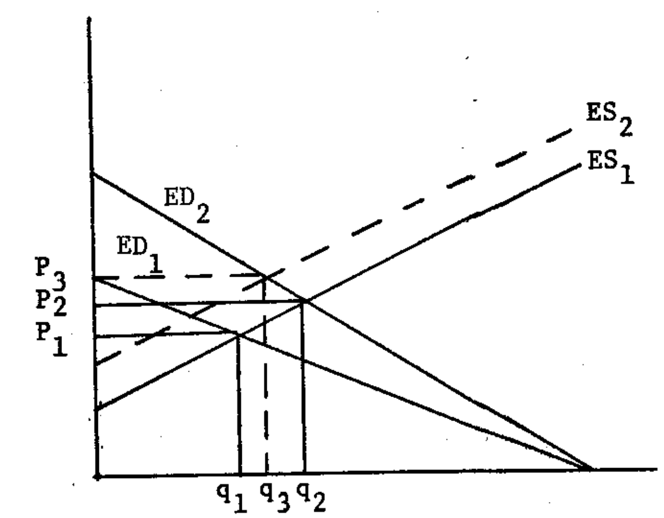
Comparing equations 2.13 and 2.6 shows they differ only by the second term in the numerator, which represents the shift in the excess supply curve caused by the impact of the exchange rate on the price of W_e. Thus, the change in the exporting country's price resulting from an exchange rate change will be larger in this model than in the previous one. Note that if the excess supply curve is homogeneous of degree zero in terms of both prices (P_e and W_e) then the elasticity of the export price with respect to the exchange rate is minus one.

The response of excess supply to a change in the exchange rate is given by

$$2.14 \qquad E_{es,r} = \frac{E_{ed}\,(E_{es} + E_{es,w})}{E_{es} - E_{ed}} \; .$$

If $E_{es,w}$ is smaller in absolute value than E_{es} this elasticity is negative, and smaller than the corresponding elasticity calculated in equation 2.7. If the excess supply curve is homogeneous of degree zero in terms of both prices the elasticity of excess supply with respect to the exchange rate is zero. Consequently, the incorporation of more than one price into the trade model results in larger price effects and smaller trade effects. This is illustrated graphically in figure 2.6 which reproduces panel (ii) from figure 2.5. As before the predevaluation equilibrium is at P_1 and q_1. Following the devaluation of the exporter's currency the import demand curve rotates from ED_1 to ED_2 and the exporter's excess supply curve shifts from ES_1 to ES_2. As derived above, the final equilibrium at P_3 and q_3 represents a higher price and smaller quantity than the solution (P_2 and q_2) where cross commodity effects are ignored.

Figure 2.6: Two-Commodity Two Region Trade Model



Chambers and Just (1979) contend that simple models of exchange rate impacts, such as those presented above, have been too restrictive in their specifications and this may account for the unclear and often conflicting results which have emerged from empirical studies. They begin with the partial two-country excess supply/demand model and show that the percentage change in price (in terms of exporter's prices from a change in its exchange rate) can never exceed the percentage change in exchange rate. They then criticize the approach as being based on some strong assumptions that are frequently violated, and proceed by describing a more general theoretical framework. Chambers and Just (1979) argue that neoclassical demand theory requires that the demand for a good depend on income and all other prices. Previous studies, however, by omitting other prices and income imply an excess demand function with zero cross-price elasticities between all other goods and traded agricultural commodities. Then they respecify the excess demand relationship as a function of the prices of all commodities in the importing country and income. Similarly, they respecify the excess supply function to incorporate all alternative production possibilities in the exporting country. They employ this new specification to show that the elasticity of price with respect to the exchange rate can exceed unity. This is possible in the general model because all other prices, income and the exchange rate cause shifts in the demand and supply curves. Consequently, they argue that with these additional shifters of supply and demand there is no reason to restrict the elasticity of price with respect to exchange rate to be less than or equal to unity.

Bredahl et al (1979) in criticizing the work of Chambers and Just (1979) calculate the elasticities of import demand, equilibrium exporter's price, and quantity traded with respect to the exchange rate for an even more general model. Structural elasticities are shown to be conceptually identical in the one-commodity and n-commodity free trade model. Moreover, in contrast to Chambers and Just (1979), it is shown that in both the single or n-commodity case the percentage change in price will never exceed the percentage change in the exchange rate (so long as all goods are substitutes). Consequently, it appears desirable to restrict the impact of an exchange rate change on an exporter's price to be between zero and minus one. In the empirical work which follows this constraint is imposed in both the short and long-run.

2.4 REGIONAL BREAKDOWN

It was suggested in Chapter 1 that the Canadian price reflects the U.S. price adjusted for transportation costs and exchange rates. This results from the dominance of the United States in the North American market and the modest trade barriers that exist between the two nations. Prices in the U.S. are determined by demand and supply conditions within their market and are largely independent of the Canadian sector. This suggests that the model should encompass the whole North American market in which the U.S. and Canada are treated as two regions. This choice is further justified in that analysis of U.S./Canadian exchange rate fluctuations necessitates separate consideration of the participants within the bilateral exchange rate.

Canada is treated as a single region, except for pork supply and cow-calf operations (cow and bull inventories, cow and bull slaughter, and feeder calf price equations) where Canada is split into Eastern (Ontario, Quebec, New Brunswick, P.E.I., Nova Scotia) and Western (B.C., Alberta, Saskatchewan, Manitoba) Canadian regions.

2.5 CLOSING THE MODEL

Having divided the North American red meat market into United States and Canadian components, it is necessary to bring these regions together so that interaction can take place between them. There are several types of international trade models and a thorough review may be found in Sarris (1979), Thompson (1980), Schuh (1981), Abbott and Thompson (1982) and Goddard (1984). For the purpose of this study both the non-spatial and spatial equilibrium models may be appropriate. These are discussed briefly below.

2.5.1 Non-Spatial Price Equilibrium Models

Thompson discusses non-spatial equilibrium models as follows:

> Non-spatial price equilibrium models are the simplest multiple region trade models. They explicitly treat the interrelations among trading regions by assuming that the world market price is determined simultaneously by the supply-demand balance in all trading regions such that the global market clears. The model solution gives the world market clearing price(s) and net trade of each region trading in the world market, but it provides no information on source-destination trade flows.

He continues by isolating three classes of the non-spatial equilibrium models which differ in the nature of the price linkages among the trading nations. The first assumes a single world price that exists within every region (eg. price in country X = price in country Y) and ignores the existence of transportation costs. The second assumes that all prices are linked to the price in one region through transportation costs (eg. price in country X = price in country Y + or - transportation costs). The final subclass links prices through transportation costs between countries who participate in trade with one another (eg. if country A exports to country B, then price in B = price in A + transportation costs and if country C exports to country A, then price in A = price in C + transportation costs). This method of price linkage does present an element of spatial price equilibrium. The solution technique however provides only the level of net trade within each region, while spatial equilibrium models generate source-destination trade flows.

2.5.2 Spatial Price Equilibrium Models

Spatial price equilibrium models are a common form of agricultural trade models used for comparative static analysis of policy changes. The spatial price equilibrium problem is described by Takayama and Judge (1971) as follows:

> We are given in each of two or more regions demand and supply functions for a given product in terms of its market price at that location. In addition unit transportation costs are also given for carrying the product between the locations. Under this specification we would like to know what will be the (1) competitive equilibrium price in each location; (2) the amount supplied and demanded in each location; and, (3) level and pattern of exports and imports.

Most models of this type are solved using quadratic programming. The objective function is given by the maximization of the area under all excess demand curves, minus the area under all excess supply curves, minus transportation costs. This function is then constrained by the following requirements.

1. The quantity entering a region must be less than or equal to the quantity demanded.

2. The quantities leaving a region must be less than or equal to the quantity supplied.

3. Prices between regions must not differ by more than the transportation costs between them.

The solution to the problem gives prices and quantities demanded and supplied in each region and trade flows between them.

2.5.3 Spatial versus Non-spatial Models

Before a choice of model specification is made it is important to compare the two possibilities outlined above. Most of the data requirements are identical in the two models, in that both techniques require internal demand and supply functions for each region. The major difference lies in the hypothesis made about how the markets are related.

In the simplest case prices in spatial models are linked directly as follows

2.15 price in A $\leq$ price in B + transportation costs.

The solution to the problem then determines which way trade flows, showing source-desintation information between regions.

Non-spatial price equilibrium models link regions indirectly using equations of the form:

2.16 price in A = X + Y * price in B.

Here the way in which prices are related is given by Y, while transportation costs are either included indirectly in the intercept or as an explicit variable. For the prices of country A and country B to be linked, it is necessary that either A or B be a consistent net exporter or net importer. This allows the appropriate sign to be given to transportation costs. The solution technique provides the net trade position of each region, but no source-destination information or shadow values. Goddard (1984) has shown that when the same price linkage equations commonly used in non-spatial models are built into a quadratic programming formulation of a spatial model, the results of the two are identical. Both techniques can be used to incorporate barriers to trade.

2.5.4 Choice of Trade Model

The differences between the spatial and non-spatial models are small. Both require the same information and provide the same answer when the prices are linked in a similar fashion, but the spatial model provides additional information on the source and destination of trade flows.

In this study the world contains only two endogenous regions (U.S. and Canada) with the rest of the world treated exogenously. With only two regions, the source-destination information of the spatial model will be identical to the net trade information of the non-spatial model. Trade between the U.S. and Canada always took place during the 1970s and early 1980s, consequently the ability of the quadratic programming technique to capture the no-trade situation is not required. Trade flows between the U.S. and Canada are known and knowledge of the North American market allows appropriate specification of the price linkages between them. Thus, there seems to be little benefit from the extra information provided in the spatial model which is also computationally much more costly. For these reasons the model is closed using price linkage equations and a non-spatial price equilibrium formulation.

2.6 MACROECONOMIC LINKAGES BETWEEN TRADING REGIONS

In the North American red meat model the prices of livestock and feed in Canada are linked to livestock and feed prices in the United States. Having linked these agricultural prices, the complete model needs to be examined to see if further variables should be linked. Throughout the model, variables appear which may be loosely described as macroeconomic, such as the consumer price index (CPI), wholesale price index (WPI), the rate of interest, the wage rate and per capita disposable income. It is suggested, with evidence from Canadian macroeconomic models supporting the assertion, that the levels of these variables in Canada are influenced by the United States which (as in the red meat market) dominates the entire North American economic performance.

2.6.1 Macroeconomic Variables

The CPI enters the model as a deflator in the demand system while the WPI is used to deflate prices occurring on the supply side of the model. These indices include a number of goods which are traded, consequently price increases in the U.S. are reflected in higher import prices, driving up the Canadian CPI and WPI. It seems reasonable therefore, to assume that the CPI and WPI in Canada are influenced by those in the U.S.

A similar argument can be put forward for linking the U.S. and Canadian interest rates. For example, if the U.S. pursues a policy of tight monetary control or runs a large budget deficit (both examples were witnessed in the 1970s and 1980s) the U.S. rate of interest increases substantially. This encourages large movements of capital from Canada to the United States and results in decreased investment and a depreciation of the Canadian dollar. To stem the flow of funds a likely response from the Canadian government is to raise interest rates. It seems reasonable therefore, that interest rates between the two countries are linked.

It is also recognized that per capita income in the U.S. and Canada are related. Imagine the U.S. economy turning into a recession during which unemployment increases, thereby resulting in decreased demand and production. The lack of U.S. purchasing power reduces the demand for Canadian imports. The lack of orders will in turn require contractions of Canadian production and employment. Soon Canada will follow the U.S. in a downward turn in its economic cycle.

Having discussed a link between prices of goods and capital, perhaps linking the prices of labour is necessary to maintain consistency. While wage rates between the two countries are related, to argue for a direct link is less appealing. This is due to the immobility of labour and barriers that restrict the free operation of the labour market. An indirect link between wage rates can be found however, since they are heavily dependent on both income and prices and these are closely related internationally in the manner described above.

2.6.2 The Purchasing Power Parity Theorem

Having described ways in which certain macroeconomic variables are linked between the United States and Canada, it is necessary to continue by developing a framework within which these variables can be related through the exchange rate. For example, assuming that the CPI in Canada is some function of the CPI in the U.S., we may wish to know how this relationship is affected by movements in the exchange rate. In the early 1900's Cassel devised the Purchasing Power Parity Theorem (PPP) which provides a framework within which to analyse the relationship between price levels and exchange rates.

The PPP theorem maintains that relative domestic purchasing power of currencies determines the level of a bilateral exchange rate. In other words, movement in a bilateral floating exchange rate is a function of divergent inflation rates. An example may clarify how this function operates. Suppose the inflation rate in the United States exceeds that of Canada, and Canada is a potential excess supplier of goods to the United States. Under a floating exchange rate the price of potential U.S. imported goods (i.e. the Canadian price) does not increase as fast as the price of domestic goods (i.e. the U.S. price). This induces a movement of goods from Canada to the U.S. Assuming that these movements are substantial, the U.S. dollar will eventually depreciate against the Canadian dollar. Canadian goods become more expensive to U.S. consumers and this stems the flow across the border. Thus the Canadian/U.S. exchange rate is determined to some extent by

the relative inflation rates existing within each country. Two versions of PPP have been described and these are discussed below.

2.6.2.1 Relative PPP

Relative PPP is derived as follows:

1. The exchange rate between countries a and b are observed in period t.
2. Inflation rates are calculated in each country between period t and period t+1 (P_a , P_b).
3. The ratio of inflation rates is calculated as, $Z = P_a/P_b$.
4. The exchange rate in period t+1 is given as the exchange rate in period t multiplied by Z.

2.6.2.2 Absolute PPP

Absolute PPP is derived as follows,

1. Calculate an average price of some bundle of goods on the domestic market P_D.
2. Calculate an average price of this bundle in a foreign market, priced in the foreign currency P_F.
3. The exchange rate is determined such that $P_D = r\,P_F$.

2.6.2.3 Mathematical Representation of PPP

The PPP theory suggests that the change in the exchange rate is given by the ratio of inflation rates in countries a and b (section 2.6.2.1, point 3).

$$2.17 \qquad E_{ab,t}/E_{ab,t-1} = \frac{P_{a,t}/P_{a,t-1}}{P_{b,t}/P_{b,t-1}}$$

where,

$E_{ab,t}/E_{ab,t-1}$ is the percentage change in the exchange rate;

$P_{a,t}/P_{a,t-1}$ is the percentage inflation rate in country a; and,

$P_{b,t}/P_{b,t-1}$ is the percentage inflation rate in country b.

Equation (2.17) can be rewritten in its logarithmic form as:

2.18 $\quad Ln(E_{ab,t}/E_{ab,t-1}) = Ln(P_{a,t}/P_{a,t-1}) - Ln(P_{b,t}/P_{b,t-1}).$

Differentiating (2.18) with respect to time yields:

2.19 $\quad \dot{E}_{ab,t} = \dot{P}_{a,t} - \dot{P}_{b,t}$

where, $\dot{E}_{ab,t}$ is the rate of change in the exchange rate; and,

$\dot{P}_{a,t} - \dot{P}_{b,t}$ is the difference in the rates of inflation.

Note, if $(P_{a,t}/P_{a,t-1}) > (P_{b,t}/P_{b,t-1})$ then, $(E_{ab,t}/E_{ab,t-1}) > 0$, i.e. devaluation; if, $(P_{a,t}/P_{a,t-1}) = (P_{b,t}/P_{b,t-1})$ then, $E_{ab,t} = E_{ab,t-1}$ i.e. no change in the exchange rate.

An example may be helpful. Let Canada be country a and the U.S. be country b. Inflation in Canada exceeds that of the United States. This leads to an increase in the demand for and price of U.S. dollars such that the Canadian dollar devalues.

2.6.2.4 Problems of PPP

Those who criticize the PPP theorem centre their objections around two main issues. The first suggests that while the PPP is acceptable in a free and competitive market, the real world is characterized by imperfections such as taxes and tariffs which detract seriously from the usefulness of the theorem. The second criticism recognizes that the theorem uses inflation rates to determine exchange rates. It is very difficult, however, to find an observable, unambiguous and unequivocal measure of price levels. Hence,

> the strict relationship between excess inflation and currency depreciation is more a conceptual than an exact practical relationship (Lee (1976)).

Despite these problems, the PPP does provide a theoretical basis upon which equations can be estimated.

2.6.3 Interest Rates

In calculating the enterprise budgets for producers of pork and beef interest rates are used to calculate the opportunity cost of operating capital. In addition, interest rates are conceptually an important determinant of the rate of livestock slaughter (Jarvis (1974)).

There is evidence of a relationship between Canada's interest rate and its exchange rate. This evidence is provided by economic theory,

casual observation and macroeconomic models of the Canadian economy (O'Reilly et al. (1983)). Unfortunately, modeling the relationship between changes in the exchange rate and interest rates is not a simple task, because they are undoubtedly determined simultaneously. In addition, econometric models of the Canadian economy furnish few answers to the problem, providing conflicting evidence as to both the size and direction of the relationship (O'Reilly et al. (1983)). Grennes (1984) illustrates the complexity of the relationship between interest rates and exchange rates as follows,

> A common view is that tighter credit strengthens a currency. For example, in the first half of 1982, Western European political leaders blamed high U.S. interest rates for the strength of the dollar and the corresponding weakness of their countries' currencies. The mechanism underlying this position is that high interest rates will attract capital flows, which add to the demand for the currency. Conversely, the monetary approach implies that higher interest rates depreciates a currency by signaling that greater inflation is expected in the future.

Despite the difficulty of modeling the relationship between exchange and interest rates, a very simple model is specified which is based upon the interest rate parity theorem (Grennes (1984)). This model can be described beginning with equation 2.20,

2.20 $\quad (1 + Ic) = (1 + Iu) * fer/ser$

where, Ic is the interest rate in Canada; Iu is the interest rate in the United States; ser is the spot exchange rate ($ Can/$ U.S.); and fer is the forward exchange rate ($ Can/$ U.S.).

This formula can be rewritten as,

2.21 $\quad Ic = Iu(fer/ser) + (fer/ser) - 1 .$

Letting FP equal the forward premium ((fer-ser)/ser) gives

2.22 $\quad Ic = Iu(fer/ser) + FP .$

Algebraic manipulation of 2.22 results in

2.23 $\quad Ic = Iu + FP(1 + Iu) ,$

which assuming the product of F_p and I_u is small gives,

2.24 $Ic = Iu + FP$.

This expression provides the starting point from which the relationship between interest rates and exchange rates is estimated in section 3.11.3. Clearly, to calculate the forward premium it is necessary to estimate the forward exchange rate. Since this variable is largely dependent on the spot rate it cannot be treated as an exogenous variable and it is estimated behaviorally. The theoretical framework for determining the forward exchange rate is based again upon the purchasing power parity theorem of exchange rate determination. Recall that this requires that a bilateral exchange rate is determined by the relative inflation rates of the countries involved. In addition to inflation rates the spot exchange rate is also included in the equation to determine the forward exchange rate. This captures the naive expectation that the future exchange rate will be unchanged from current levels.

2.7 ENTERPRISE BUDGETS

Having discussed how exchange rates affect both price levels and macro variables and how these might behave following a depreciation of the Canadian dollar, it is important to further identify how these variables affect the well being and profitability of the livestock sector. Moreover, it is important to determine the relative effects on the different types of enterprise in each sector and then to evaluate whether producers are affected greatly by the exchange rate or whether it plays only a minor role in economic performance. To access if the exchange rate is an important or unimportant variable in the determination of profitability it is necessary to compare it with changes in other variables also affecting profit in the livestock sector (eg. the price of feed). In order to carry out this analysis enterprise budgets are used. Six budgets are developed which cover beef feedlot, cow-calf and farrow-to-finish enterprises for both Western and Eastern Canada.

To construct enterprise budgets (returns per cwt. produced or returns per animal sold) costs are generally divided into two broad categories and include the variable costs, which vary with the level of production (eg. feed and livestock purchases, marketing, transport, hired labour) and fixed costs, which are incurred independent of production levels, (eg. returns on investment and operator's labour, rent, depreciation).

In order to evaluate the impact of exchange rates on these budgets it is necessary to partition the costs and returns into tradable and non-tradable items. Within the tradable category are those variables which are dependent on the exchange rate. These include not only those items which are actually traded but also those whose price is influenced

by exchange rate variations (eg. silage and hay). The non-tradable items include those whose prices are independent of the U.S. market and are unaffected by movements in the exchange rate (eg. taxes and depreciation).

Enterprise budgets are constructed for the three types of enterprises and worked into the framework described in table 2.3. The revenues and costs are based on the production of a cwt. of beef and pork which is the form in which livestock prices are calculated in the model.

The traded cash costs include feed, purchased livestock and interest on operating capital. Interest on operating capital is given by the rate on one-half the cost of feed and livestock purchases. The figure of one-half was chosen after consultation with livestock production experts but nevertheless was selected arbitrarily.

The non-tradable cash costs are exogenous in the model and are listed in table 2.3. Some of the items may be influenced to some extent by the exchange rate. For example, the cost of fuel is included under marketing and transport and is probably influenced by the exchange rate. Some medicine and veterinary equipment is imported, and within the machinery, building, equipment and repairs categories are numerous minor imported components. While all of these factors are recognized, the influence of the exchange rate on these costs, at least in the short-run, are minimal.

Table 2.3: Enterprise Budget (cwt produced)

<u>Total Return</u>: = Price of livestock

<u>Cost</u>: <u>Cash Costs</u> (Traded) - Endogenous

(1) Feed

(2) Livestock purchases

(3) Interest on operating capital (=((1) + (2))*50%*Rate of Interest)

<u>Cash Costs</u> (Non-Traded) - Exogenous

(1) Marketing and transport

(2) Vet, med, AI.

(3) Machinery, buildings, equipment, repairs

(4) Taxes, telephone, hydro, insurance

(5) Hired labour

(6) Others

Furthermore, isolating and valuing the traded content of these inputs presents an almost impossible task. The cash costs for non-traded items represents less than 20 percent of all costs in the gross margin.

The budgets used in the analysis are expressed as gross margins and exclude the deduction of fixed costs from total returns. Fixed costs include depreciation, farm insurance, rent, interest on investment and return on operator's labour. Gross margins provide a useful indication of how producers' profitability is affected by the exchange rate in the short-run, and are realistic guides for farm management decisions. The gross margins enter the model as a set of identities an example of which is given below.

Enterprise budget identity for Eastern beef feedlot ($/cwt.)

Gross margin = price steers − (Z_0 * price corn + Z_1 * price soybean meal + Z_2 * value silage + Z_3 * price hay) − Z_4 * price feeder steers − rate of interest * 0.5 * ((Z_0 * price corn + Z_1 * price soybean meal + Z_2 * value silage + Z_3 * price hay) + Z_4 * price feeder steers) − non-traded cash costs.

Endogenous variables: price steers; price corn; price soybean meal; rate of interest; value silage; price hay.

Exogenous variables: non-traded cash costs.

Z_i = technical coefficients (eg. Z_1 = tonnes of corn required to produced one cwt. of steer).

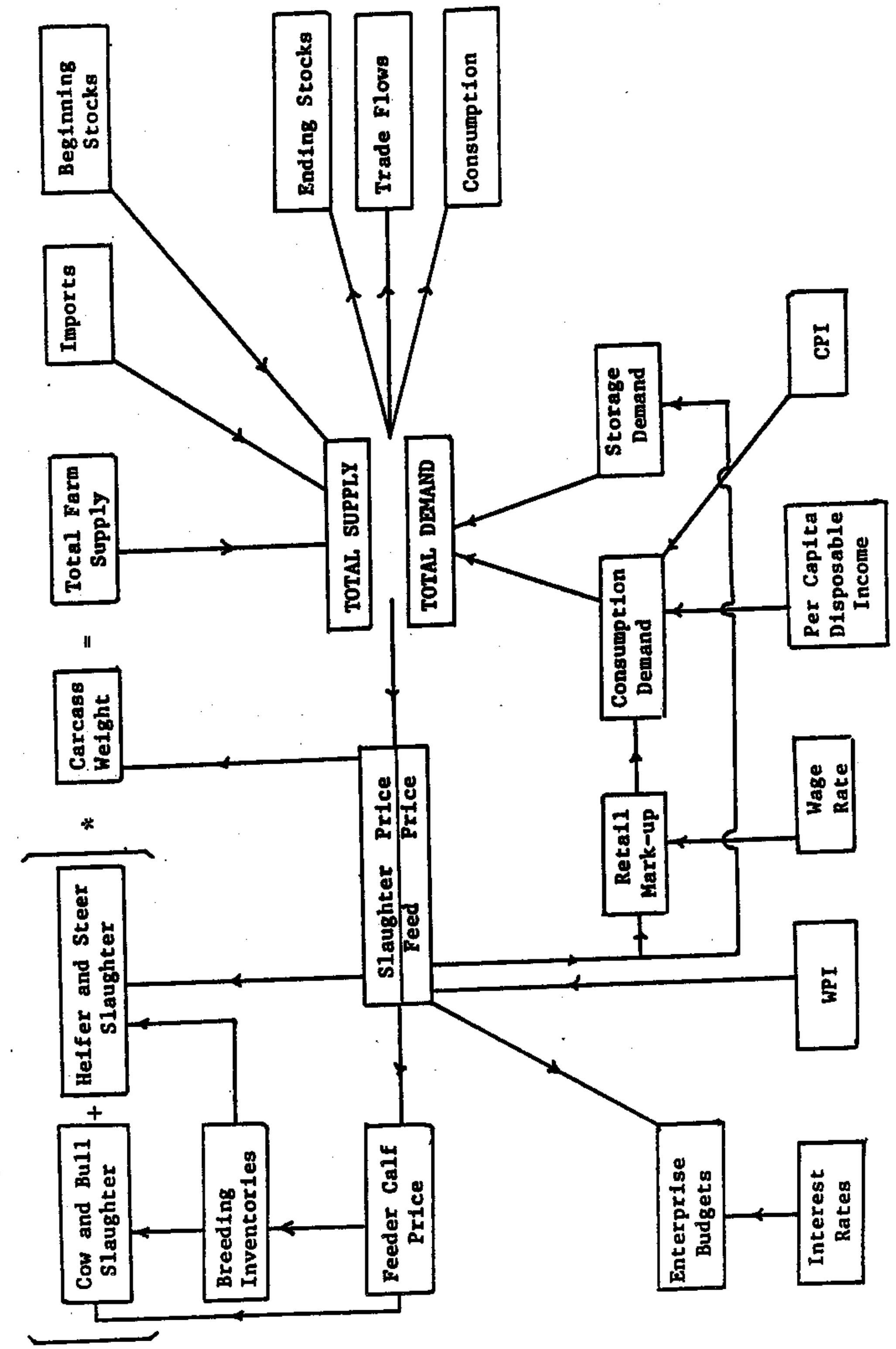
Budgets for the other enterprises follow this format and were obtained for every quarter within the simulation period. A description of all the enterprise budgets is available from the senior author. The effect of exchange rate changes are felt through changes in the endogenous variables so that changes in gross margins before and after a devaluation of the Canadian dollar can be captured.

Because the technical coefficients in the budgets are fixed, changes in the budgets resulting from various policy experiments can only provide clues as to the direction of change in producers' well being and rankings of the impacts of various policy changes. Little confidence should be attached to the absolute values of the budget numbers.

2.8 THE COMPLETE MODEL

The complete model is made up of the various components discussed in this chapter. These include the supply and demand relationships that describe the red meat sector, the price linkages which connect the regions, the macroeconomic variables and finally the enterprise budgets. A schematic diagram is presented for both the beef (figure 2.7) and pork markets (figure 2.8). They are shown separately but are in fact linked

Figure 2.7 Regional Beef Model



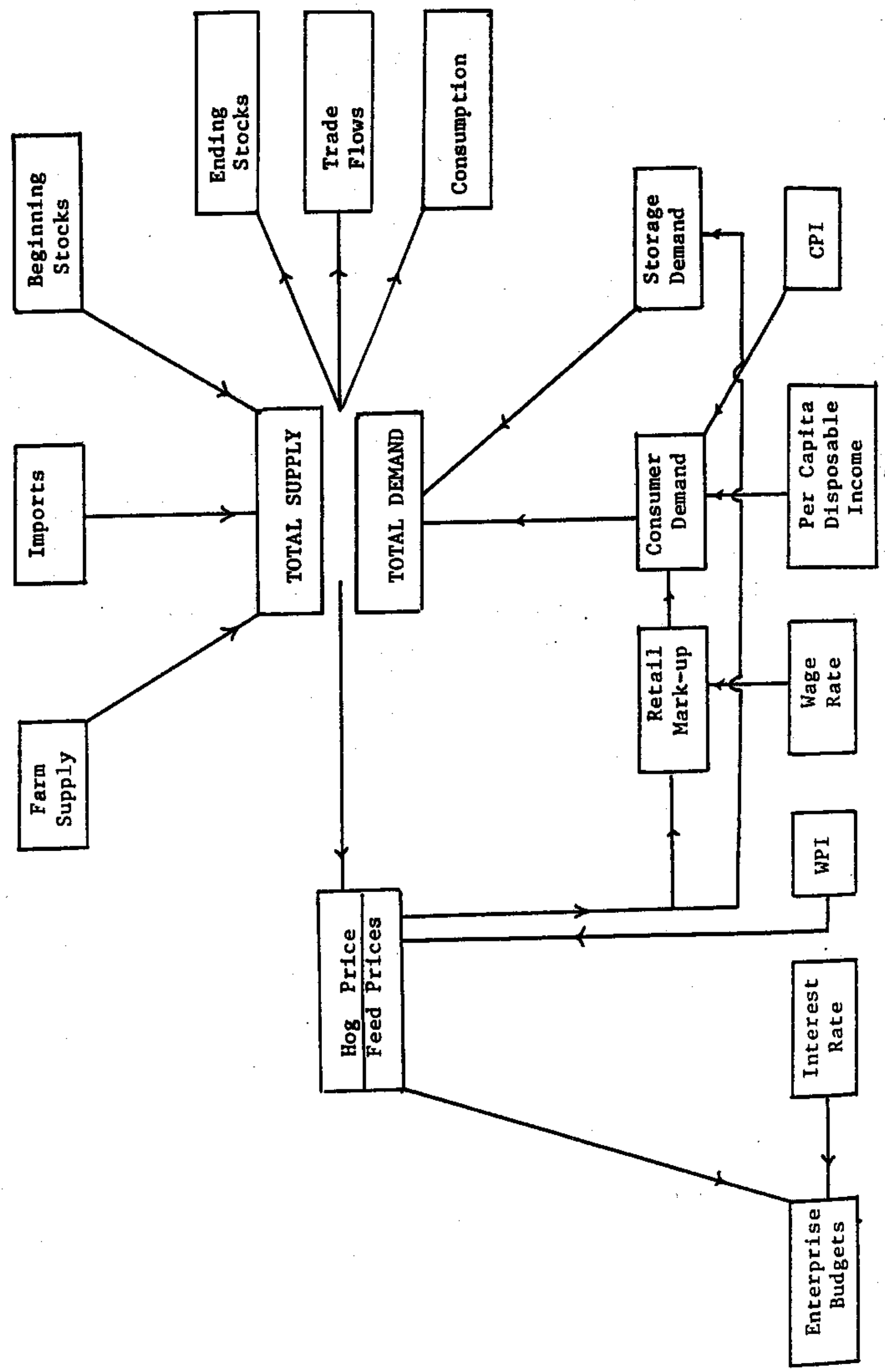


Figure 2.8 Regional Pork Model.

through the equations for consumer demand. Most of the variables in the model are endogenous although the non-traded items within the enterprise budgets, U.S. feed prices and the values of U.S. macroeconomic variables remain exogenous.

Having described the general components which make up the model it is now necessary to specify how these components are determined and how they are related to one another. This requires the specification and estimation of the structural model and is dealt with in Chapter 3.

CHAPTER THREE

ESTIMATION OF THE MODEL

3.1 INTRODUCTION

This chapter presents estimates of the behavioral equations in the model. The equations are estimated using quarterly data and where possible over an identical sample period. Complete uniformity of regression bounds is, however, neither possible nor appropriate. This is particularly true for variables determined by long lags and cycles (eg. beef supply) which require a longer regression period than those variables determined more by current events (eg. demand). Data sources for all variables and their mnemonics are identified in Appendix I.

3.2 CHOICE OF ESTIMATOR

The estimates presented below reveal many cases in which current endogenous variables appear as regressors on the right hand side of structural equations. Consequently, the model is simultaneous. The use of the ordinary least squares estimator (OLS) in the estimation of a system of simultaneous equations provides estimates of parameter values that are both biased and inconsistent (Johnston (1972); Intriligator (1978)).

Two major categories of estimators for a system of simultaneous equations can be identified. Single-equation methods estimate a system of simultaneous equations by estimating each equation (provided it is identified) separately, while the systems methods estimate all the equations in a system simultaneously. Both methods produce biased coefficient estimates but they are nevertheless consistent.

Although several simultaneous equation estimators exist it is not clear how to choose among them. Most of the properties of these estimators are asymptotic, while considerably less is known about their small sample properties. Monte Carlo experiments have shown that there is little difference in performance amongst these estimators and that where the sample size is small, OLS may perform relatively better than the simultaneous estimators (Johnston (1972)).

A possible estimator within the single equation method is the instrumental variable technique of which two stage least squares (2SLS) is the best known. In 2SLS the endogenous variables which appear as regressors are replaced by instrumental variables, created (in stage one) by regressing the endogenous regressors on all the exogenous variables in the model. In stage two the instrumental variable replaces the right-hand side endogenous regressor and the equation is re-

estimated using OLS. The 2SLS parameters are biased but consistent. Monte Carlo studies have shown 2SLS to be superior to most other techniques based on small sample properties. Moreover, these desirable properties are less sensitive to other estimation problems such as multicollinearity and specification error than are other estimators. In addition to these benefits, 2SLS has low computational costs. For these reasons 2SLS is the most popular and widely used estimator of simultaneous equation systems.

Systems methods of estimation include three stage least squares and full information maximum likelihood techniques which estimate all the structural equations as a set instead of estimating the structural parameters of each equation separately. The major benefit of using these techniques is that they use all the available information in creating their estimates and provide consistent parameter values. Errors in specification however, are transmitted to estimates in the whole model and are not confined to the equations in which the errors occur. These estimators require a large sample size and have high computational costs. For these reasons systems methods are rarely used for large models.

From this brief review of estimation techniques 2SLS appears to be the most appropriate to avoid the inconsistency of OLS. This choice is supported by Monte Carlo experiments summarized by Intriligator (1978), Johnston (1972), and Kmenta (1971).

In the first stage, of the 2SLS procedure, instrumental variables are created by regressing current endogenous variables on all exogenous variables within the system. For many models (including the one developed in this study) the number of exogenous variables exceeds the number of observations and the degrees of freedom problem prevents the use of 2SLS. To overcome this problem a subset of exogenous variables can be selected and used as regressors in the first stage. No hard and fast rules exist on how to choose the set of exogenous variables used in the first stage. Intriligator (1978) suggests one criterion,

> is to select only those exogenous variables that are most closely related to the endogenous variable in the equation, excluding from each equation those exogenous variables believed to be unimportant on the basis of *a priori* considerations.

Alternatively, principle components can be created which are themselves instrumental variables and which capture a specified amount of the variability in the set of exogenous variables. The principle components are then used as regressors in the first stage. For this technique to be consistent the exogenous regressors on the right-hand side of the equation must be included explicitly in the regression of the first stage. In this study degrees of freedom problems were overcome by regressing current right-hand-side endogenous variables on those exogenous variables that appear explicitly in the equation being estimated, and on enough principle components to explain 95 percent of the variation of all the other exogenous variables not treated explicitly. This technique was complicated by the existence of autocorrelation adjustments and non-linearities which required additional modifications to the procedure (Kelejian and Oates (1981)).

Using the procedure outlined above, 2SLS estimates were obtained for the model. When these estimates were used for simulation the model became explosive. This led to close inspection of the 2SLS estimates and to comparisons with their OLS counterparts. The two estimators produced parameter values that were very similar except for those on the current price of steers in both the U.S. and Canadian heifer and steer slaughter equations. When OLS estimates for these equations were used along with the 2SLS estimates for all other equations, the model solved and gave satisfactory results. Although this isolated the problem it did not seem appropriate to use 2SLS in some equations and not in others. Thus in this study OLS estimates are used in all simulations. Both the OLS and 2SLS estimates, however, were obtained and are reported where appropriate in the equation descriptions which follow.

Although OLS is biased and inconsistent it does possess a number of redeeming qualities that make it an adequate and sometimes more appropriate estimator. These include the following:

1. Although the OLS estimator is biased, so are all alternative estimators. Moreover, OLS has minimum variance among alternatives and so it is possible that in small samples it has the smallest minimum mean squared error.

2. Monte Carlo studies have shown that the properties of the OLS estimator are more robust (ie. less sensitive to estimation problems such as mis-specification and multicollinearity) than alternative estimators.

3. OLS can be useful as a preliminary or exploratory estimator. Also, Johnson (1977) points out that greater gains are to be had in devoting resources to model specification and the assembly of good data rather than in the use of more elaborate estimation techniques.

3.3 THE THEORETICAL MODEL

It is customary to specify a theoretical model before equations are estimated to provide information on how the model's framework should be structured and how the equations should be specified. Moreover, classical statistical theory requires that a variable cannot be reported as significant or insignificant unless the true model has already been specified.

The theoretical framework for both livestock demand and supply is by now familiar and does not require repeating here. The framework used

in this study for livestock supply is based on the work of Jarvis (1974) which has been succinctly reviewed by Goddard (1984) and Haack (1978). The demand equations are based on neoclassical consumer theory which is discussed in most microeconomic textbooks.

Although the theory is not reviewed, the current model is derived to a large extent from past models which have slowly added to both the theoretical and empirical body of literature on livestock commodity models. Throughout the text, past studies will be referred to which provide the starting point from which the current model evolved.

3.4 OVERVIEW OF THE MODEL

An overview of the model is presented in table 3.1. The complete model consists of 88 equations solving for 88 unknown endogenous variables. Of these, 27 are estimated behaviorally for the beef market and 11 for the pork market. In addition there are 29 identities, nine equations linking the prices of feed, 4 behavioral equations for the macroeconomic variables and 12 gross margin identities. Not all the equations are reported in table 3.1. This is because many of the specifications for a particular equation are identical between regions. The regions for which equations are estimated are reported in parentheses after each equation and later in the endogenous variable list. Each equation is described fully in the sections which follow.

3.5 STRUCTURAL EQUATIONS

This section presents the individual behavioral equations of the model. Justification is provided for each equation specification and reference is made to previous work where applicable. For each equation the coefficients, elasticities (given in square brackets) and t-values (given in parentheses) are shown, as well as the coefficient of determination (R squared), the Durbin-Watson statistic (D.W.), Durbin's h-statistic (h-stat), and the autocorrelation adjustment parameter (Rho). Finally, the sample period over which the equations were regressed are reported.

3.6 DEMAND BLOCK

The demand for red meat at the consumer level consists of equations for per capita consumption, and farm price to retail price mark-up equations. At the wholesale level equations are estimated for closing stocks of red meat. These are specified for beef and pork in both the U.S. and Canada. Equations for Canadian demand are not separated into Eastern and Western Canada. In section 2.5 it was argued that production practices and geographical and environmental demarcations

Table 3.1 An Over View of the Model.

Beef Supply

Inventory of Cows and Bulls (Beef Sector) = (Current and Lagged Annual Deflated Prices of Feeder Calves). (West, East, U.S.).

Inventory of All Cows and Bulls = (Inventory of Cows and Bulls, Beef Sector) + (Inventory of Cows and Bulls, Dairy Sector). (West, East, U.S.).

Price of Feeder Calves = (Price of Steers, Price of Feed, LDV). (West, East, U.S.).

Annual Deflated Price of Feeder Calves = (Sum of Deflated Feeder Calf over last four quarters) * 0.25. :Identity (West, East, U.S.).

Cow and Bull Slaughter = (Deflated Price of Feeder Calves, Current Inventory of All Cows and Bulls, LDV). (West, East, U.S.).

Heifer and Steer Slaughter = (Current Deflated Price of Steers, Current Price of Feed, Lagged Deflated Price of Steers, Lagged Deflated Price of Feed, Lagged Inventory of All Cows and Bulls). (Canada, U.S.).

Average Carcass Weight = (Lagged Deflated Price of Steers, Lagged Deflated Price of Feed, LDV). (Canada, U.S.).

Production of Beef = (Cow and Bull Slaughter + Heifer and Steer Slaughter) * Average Carcass Weight. :Identity (Canada, U.S.).

Beef Demand

Per Capita Demand for Beef = (Deflated Retail Price of Beef, Deflated Retail Price of Pork, Deflated Per Capita Disposable Income). (Canada).

Deflated Retail Price of Beef = (Per Capita Demand for Beef, Deflated Retail Price of Pork, Deflated Per Capita Disposable Income). (U.S.).

Retail Price of Beef = (Price of Steers, Wages and Salaries). (Canada, U.S.).

Deflated Retail Price of Beef = (Retail Price of Beef/Consumer Price Index). :Identity (Canada, U.S.).

Closing Stocks of Beef = (Change in the Deflated Price of Steers, Production of Beef, Imports from the ROW, LDV). (Canada, U.S.).

Supply-Demand Identity to Determine Net Trade in Beef

Production + Beginning Stocks - Disappearance - Ending Stocks = Net trade with ROW + Net trade between Canada and the U.S. :Identity (Canada, U.S.)

Net Trade Identity to Determine the U.S. Farm Price of Steers

Canada's net beef trade with U.S. = U.S. net beef trade with Canada. :Identity

Canada Farm Price of Steers = (U.S. Farm Price of Steers * Exchange Rate, Net Trade in Beef). (West, East)

Pork Supply

Production of Pork = (Lagged Deflated Price of Hogs, Lagged Deflated Price of Feed, LDV). (West, East, U.S.).

Production (Canada) = Production (West) + Production (East). :Identity (Canada).

Pork Demand

Per Capita Demand for Pork = (Deflated Retail Price of Pork, Deflated Retail Price of Beef, Deflated Per Capita Disposable Income). (Canada)

Deflated Retail Price of Pork = (Per Capita Demand for Pork, Deflated Retail Price of Beef, Deflated Per Capita Disposable Income). (U.S.)

Retail Price of Pork = (Price of Hogs, Wages and Salaries). (Canada, U.S.).

Deflated Retail Price of Pork = (Retail Price of Pork/Consumer Price Index). :Identity (Canada, U.S.).

Closing Stocks of Pork = (Change in the Deflated Price of Hogs, Production of Pork, Imports from ROW, LDV). (Canada, U.S.).

Canada Farm Price of Hogs = (U.S. Farm Price of Hogs * Exchange Rate, Net Trade in Pork). (West, East).

Supply-Demand Identity to Determine Net Trade in Pork

Production + Beginning Stocks - Disappearance - Ending Stocks = Net Trade with ROW + Net Trade between Canada and the U.S. :Identity (Canada, U.S.).

Net Trade Identity to Determine the U.S. Farm Price of Hogs

Canada's Net Pork Trade with U.S. = U.S. Net Pork Trade with Canada.

Feeder Steer Price Equations

Price of Feeder Steers (Western Canada) = (Price of Steers, Price of Feed, LDV). (West).

Price of Feeder Steers (Eastern Canada) = (Price of Feeder Steers (Western Canada)). (East).

Cow and Bull Price Equations

Price of Cows and Bulls = (Price of Steers, Price of Feed, Price of Hogs, Per Capita Disposable Income, LDV). (West, East).

Price of Bulls = (Price of Cows). :Identity (West, East).

Feed Price Linkage Equations

Price of Barley (West) = (Price of Corn (East), Stocks of Barley, LDV). (West).

Price of Corn (East) = (Price of Corn (U.S.) * Exchange Rate). (East).

Price of Rapeseed Meal (West) = (Price of Soybean Meal (U.S.) * Exchange Rate). (West).

Price of Soybean Meal = (Price of Soybean Meal (U.S.) * Exchange Rate). (East, West)

Value of Silage = (Price of Barley). (West).

Value of Silage = (Price of Corn). (East).

Price of Hay (East) = (Price of Corn (East)). (East).

Price of Feed = 0.582 * Price Barley + 0.418 * Price Corn. :Identity (Canada).

Macro Variable Linkage Equations

WPI (Canada) = (WPI (U.S.), Exchange Rate, LDV). (Canada).

CPI (Canada) = (WPI (Canada), CPI (U.S.), Exchange Rate Unemployment Rate, LDV). (Canada).

Rate of Interest (Canada) = (Rate of Interest (U.S.), Forward Premium, Real Income, LDV). (Canada).

Nominal Wage Rate = (Real Wage Rate * Consumer Price Index). :Identity (Canada).

Forward Exchange Rate = (Spot Exchange Rate, CPI (Canada), CPI (U.S.)). (Canada).

Forward Premium = (Forward Exchange Rate - Spot Exchange Rate) / Spot Exchange Rate.) :Identity

Accounting Identities

Price of Steers Canada = 0.582 Price of Steers (West) + 0.418 Price of Steers (East)

Price of Hogs Canada = 0.379 Price of Hogs (West) + 0.621 Price of Hogs (East)

Value of Beef Trade Canada = Net Beef Trade with U.S. * Price of Steers Canada

Value of Pork Trade Canada = Net Pork Trade with U.S. * Price of Hogs Canada

Gross Margins

Beef Feedlot (West) = Price Steers - (Z_i * Price Barley + Z_i * Price Rapeseed Meal + Value Silage + Other Feed) - Price Feeder Steers
- Rate of Interest * (Z_i * Price Barley + Z_i * Price Rapeseed Meal + Value Silage + Other Feed - Price Feeder Steers)
- Cash Costs Non-Traded.

Beef Feedlot (West) = Price Steers - (Z_i * Price Barley + Z_i * Price Rapeseed Meal + Value Silage + Other Feed) - Price Feeder Steers.
(after feed and livestock)

Beef Feedlot (East) = Price Steers - (Z_i * Price Corn + Z_i * Price Soybean Meal + Value Silage + Z_i * Price Hay) - Price Feeder Steers
- Rate of Interest * (Z_i * Price Corn + Z_i * Price Soybean Meal + Value Silage + Z_i * Price Hay - Price Feeder Steers)
- Cash Costs Non-Traded.

Beef Feedlot (East) = Price Steers - (Z_i * Price Corn + Z_i * Price Soybean Meal + Value Silage + Z_i * Price Hay) - Price Feeder Steers.
(after feed and livestock)

Cow-Calf (West) = (Z_i * Price Feeder Calves + Z_i * Price Cows + Z_i * Price Bulls) - (Z_i * Price Barley + Z_i * Price Rapeseed Meal + Other Feed
+ Z_i * Replacement Bull) - Rate of Interest * (Z_i * Price Barley + Z_i * Price Rapeseed Meal + Other Feed
+ Z_i * Replacement Bull) - Cash Costs Non-Traded.

Cow-Calf (West) = (Z_i * Price Feeder Calves + Z_i * Price Cows + Z_i * Price Bulls) - (Z_i * Price Barley + Z_i * Price Rapeseed Meal + Other Feed
(after feed
and livestock) + Z_i * Replacement Bull).

Cow-Calf (East) = (Z_i * Price Feeder Calves + Z_i * Price Cows + Z_i * Price Bulls) - (Z_i * Price Hay + Other Feed + Z_i * Replacement Bull)
- Rate of Interest * (Z_i * Price Hay + Other Feed + Z_i * Replacement Bull) - Cash Costs Non-Traded.

Cow-Calf (East) = (Z_i * Price Feeder Calves + Z_i * Price Cows + Z_i * Price Bulls) - (Z_i * Price Hay + Other Feed + Z_i * Replacement Bull)
(after feed and livestock)

Farrow to Finish (West) = Price Hogs - (Z_i * Price Barley + Z_i * Price Soybean Meal + Other Feed) - Rate of Interest * (Z_i * Price Barley
+ Z_i * Price Soybean Meal + Other Feed) - Cash Costs Non-Traded.

Farrow to Finish (West) = Price Hogs - (Z_i * Price Barley + Z_i * Price Soybean Meal + Other Feed).
(after feed and livestock)

Farrow to Finish (East) = Price Hogs - (Z_i * Price Corn + Z_i * Price Soybean Meal + Other Feed) - Rate of Interest * (Z_i * Price Corn
+ Z_i * Price Soybean Meal + Other Feed) - Cash Costs Non-Traded.

Farrow to Finish (East) = Price Hogs - (Z_i * Price Corn + Z_i * Price Soybean Meal + Other Feed).
(after feed and livestock)

justify the division of Canada into two supply regions, East and West. There is no reason to believe however, that consumer and processor behaviour is different between these regions despite perhaps minor differences in price levels and income.

3.6.1 Per Capita Disappearance Equations

The per capita consumption equations are based on neoclassical consumer theory in which demand curves are derived from the maximization of an individual's utility function subject to a budget constraint. The solution to the maximization process provides a demand curve, in which consumption is dependent on the prices of all goods that are included in the budget constraint and income. Since degrees of freedom make it impossible to include the prices of all other goods separately within the demand function, only those deemed close substitutes are typically included as separate regressors while all other goods are captured in a general price deflator (CPI).

This theoretical framework provided the basis for specifications used in earlier models. Haack (1978) specified the per capita demand for beef as a function of seasonal dummies, the farm prices of hogs and steers, and income. Goddard (1979) used Haack's specification with the addition of beef imports from the rest of the world. In both studies prices were not deflated and farm level rather than retail prices were used.

The specification employed in this study has consumption as a function of the deflated retail prices of beef and pork, and real income. The equation is estimated on a per capita basis and income is entered in its logarithmic form. This transformation is applied so that the income elasticity of demand diminishes as income rises. This is more intuitively appealing than the linear specification in which the income elasticity and income may move in the same direction (Moschini and Meilke (1984)). Finally, the demand for red meats has been shown to display marked seasonality and to capture this phenomenom seasonal dummies are added to the specification.

The disappearance of beef and pork in the U.S. is estimated using a price dependent demand equation. This specification is consistent with a market represented by a relatively inelastic short-run supply curve, such that price must adjust to equate supply and demand. This specification seems appropriate for the U.S. market and consequently disappearance equations for beef and pork are of this form. This approach is not pursued in the Canadian equations since Canada is essentially a small country whose price is largely determined in the U.S. market.

The estimated equations for beef demand are presented in table 3.2. The coefficients all have the correct signs and large t-values except for the 2SLS estimates of the income coefficient in the United States. The U.S. equation requires an autocorrelation adjustment with a first

Table 3.2 Per Capita Beef Demand, United States and Canada, 1966(1)-1980(4)

Region	Dependent Variable	Estimator	Intercept	Deflated Retail Price of Beef. (DRPBF3)	Deflated Retail Price of Pork (DRPPK3)	Log of Deflated Per Capita Disposable Income. (PCDY3)	R^2	D.W.	h-stat.	Rho
Canada	Per Capita Demand for Beef (DBF3/POPN3)	OLS	I 7.70 II 7.48 III 7.32 IV 7.57	-8.84 (-15.75) [-0.46]	1.19 (1.93) [0.075]	10.08 (20.16) [1.02]	.91	1.85		
		2SLS	I 8.23 II 7.98 III 7.84 IV 8.10	-8.99 (-15.0) [-0.47]	0.73 (1.05) [0.046]	10.19 (19.90) [1.03]	.91	1.83		
Region	**Dependent Variable**	**Estimator**	**Intercept**	**Per Capita Demand for beef (DBF4/POPN4)**	**Deflated Retail Price of Pork. (DRPPK4)**	**Log of Deflated Per Capita Disposable Income. (PCDY4)**	**R^2**	**D.W.**	**h-stat.**	**Rho**
U.S.A	Deflated Retail Price of Beef (DRPBF4)	OLS	I 0.05 II 0.05 III 0.06 IV 0.04	-0.025 (-6.67) [-0.80]	0.42 (5.19)	0.52 (2.12)	.91	1.83		0.84
		2SLS	I 0.03 II 0.04 III 0.05 IV 0.03	-0.024 (-3.46) [-0.78]	0.52 (4.18)	0.43 (1.34)	.90	1.88		0.92

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

order auto regressive parameter (Rho) of 0.84. The R-squared shows that both equations have good explanatory power. The calculated elasticities are presented in table 3.2 and are compared in table 3.3 with those obtained from other research. This study obtained a Canadian direct price elasticity of -0.46. This is more inelastic than those from earlier works, especially as it is calculated at the retail level. The flexibility of -0.80 in the U.S. is also smaller than those obtained by Hayenga and Hacklander (1970) and Martin (1983). This value implies an elastic demand curve in which consumers are quite responsive to price changes. The cross-price elasticity with respect to the price of pork in the Canadian market is 0.075 and is similar to that obtained in other studies. This suggests that beef and pork are substitutes but that the substitution between them is weak.

The disappearance of pork is specified to depend on deflated retail prices of beef and pork, and per capita disposable income. The U.S. equation is price dependent and includes the retail price of chicken which is significant in the U.S., but not in Canada. The results obtained are presented in table 3.4. The Canadian equation seems satisfactory with statistically significant parameter values and high explanatory power. An autocorrelation adjustment produces an acceptable D.W. statistic. The U.S. equation gives results similar to the Canadian equation except that the income term has a small t-value. The elasticities obtained from the pork equations are compared with those from other studies in table 3.5. The direct price elasticity in Canada is -0.78 at the retail level.

3.6.2 Retail Price Equations

The prices which enter the demand equations are retail prices, while the model solves for prices at the producer level. It is necessary, therefore, to specify farm to retail mark-up equations in which the relationship between prices at the two levels is described explicitly.

A discussion of farm to retail mark-up equations at a theoretical level is provided by Heien (1980). Many studies have estimated the retail to farm margin combined with an identity in which the retail price equals the producer price plus the margin. Freebairn and Rausser (1975) use this specification in which the margin depends on the farm price, the change in the farm price, and wages. Arzac and Wilkinson (1979) express the farm to retail spread as a function of the retail price, the wage rate and a variable representing a by-product allowance. Martin (1983) shows the margin to depend on present and lagged farm prices, wages, the value of by-products, and seasonal dummies.

In tables 3.6 and 3.7 mark-up equations for both beef and pork are presented. The retail price is expressed as a function of the farm price, wages and salaries in the meat processing sector, and a lagged dependent variable. The U.S. equation for beef also includes a dummy variable for the third quarter of 1973 to capture both the Canadian

Table 3.3: Comparison of Beef Demand Elasticities Found in This and Other Studies

Study	Estimation Period	Direct Elasticity	Cross Elasticity (with pork)	Income Elasticity
CANADA				
Klushreshta and Wilson				
- Farm Level	1949-1969	-0.31		
- Retail Level		-0.80	0.50	1.04
Hassan and Johnson				
- Retail Level	1957-1972	-0.72	0.20	0.49
Haack				
- Farm Level-West	1963-1975	-0.81	0.03	0.89
- Farm Level-East	1963-1975	-0.71	0.10	0.73
This Study				
- Retail Level	1966-1980	-0.47	0.05	1.03
UNITED STATES		Flexibility		
Hayenga and Hacklander				
- Farm Level	1963-1968	-1.10		
Martin				
- Retail Level	1962-1979	-0.93		
This Study				
- Retail Level	1966-1980	-0.78		
UNITED STATES		Elasticity		
Brandow				
- Retail Level		-0.95		
Haack				
- Farm Level	1963-1975	-0.43		
Arzac and Wilkinson				
- Retail Level	1960-1975	-1.86		

Table 3.4 Per Capita Pork Demand, United States and Canada, 1970(1)-1980(4).

Region	Dependent Variable	Estimator	Intercept	Deflated Retail Price of Pork. (DRPPK3)	Deflated Retail Price of Beef. (DRPBF3)	Log of Deflated Per Capita Disposable Income (PCDY3)	R^2	D.W.	h-stat	Rho
Canada	Per Capita Demand for Pork (DPK3/POPN3)	OLS	I 8.48							
			II 7.63	-8.43	3.52	3.63	.94	1.88		0.34
			III 7.41	(-12.54)	(7.07)	(4.72)				
			IV 8.59	[-0.78]	[0.28]	[0.57]				
		2SLS	I 5.37							
			II 4.34	-9.45	3.06	4.35	.94	2.16		0.59
			III 4.12	(9.87)	(3.76)	(3.42)				
			IV 5.38	[-0.88]	[0.25]	[0.69]				

Region	Dependent Variable	Estimator	Intercept	Per Capita Demand for Pork. (DPK4/POPN4)	Deflated Retail Price of Beef. (DRPBF4)	Log of Deflated Per Capita Disposable Income. (PCDY4)	Deflated Retail Price of Chicken. (DRPCK4)	R^2	D.W.	h-stat	Rho
U.S.A.	Deflated Retail Price of Pork (DRPPK4)	OLS	I 0.03								
			II 0.00	-0.04	-0.33	0.11	0.29	.96	1.88		0.91
			III 0.02	(-7.96)	(-3.82)	(0.40)	(2.32)				
			IV 0.06	[-0.84]							
		2SLS	I 0.07								
			II 0.05	-0.04	-0.47	-0.09	0.16	.96	2.00		0.89
			III 0.06	(-5.88)	(-3.52)	(-0.30)	(1.05)				
			IV 0.12	[-0.91]							

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [.].

Table 3.5 Comparison of pork demand elasticities found in this and other studies.

Study	Estimation Period	Direct Elasticity	Cross Elasticity (with beef)	Income Elasticity
CANADA				
Yeh (Farm level)	1930–1958	-0.34	0.02	-0.44
Tryphos and Tryphouopolos (Farm level)	1954–1970	-1.05	0.28	-0.004
Zwart and Martin (Farm level)	1961–1973	-0.47	0.03	0.33
Goddard (Farm level - West)	1964–1976	-0.40	0.12	0.35
(Farm level - East)	1964–1976	-0.40	0.20	0.33
This Study (Retail level)	1970–1980	-0.88	0.25	0.69
UNITED STATES		Flexibility		
Hayenga and Hacklander (Farm level)	1963–1968	-1.60		
This Study (Retail level	1970–1980	-0.91		
UNITED STATES		Elasticity		
George and King (Farm level)		-0.24		
Harlow (Farm level)		-0.35		
Maki (Farm level)		-0.37		
Zwart (Farm level)		-0.37		

Table 3.6: Retail to Producer Price Mark-up for Beef, United States and Canada, 1970(1)-1980(4)

Region	Dependent Variable	Estimator	Intercept	Producer Price of Steers (PSS3)	Wages and Salaries (WAPK3)	Lagged Dependent Variable	R^2	D.W.	h-stat	Rho
Canada	Retail Price of Beef (RPBF3)	OLS[a/]	I -8.27	2.15	0.07	0.42	.99	2.24	0.86	0.42
			II -12.19	(12.61)	(1.38)	(7.18)				
			III -8.60	[0.66]	[0.10]					
			IV -10.67							

Region	Dependent Variable	Estimator	Intercept	Producer Price of Steers (PSS4)	Wages and Salaries (WAPK4)	Lagged Dependent Variable	Dummy for 1973(3) (D19733)	R^2	D.W.	h-stat	Rho
U.S.A.	Retail Price of Beef (RPBF4)	OLS[a/]	I -6.24	1.91	0.13	0.33	-4.56	.99	1.81	0.66	0.43
			II -9.16	(18.34)	(4.11)	(6.89)	(-1.74)				
			III -9.34	[0.57]	[0.21]						
			IV -9.80								

Coefficients given without brackets.
t-values given in parentheses, ( ).
Short-run elasticities given in square brackets, [ ].

a/ See Coleman (1984) for a comparison of OLS and 2SLS estimates using a slightly different specification of this equation.

Table 3.7: Retail to Producer Price Mark-up for Pork, United States and Canada, 1970(1)-1980(4)

Region	Dependent Variable	Estimator	Intercept	Producer Price of Hogs (PHG3)	Wages and Salaries (WAPK3)	Lagged Dependent Variable	R^2	D.W.	h-stat	Rho
Canada	Retail Price of Pork (RPPK3)	OLS[a/]	I -1.99	1.18	0.25	0.35	.99	1.21	2.76	
			II -4.72	(14.82)	(9.55)	(7.28)				
			III 0.72	[0.34]	[0.32]					
			IV 0.92							

Region	Dependent Variable	Estimator	Intercept	Producer Price of Hogs (PHG4)	Wages and Salaries (WAPK4)	Lagged Dependent Variable	R^2	D.W.	h-stat	Rho
U.S.A.	Retail Price of Pork (RPPK4)	OLS[a/]	I 0.98	1.28	0.12	0.35	.99	1.68	1.09	
			II 0.38	22.42	(10.60)	(10.59)				
			III 1.92	[0.41]	[0.24]					
			IV 0.73							

Coefficients given without brackets.
t-values given in parentheses, ( ).
Short-run elasticities given in square brackets, [ ].

a/ See Coleman (1984) for a comparison of OLS and 2SLS estimates using a slightly different specification of this equation.

imposition of export controls on beef moving to the U.S., and the U.S. removal of price controls on beef. Wages represent a major cost of production in the meat processing and retailing sectors so that increases in wages should lead to higher retail prices in order to maintain profit margins.

Both the equations perform well in terms of explanatory power. The coefficient on wages and salaries has a small t-value in the Canadian beef equation but it is retained to maintain consistency with other equations. The elasticities show that in the current time period 66 percent and 57 percent (for Canada and the U.S., respectively) of farm beef price changes are transmitted through to the retail sector. In the long-run 85 percent of the increase is passed through in the U.S. market while in the Canadian market increases in farm prices are passed on more than proportionately (1.14). In the Canadian pork market the price transmission elasticities are 0.34 in the short-run and 0.52 in the long run, and in the United States they are 0.41 and 0.63 in the short and long-run, respectively.

3.6.3 Demand for Ending Stocks of Red Meats

As described in section 2.3.4 some beef and pork is held in stocks and this demand results from both transactionary and speculative motives. The specifications used to explain this demand attempt to capture both of these influences. Haack (1978) specifies ending stocks to depend upon the quantity of beef demanded, imports of beef, the price of steers, seasonal dummies, and a lagged dependent variable. Agriculture Canada (1983) uses a similar specification although both imports and prices are excluded. These prove to be serious omissions since without them the explanatory power of the equation is unacceptably low. Also, the quantity supplied variable is replaced by quantity demanded. Both these variables capture the transactions demand for stocks and it is not clear which is theoretically more appropriate. Martin (1983b) specifies ending stocks of beef to depend on the demand for beef, imports of beef, a lagged dependent variable, seasonal dummies and the rate of interest. The rate of interest is included to capture the opportunity cost of investment tied up in inventories. The higher the rate, the greater the cost of holding stocks and therefore the demand for stocks diminishes. This variable was tried in all inventory equations and found to be insignificant. This is surprising as real interest rates have varied considerably in recent years.

Equations explaining closing inventories of pork are very similar to those for beef. Zwart and Martin (1974) show pork stocks to depend on the supply and price of pork, seasonal dummies, and a lagged dependent variable while Robertson (1980) uses a similar equation although prices are omitted from the specification.

In this study, transactions demand is captured by the inclusion of total domestic supplies and imports of beef from all countries excluding the United States. Domestic supplies and imports are separated because

typically they are of different quality and are obtained through different marketing channels. These variables take account of the transactions demand because the percentage of total supplies held as stocks has remained fairly constant through time. In general increases in supply lead to a greater transactions demand and stock holding. Since imports of pork by Canada are minimal they are excluded from the specification.

The speculative demand is modeled using the change in deflated price levels. When the variable is positive (ie. prices are rising) processors' demand for stocks fall as inventories are run down to delay paying the higher prices. If prices are falling then processors' demand increases in order to replenish stocks before prices move up. Expectations are further captured by the inclusion of a lagged dependent variable. Seasonality in demand warrants the inclusion of seasonal dummy variables and the extraordinarily high levels of pork stocks in 1971 (first calendar quarter) requires the inclusion of a dummy variable. Finally, a dummy variable for the last quarter of 1973 for U.S. beef demand is included to capture the effects of the U.S. price freeze imposed at that time. In these equations prices are deflated by the wholesale price index (WPI). The WPI is chosen because it is not heavily weighted by variables included in the model and because it represents the appropriate level in the production process.

The estimated equations are displayed in tables 3.8 and 3.9. All the variables have the correct signs although the price and quantity supplied variables have small t-values in the pork equations. The elasticities of the price variables appear very small (0.0003 and 0.0004 for Canadian and U.S. steer prices, respectively), but it must be remembered that these variables are expressed as changes in deflated price levels.

3.7 SUPPLY BLOCK

The supply of red meats consists of seven equations for each region (table 3.1). The supply of pork is estimated using one equation and the supply of beef using six. This reflects the complexity of estimating beef supply with its numerous components and complicated production lags. The cow-calf enterprise is represented by equations for the price of feeder calves, breeding inventories, and cow and bull slaughter. The feedlot sector is represented by an equation for heifer and steer slaughter. The sum of cow, bull, heifer, and steer numbers are then multiplied by an average carcass weight, which is estimated behaviourly, to convert numbers of animals slaughtered into pounds of meat. This gives total farm supply (figure 2.8). Finally, an identity is included to combine livestock inventories from the beef and dairy sectors to give the total inventory of cattle.

Table 3.8 Closing demand for stocks of beef, United States and Canada, 1966(1)-1980(4).

Region	Dependent Variable	Estimator	Intercept	Lagged Dependent Variable	Change in Deflated Price of Steers (PSS3/WPI3)	Production of Beef (QBF3)	Imports of Beef from ROW (IM3BF9)	R^2	D.W.	h-stat	Rho
Canada	Closing Stocks of Beef (IBF3)	OLS	I -23.44 II -30.95 III -36.27 IV -19.04	0.49 (6.84)	-99.05 (-0.83) [-0.0003]	0.01 (3.18) [0.75]	0.38 (6.94) [0.26]	.91	1.81	0.89	
		2SLS	I -21.77 II -29.06 III -35.01 IV -17.63	0.48 (6.34)	-204.72 (-1.18) [-0.007]	0.09 (2.80) [0.72]	0.39 (7.25) [0.27]	.91	1.88	0.63	

Region	Dependent Variable	Estimator	Intercept	Lagged Dependent Variable	Change in Price of Steers (PSS4/WPI4)	Production of Beef (QBF4)	Imports of Beef from ROW (IM4BF9)	Dummy 1973 (4) (D19734)	R^2	D.W.	h-stat	Rho
U.S.A.	Closing Stocks of Beef (IBF4)	OLS	I -95.29 II-118.47 III-137.27 IV -65.86	0.66 (8.54)	-349.44 (-1.47) [-0.0004]	0.03 (2.19) [0.47]	0.15 (2.85) [0.19]	98.34 (2.76)	.82	1.57	2.07	
		2SLS	I -73.41 II -96.32 III-116.52 IV -43.71	0.66 (8.05)	-396.90 (-0.87) [-0.0005]	0.03 (1.64) [0.52]	0.15 (2.98) [0.19]	95.34 (2.40)	.82	1.58	2.06	

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

Table 3.9 Closing demand for stocks of pork, United States and Canada, 1966(1)-1980(4).

Region	Dependent Variable	Estimator	Intercept	Lagged Dependent Variable	Change in Deflated Price of Hogs (PHG3/WPI3)	Production of Pork (QPK3)	Dummy 1971 (2) (D19712)	R^2	D.W.	h-stat	Rho
Canada	Closing Stocks of Pork (IPK3)	OLS	I 13.96 II 8.35 III 3.35 IV 9.26	0.49 (5.58)	-87.22 (-1.70) [-0.002]	0.01 (1.38) [0.17]	24.47 (5.88)	.79	1.77	0.94	
		2SLS	I 14.60 II 9.04 III 3.23 IV 10.04	0.51 (5.72)	-40.95 (-0.49) [-0.001]	0.01 (1.10) [0.11]	24.46 (5.80)	.79	1.68	1.33	

Region	Dependent Variable	Estimator	Intercept	Lagged Dependent Variable	Change in Price of Hogs (PHG4/WPI4)	Production of Pork (QPK4)	Dummy 1971 (2) (D19712)	Imports of Pork from ROW (IM4PK9)	R^2	D.W.	h-stat	Rho
U.S.A	Closing Stocks of Pork (IPK4)	OLS	I 136.30 II 125.06 III 36.12 IV 151.07	0.60 (6.34)	-239.78 (-1.50) [-0.001]	0.02 (1.33) [0.21]	107.73 (3.80)	0.51 (2.07) [0.24]	.87	1.66	1.44	
		2SLS	I 143.18 II 132.40 III 40.61 IV 161.47	0.62 (6.85)	-190.70 (-0.74) [-0.001]	0.01 (0.95) [0.16]	106.60 (3.71)	0.51 (1.98) [0.24]	.87	1.66	1.44	

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

3.7.1 Price of Feeder Calf Equations

The price of feeder calves is a very important variable within the beef sector because it represents the amount cow-calf producers receive for their output. Consequently, it is the major variable influencing the size of the breeding herd and the level of cow and bull slaughter. Ideally these prices would be obtained by modeling both the supply of, and demand for feeder calves which could then be used to solve for price. It is important however, to place some limits on the scope of this study and attempts to model the feeder calf market by MacAulay (1976) suggest that the task would be sizeable. Hence, a reduced form equation for feeder calf price is estimated which is specified to contain factors influencing both the demand and supply of feeder calves. The demand for feeder calves comes from feedlot operators who base their decisions to purchase calves on the expected price of their output (heifers and steers) and inputs (feed). The supply of feeder calves is determined principally by the size of the breeding herd in previous time periods.

Other researchers have used a variety of different specifications to determine the price of feeder cattle. Arzac and Wilkinson (1979) specify the price of feeder steers to depend upon the prices of both fed and non-fed beef, the price of corn and changes in calf slaughter. Feeder steer prices are then used in the equations for breeding inventories and calf slaughter. Martin (1983b) estimates an equation for the deflated price of feeder steers. This is shown to depend upon the deflated prices of steers and corn and current and lagged cattle placed on feed. The cattle placed on feed variable is in turn endogenously determined and depends upon the feeder calf availability, deflated prices of fed and non-fed beef, and the expected price of feeder calves. Freebairn and Rausser (1975) specify an equation for feeder calf prices in which the expected price of choice steers and changes in the supply of feeder calves are employed as regressors. Haack (1978) and Agriculture Canada (1983) estimate equations for feeder calf prices which depend upon the expected prices of steers and corn which are lagged by different periods.

In this study, equations are estimated for Eastern and Western Canada, and the United States. Feeder calf prices are shown to depend on the price of steers and the price of feed. Since feedlot operators base their demand on future prices, a lagged dependent variable is included to incorporate an adaptive expectations hypothesis. Dummy variables are also included to model the seasonality in prices and the changes in U.S./Canadian trade policy in late 1973. The equations for Western Canada and the U.S. also contain seasonal slope dummies for the price variables which are used to accommodate large differences in price transmission between quarters. The specification does not include any supply variables. Lagged breeding inventories were tried but only in the U.S. did it have the correct sign (negative) and only then with an unacceptably low t-value. Interest rates were also included but were found to be insignificant. Finally, since prices appear on both the right and left hand side of the equation it was not necessary to deflate

the prices.

Trade in feeder calves between Canada and the U.S. is important and not subject to any stringent trade restrictions. Because of this, Canadian feeder calf prices are influenced by supply and demand forces in the U.S. market. An attempt to incorporate the influence of the U.S., and the exchange rate on the feeder calf market was attempted through the inclusion of the U.S. feeder calf price multiplied by the exchange rate in the behavioral equations. The explanatory power of the equation increased (based on the corrected R-squared and standard error of regression) and the variable had a high t-value. The coefficient on the variable was large however, and caused problems when the model was simulated. The U.S. price of feeder calves was therefore dropped. Essentially this implies that Canadian feeder calf prices are determined by economic factors within Canada. The impact of the exchange rate is still felt indirectly through the Canadian steer and feed prices which are linked directly to their U.S. counterparts.

In view of the long lags and cycles in beef production it is necessary to use a long sample period. Hence, in this and in most other equations for beef supply, quarterly data are used from 1962 through 1980.

The equations for the price of feeder calves in Eastern and Western Canada and the U.S. are presented in tables 3.10 and 3.11. All explanatory variables have large t-values and possess the correct sign. The elasticity with respect to steer prices indicate that feeder calf prices are very sensitive to changes in steer prices, and that in the long-run steer price changes affect calf prices more than proportionately. This is consistent with the findings of Haack (1978). Moreover, the lagged dependent variable suggests that Canadian calf prices respond more quickly to steer and feed prices than in the United States. The h-statistic in the Eastern Canadian equation (2.01) indicates autocorrelation is a problem, but the autocorrelation correction resulted in a small and insignificant Rho value. Consequently, it was dropped from the final specification.

3.7.2 Breeding Inventory Equations

The inventory of breeding stock is perhaps the most important variable affecting supply. It largely determines the number of cows and bulls that are slaughtered and constrains the level of production in the future.

A breeding herd can be considered a capital asset in that it can be used to produce additional output or it can be sold as a consumption good. Demand theory for capital goods requires that an asset be retained up to the point at which its discounted present value of future returns is equal to its salvage value. Beyond this point the asset is sold. For breeding inventories the future return stream is made up of the number of calves produced in the future multiplied by the price of

Table 3.10 Price of feeder calves Western and Eastern Canada, 1962(1)-1980(4).

Region	Dependent Variable	Estimator	Intercept	Lagged Dependent Variable	Price of Steers (PSS1)	Price of Barley (OPBA3)	Price of Steers in 1st Quarter (PSS1*JS1)	Dummy for 1973 (3) and (4) (D19734+D19734)	R^2	D.W.	h-stat	Rho
Western Canada	Price of Feeder Calves (PFC1)	OLS	I -5.41	0.42	1.05	-0.23	0.14	7.87				
			II -2.05	(7.64)	(11.06)	(-9.72)	(2.57)	(3.18)	.98	1.84	0.79	
			III -2.38		[0.91]	[-0.30]						
			IV -0.62									
		2SLS	I -7.89	0.43	1.00	-0.22	0.23	7.93				
			II -1.20	(6.75)	(9.07)	(-8.51)	(4.07)	(3.10)	.98	1.83	0.89	
			III -1.53		[0.87]	[-0.29]						
			IV 0.22									

Region	Dependent Variable	Estimator	Intercept	Lagged Dependent Variable	Price of Steers (PSS2)	Price of Corn (FPCO2)	Dummy for 1973 (3) and (4) (D19733+D19734)	R^2	D.W.	h-stat	Rho
Eastern Canada	Price of Feeder Calves (PFC2)	OLS	I 2.80	0.53	0.81	-0.20	6.65				
			II 3.10	(8.75)	(8.92)	(-7.07)	(2.66)	.97	1.61	2.01	
			III 1.59								
			IV 2.00		[0.75]	[-0.34]					
		2SLS	I 2.70	0.60	0.72	-0.18	6.26				
			II 3.01	(9.70)	(7.54)	(-6.30)	(2.48)	.97	1.74	1.34	
			III 1.45								
			IV 1.99		[0.63]	[-0.23]					

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

Table 3.11 Price of feeder calves United States, 1962(1)-1980(4).

Region	Dependent Variable	Estimator	Intercept	LDV in 3rd and 4th Quarter	LDV in 1st and 2nd Quarter	Price of Steers in 3rd and 4th	Price of Steers in 1st and 2nd (Pss4*(JS1+JS2))	Price of Corn (PCO4)	R^2	D.W.	h-stat	Rho
U.S.A	Price of Feeder Calves (PFC4)	OLS	I -2.00	0.77	0.59	0.59	0.99	-0.15				
			II -2.12	(14.04)	(-3.54)	(6.00)	(3.57)	(-7.98)	.98	1.24	~~3.93~~	
			III -1.70									
			IV -1.72			[0.50]		[-0.25]				
		2SLS	I -2.00	0.84	-0.27	0.44	0.44	-0.13				
			II -2.78	(14.12)	(-3.27)	(4.10)	(3.71)	(-6.25)	.98	1.30	~~3.57~~	
			III -0.03									
			IV -0.70			[0.37]		[-0.22]				

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

feeder calves, while the salvage value is the price paid to farmers for cull cows. The theoretical framework suggests that breeding inventories depend upon the price of feeder calves, the price of cows and the rate of interest (to proxy for a discount rate).

Specifications used in other livestock models are diverse and there is little consistency between studies. Arzac and Wilkinson (1979) show inventories to depend upon feeder steer prices lagged one and two quarters, the price of non-fed beef (cow price) and a lagged dependent variable. Martin (1983b) estimates the change between current and future inventory levels. Here expected deflated feeder steer and steer prices, and the absolute level of inventories are used as regressors. Haack (1978) simply uses feeder calf prices and a lagged dependent variable in an annual equation. Agriculture Canada (1983) employs variables for cow and bull marketings, lagged feeder calf prices and interest rates. Also included is the lagged ratio of heifer to steer marketings and a lagged heifer price. Kulshrestha and Wilson (1972) specify annual breeding levels to depend upon the number of live feeder cattle exported from Canada, lagged slaughter of heifers and steers, net feed grain supply, the ratio of beef and feed prices, and lagged total slaughter. Tryfos (1974), Ospina and Shumway (1980), and Goddard (1984) take account of the interdependence between inventory levels and cow slaughter. Tryfos (1974) states that available livestock can be used for slaughter, building up the breeding herd or for export. Available livestock depends upon past inventory levels, and desired livestock inventories depend upon expected livestock and feed prices. These two components are combined in a partial adjustment mechanism which yields inventory levels determined by expected livestock and feed prices and lagged inventory levels. Having determined inventory levels, cow slaughter is given by the total number of livestock available less the difference between current and lagged inventory levels. Ospina and Shumway (1980) employ a similar format.

The breeding inventory census is conducted annually and figures are reported for January 1st.[1/] Data for inventories between this date are extrapolations and are less reliable. The inventory equations are therefore estimated annually using the January 1st data.[2/]

1/ December 1st prior to 1973.

2/ The data in a sense remains quarterly with the use of zeros in the first three quarters and the inventory appearing in the fourth quarter during simulations of the model. The right-hand-side of the equation is made compatible through the use of a seasonal dummy, equal to one in the last quarter and zero elsewhere. This dummy variable is multiplied by all the regressors appearing in the equation so that they, (like the inventory data) equal zero in the first three quarters and provide a value in the fourth.

Following the theoretical framework, the initial specification employed the price of feeder calves, the price of cows and the rate of interest. This specification proved to be unsuccessful in that both cow prices and interest rates produced coefficients with signs different from those predicted on the basis of economic theory. Feed prices and prices pertinent to alternative enterprises were also unimportant. This, however, is not surprising since the majority of breeding stock are maintained on range land which has few alternative production opportunities. Since the decision over inventory levels is based on expected future returns, a lagged dependent variable was tried within the specification. This increased the explanatory power greatly and was maintained in the specification until the model was simulated. During simulation the equations failed to track satisfactorily leading to close inspection of the coefficients. The coefficient on the lagged dependent variable was very high (between 0.88 and 0.95) and therefore overpowered the influence of all other variables in the specification. Moreover, the coefficient of adjustment implied an extremely slow adjustment process which did not seem realistic. The lagged dependent variable was therefore dropped.

The final specification uses only deflated feeder calf prices to explain inventory levels. This variable is repeated in the specification using different lags so that current inventory holdings depend upon average annual prices over the preceding seven years. The annual prices are lagged two quarters because producers typically decide to breed or cull a cow in the spring. A time variable is also included to capture the trend increase in inventories over the regression period.

The estimated equations for breeding inventories are presented in table 3.12. All equations have very high explanatory power and all variables are correctly signed. The equations are regressed using annual data from 1966 through 1981. With the long lags involved 1966 was the earliest starting period in which the regressions could begin, and the sample period is extended to 1981 to maximize degrees of freedom. The t-values for many of the price variables are small but an F-test indicates the price variables taken as a group are highly significant. The equation for Western Canada displays autocorrelation but attempts to correct for this problem failed to improve the performance of this variable in the simulation. The equations are regressed using only OLS because all endogenous variables appearing in the equations are predetermined. The short-run elasticities (given in parentheses) can be summed to give long-run elasticities of 1.06 in Western Canada, 1.14 in Eastern Canada and 0.94 in the United States.

3.7.3 Cow and Bull Slaughter Equations

Cow and bull slaughter is very closely related to the breeding inventory decision. From the theoretical framework employed (section 3.7.2) cows and bulls are slaughtered when their cull value exceeds the present discounted value of all future returns. Culling therefore will depend upon expected feeder calf and cow prices and the interest rate.

Table 3.12 Inventory of Cows and Bulls (Beef Sector), Western and Eastern Canada, United States, 1966-1981 Annual equations.

Region	Dependent Variable	Intercept	Current Calf Price PFC1/WPI3	Calf Price PFC1/WPI3 (-1)	Calf Price PFC1/WPI3 (-2)	Calf Price PFC1/WPI3 (-3)	Calf Price PFC1/WPI3 (-4)	Calf Price PFC1/WPI3 (-5)	Calf Price PFC1/WPI3 (-6)	Time	R^2	D.W.	h-stat
Western Canada	Inventory of Cows and Bulls (IBW1)	-741.92	2394.05 (1.06) [0.09]	5394.82 (1.84) [0.20]	2952.93 (0.79) [0.11]	5629.46 (1.32) [0.20]	3918.58 (0.85) [0.14]	5030.13 (1.15) [0.18]	3793.33 (0.83) [0.14]	39.56 (3.10)	.95	0.92	
Region	**Dependent Variable**	**Intercept**	**Current Calf Price PFC2/WPI3**	**Calf Price PFC2/WPI3 (-1)**	**Calf Price PFC2/WPI3 (-2)**	**Calf Price PFC2/WPI3 (-3)**	**Calf Price PFC2/WPI3 (-4)**	**Calf Price PFC2/WPI3 (-5)**	**Calf Price PFC2/WPI3 (-6)**	**Time**	**R^2**	**D.W.**	**h-stat**
Eastern Canada	Inventory of Cows and Bulls (IBW2)	-338.39	-39.47 (-0.07) [-0.01]	3003.03 (4.19) [0.50]	1438.10 (1.87) [0.04]	864.84 (1.04) [0.14]	398.72 (0.42) [0.06]	1724.17 (1.88) [0.28]	1332.99 (1.59) [0.22]	1.71 (0.69)	.97	2.16	
Region	**Dependent Variable**	**Intercept**	**Current Calf Price PFC4/WPI4**	**Calf Price PFC4/WPI4 (-1)**	**Calf Price PFC4/WPI4 (-2)**	**Calf Price PFC4/WPI4 (-3)**	**Calf Price PFC4/WPI4 (-4)**	**Calf Price PFC4/WPI4 (-5)**	**Calf Price PFC4/WPI4 (-6)**	**Time**	**R^2**	**D.W.**	**h-stat**
U.S.A.	Inventory of Cows and Bulls (IBW4)	-3466.28	12503.4 (3.92) [0.09]	24967.9 (6.38) [0.18]	23070.2 (5.16) [0.16]	21622.5 (4.90) [0.15]	20833.1 (4.20) [0.15]	15043.5 (3.36) [0.11]	14276.0 (3.57) [0.10]	364.38 (12.11)	.99	1.33	

Calf Price (-1) is an annual price lagged 1 years.

An annual price is derived from quarterly data as follows , PFCA = (PFC(-2)/WPI(-2) + PFC(-3)/WPI(-3) + PFC(-4)/WPI(-4) + PFC(-5)/WPI(-5)) * 0.25
(Also see PFC1A , PFC2A and PFC4A in Appendix 2) This variable is created only once per year.

Coefficients given without brackets. t-values given in parentheses, ( ). Short-run elasticities given in square brackets, [ ].

In addition to these market influences biological factors are important. As the breeding inventory ages its value diminishes and as a result a certain percentage of the breeding herd is culled to make room for replacements. Thus, culling levels tend to change with the size of the breeding herd.

The specification used in this study includes a current deflated price of feeder calves and current cow and bull inventories. These inventories include animals from both beef and dairy origins. Both interest rates and cow prices were tried in the specification but were always insignificant, possibly because a large proportion of cow and bull slaughter is from the dairy sector. Dairy inventories are added to beef inventories and are exogenous to the system. Apart from the inclusion of the dairy herd within the inventory level no other attempt is made to capture the dairy influence. The final specification includes current deflated prices of feeder calves, beginning of year inventories, a lagged dependent variable and seasonal dummy variables.

This specification follows those used in other research. Martin (1983b) estimates two equations, one for each of cow and bull slaughter. Both use the same regressors however, and include cow inventories, deflated steer prices and an average price of feeder steers. Haack (1978) employs a specification identical to the one used here except that feeder calf prices are in nominal terms and are lagged two quarters. Agriculture Canada (1983) follows this same specification but includes lagged hog prices to capture the possibility of alternative production opportunities.

The estimated equations are presented in tables 3.13 and 3.14. All variables possess the correct signs and most are significant although the coefficients on both Canadian cattle inventories have small t-values. The low R-squared values (0.74 and 0.75 for Eastern and Western Canada, respectively) can perhaps be explained by the failure to capture events occurring in the dairy sector which affect cow and bull slaughter.

3.7.4 Heifer and Steer Slaughter Equations

Heifer and steer slaughterings contribute the largest source of total beef production and are determined by a number of complex market forces. While heifers and steers are considered together in this study, there is a rationale for treating them separately since the decision to slaughter male and female animals is based on different criteria. The major decision to be made for steers is when and at what weight they should be slaughtered. Heifers, however, can be used for breeding and so the decision to slaughter is based upon their relative market and capital values. Attempts to estimate heifer and steer slaughter separately were unsuccessful and led to the decision to estimate a single aggregate equation.

The factors that determine heifer and steer slaughter are

Table 3.13 Cow and Bull Slaughter Western and Eastern Canada, 1962(1)-1980(4).

Region	Dependent Variable	Estimator	Intercept	Lagged Dependent Variable	Deflated Price of Feeder Calves (PFC1/WPI3)	Current Inventory of Cows and Bulls (IBW1)	R^2	D.W.	h-stat	Rho
Western Canada	Cow and Bull Slaughter (DBW1)	OLS	I 34.51 II 31.01 III 52.48 IV 74.75	0.54 (6.13)	-229.80 (-3.30) [-0.26]	0.007 (1.61) [0.27]	.74	1.97	0.20	
		2SLS	I 38.13 II 34.75 III 56.25 IV 78.53	0.54 (6.21)	-249.80 (-3.38) [-0.28]	0.007 (1.47) [0.23]	.74	1.97	0.20	

Region	Dependent Variable	Estimator	Intercept	Lagged Dependent Variable	Deflated Price of Feeder Calves (PFC2/WPI3)	Current Inventory of Cows and Bulls (IBW2)	R^2	D.W.	h-stat	Rho
Eastern Canada	Cow and Bull Slaughter (DBW2)	OLS	I 14.21 II 24.30 III 35.03 IV 47.64	0.65 (7.99)	-117.66 (-2.76) [-0.16]	0.005 (1.08) [0.15]	.75	1.93	0.22	
		2SLS	I 14.29 II 24.56 III 35.31 IV 47.87	0.66 (8.14)	-121.03 (-2.72) [-0.16]	0.005 (1.03) [0.15]	.75	1.94	0.37	

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

Table 3.14 Cow and Bull Slaughter United States, 1962(1)-1980(4).

Region	Dependent Variable	Estimator	Intercept	Lagged Dependent Variable	Deflated Price of Feeder Calves (PFC4/WPI4)	Current Inventory of Cows and Bulls (IBW4)	R^2	D.W.	h-stat	Rho
U.S.A.	Cow and Bull Slaughter (DBW4)	OLS	I -892.68 II -752.05 III -455.84 IV -428.60	0.67 (12.98)	-1541.02 (-4.56) [-0.23]	0.033 (4.25) [0.88]	.92	1.92	0.29	
		2SLS	I -793.37 II -648.99 III -352.90 IV -328.71	0.68 (13.31)	-1635.36 (-4.65) [-0.25]	0.032 (4.00) [0.84]	.92	1.94	0.29	

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

complicated by the lags in the production cycle, the consumption and capital aspects of the females and by price expectations. These factors give rise to very different responses to prices in the short-run versus the long-run.

Cattle can either be valued as a capital or consumption good and changes in current prices cause changes in expectations of future prices which affect expected capital and market values. If prices are rising, producers may expect prices to rise in the future thereby increasing both the expected capital and market value of the livestock. If the expected rise in the capital value exceeds the expected rise in market value then marketings will decrease, giving a negative short-run supply response. The heifers which are held back are bred, and after two or three years their offspring come on to the market causing marketings to rise. Thus, the long-run response to increased livestock prices is positive. An identical (but opposite) argument can be put forward for increases in the price of grain. This leads to increased marketings in the short-run as breeding herds are liquidated and the demand for replacement heifers falls. This eventually brings a reduction in supply and a negative supply response in the long-run. It is important therefore to capture both short and long-run influences within the equation specification. Slaughter is also constrained by the number of calves born previously which is directly associated with the size of the breeding inventory.

There seems to be little consensus within the literature on the appropriate specification for heifer and steer slaughter equations. MacAulay (1976) shows fed heifer and steer slaughter to depend upon stocks of feed, corn production, feeding margin and inventory levels, while non-fed slaughter varies with the margin over feed, inventory levels and time. Martin (1983) explains fed animal slaughter with lagged prices of feeder steers and cattle placed on feed lagged two quarters. The non-fed slaughter equation includes cattle placed on feed lagged one to three quarters, feeder calf availability, and the expected prices of steers and feeder steers. Ospina and Shumway (1980) employ a further disaggregation by specifying equations for each of "choice" and "good", heifers and steers. Haack (1978) attempts to capture the supply response by using a third degree polynomial distributed lag structure. Lags up to eight quarters are used and an inventory variable captures the effects of factors occurring before this time. This specification is both intuitively appealing and gave results consistent with prior expectations. Recent prices carry a negative sign (indicating a perverse short-run supply response) which slowly turns positive as slaughter increases with time.

Polynomial lags of various degrees and lengths were used in early specifications of the heifer and steer slaughter equation, but they were abandoned because of incorrect signs and insignificant coefficients. The final specification uses current deflated steer and corn prices, lagged deflated steer and corn prices and lagged inventories. The variables representing lagged prices consist of the sum of prices lagged one, two and three quarters. Thus, the coefficient on each of these lagged

prices is constrained to be the same. The expected sign of the coefficients for lagged steer and corn prices are positive and negative, respectively, while those for current steer and corn prices are negative and positive, respectively. The inventory variable is lagged two years and includes animals from both the beef and dairy sectors. Finally, dummy variables are included to capture the seasonality in production and to account for the changes in trade policy occurring in the U.S. during 1973.

The current specification does not split Canada into East and West despite differences in the production process between the two regions. Early attempts to estimate separate equations for Eastern and Western Canada failed to give satisfactory results. The major problem came from the inventory variable which was insignificant and sometimes incorrectly signed. Careful inspection of the data enabled the difficulty to be isolated. Eighty percent of the breeding herd is situated in the West while large numbers of feeder calves and steers are transported East to feedlots in Ontario and Quebec. The data on this inter-regional trade are poor and incomplete. Thus, it is impossible to link inventory in a region to slaughter in that region. By combining East and West the movement of animals between regions becomes irrelevant.

The results of estimation are presented in table 3.15. All the variables carry the expected sign, except for the current corn price in the U.S. equation, although some have small t-values. Two factors are apparent when looking at these results. The first is the large differences in coefficients between the OLS and 2SLS estimates. This is especially a problem on current steer prices (-2310.8 and -1297.0 for OLS and 2SLS, respectively for Canada; and -3897.9 and -147.1 for OLS and 2SLS, respectively for the U.S.). Simulations using the 2SLS parameters caused the model to become unstable and validation statistics indicated that the model had become explosive. It is therefore due to these equations that the OLS estimates of all the coefficients are used in the simulation. Second, the Durbin-Watson statistic indicates severe problems of autocorrelation. This indicates some form of misspecification. In fact the residuals display a pronounced cyclical pattern which is not being captured by the existing specification. An exhaustive attempt was made to capture the cycle in the residuals with explanatory variables, including time trend variables of various types and specifications, manipulations of the inventory variable and numerous dummy variables. After repeated tries an adequate variable still remained elusive and further efforts were renounced. The autocorrelation, however, is not corrected for in the model. When the equation was corrected for autocorrelation, the autocorrelation coefficient (Rho) was found to be 0.99. When the model was simulated using the corrected equation the influence of the lagged dependent variable, multiplied by 0.99, which enters through the adjustment process overpowered all the other variables and gave totally unsatisfactory results. The unadjusted equations do, however, produce satisfactory values during simulation. Pyndyck and Rubinfeld (p. 362) provide some justification for this procedure.

Table 3.15 Heifer and Steer Slaughter United States and Canada, 1962(1)-1980(4).

Region	Dependent Variable	Estimator	Intercept	Current Deflated Price of Steers (PSS3/WPI3)	Lagged Deflated Price of Steers (PSS3/WPI3)	Current Deflated Price of Feed (PCO3/WPI3)	Lagged Deflated Price of Feed (PCO3/WPI3)	Lagged Cow and Bull Inventory (IBW1+IBW2)	R^2	D.W.	h-stat	Rho
Canada	Heifer and Steer Slaughter (DHFS3)	OLS	I -854.47 II -833.89 III -826.28 IV -852.95	-2310.80 (-2.74) [-0.44]	1180.40 (4.17) [0.68]	318.03 (0.89) [0.10]	-540.50 (-4.16) [-0.52]	0.25 (14.95) [2.84]	.83	0.67		
		2SLS	I -927.74 II -911.08 III -902.80 IV -928.39	-1297.02 (-1.05) [-0.24]	950.30 (2.70) [0.54]	234.86 (0.64) [0.07]	-479.80 (-3.44) [-0.46]	0.26 (14.67) [2.84]	.82	0.70		

Region	Dependent Variable	Estimator	Intercept	Current Deflated Price of Steer (PSS4/WPI4)	Lagged Deflated Price of Steer (PSS4/WPI4)	Current Deflated Price of Feed (PCO4/WPI4)	Lagged Deflated Price of Feed (PCO4/WPI4)	Lagged Inventory Cows and Bulls (IBW4)	Dummy 1973 2nd and 3rd	R^2	D.W.	h-stat	Rho
U.S.A.	Heifer and Steer Slaughter (DHFS4)	OLS	I -3090.9 II -2973.1 III -2852.9 IV -3124.4	-3897.90 (-1.51) [-0.15]	2373.10 (2.54) [0.31]	1261.70 (1.21) [0.09]	-531.10 (-1.33) [-0.12]	0.20 (12.64) [1.54]	-672.24 (-1.94)	.74	0.42		
		2SLS	I -3850.5 II -3762.8 III -3644.2 IV -3867.8	-147.13 (-0.04) [-0.01]	1696.2 (1.65) [0.19]	-991.09 (-0.92) [-0.07]	-475.90 (-1.18) [-0.11]	0.20 (12.53) [1.54]	-811.27 (-2.21)	.73	0.54		

For all lagged price variables, the sum of three previous time periods is used.

i.e. Lagged deflated price of steers in Canada equals (PSS3(-1)/WPI3(-1) + PSS3(-2)/WPI3(-2) + PSS3(-3)/WPI3(-3)).

Cow and Bull Inventories are lagged eight quarters. Coefficients given without brackets. Short-run elasticities given in square brackets, [ ]. t-values given in parentheses, ( ).

In practice it may be necessary to use specifications for some of the equations in the model that are less desirable from a statistical point of view but improve the ability of the model to simulate well. The model builder is thus forced to make some compromises, accepting some equations which do not have a particularly good statistical fit in order to build a complete structural model.

3.7.5 Average Carcass Weight Equations

In the slaughter equations described above the number of cattle slaughtered is determined. In order to convert numbers slaughtered into the number of pounds of beef supplied by farms, it is necessary to multiply by an average carcass weight. The average carcass weight varies with changes in prices and at different times during the production cycle. Consequently, carcass weight is a variable which must be estimated.

Carcass weights vary for two major reasons. First, if producers expect the ratio of steer prices to feed prices to rise, animals are typically kept in the feedlot to be slaughtered at heavier weights. Second, carcass weights vary according to the different types of animal (heifers, steers, cows, bulls) which make up total slaughter. If the expected price of steers increases, more heifers are held back for breeding purposes. Thus, the percent of males that comprise total slaughter rises. Since male animals are heavier than females the average carcass weight also increases. Consequently, a positive relationship between prices and average carcass weight can be expected. Ideally, carcass weights should be calculated for each category of animal but since the data are not available, the average is the only alternative.

The current specification includes deflated prices of steers and corn both lagged one quarter, a lagged dependent variable and seasonal dummy variables. The prices are lagged one quarter to capture the time involved in fattening an animal to heavier weights following an increase in the price of steers or decrease in the price of feed. The lagged dependent variable assumes that expected prices are formed as a weighted average of previous prices using geometrically declining weights. The equation is estimated for all Canada since there is little evidence that producers in the East and West behave differently to changes in price expectations. This specification is by now fairly standard and is used in many other studies (Haack (1978); Agriculture Canada (1983); Kulshreshtha and Wilson (1972); and Goddard (1984)).

The estimated equations are presented in table 3.16. All variables are correctly signed although the Canadian steer price and U.S. corn price have small t-values. The h-statistic in the U.S. equation (2.12) indicates a problem with autocorrelation, however, an adjustment failed to improve the results. The equation, nevertheless, gives good validation statistics in simulation. The coefficients on the lagged

Table 3.16 Average Carcass Weight, United States and Canada, 1962(1)-1980(4).

Region	Dependent Variable	Estimator	Intercept	Lagged Deflated Price of Steers (PSS3/WPI3)	Lagged Deflated Price of Feed (PCO3/WPI3)	Lagged Dependent Variable	R^2	D.W.	h-stat	Rho
Canada	Average Carcass Weight (CWBF3)	OLS	I 101.77 II 91.04 III 101.44 IV 93.17	102.08 (1.24) [0.02]	-78.33 (-2.47) [-0.01]	0.84 (15.38)	.85	1.87	0.64	
Region	Dependent Variable	Estimator	Intercept	Lagged Deflated Price of Steers (PSS4/WPI4)	Lagged Deflated Price of Feed (PCO4/WPI4)	Lagged Dependent Variable	R^2	D.W.	h-stat	Rho
U.S.A	Average Carcass Weight (CWBF4)	OLS	I 70.46 II 61.32 III 50.38 IV 66.90	121.17 (3.09) [0.05]	-12.69 (-1.03) [-0.01]	0.85 (16.08)	.83	1.57	2.12	

All price variables are lagged one quarter.

Coefficients given without brackets.
t
t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

dependent variable (0.84 and 0.85 for Canada and the U.S., respectively) suggest a fairly slow response to price changes. This result is consistent with the findings of Haack (1978).

3.7.6 Beef Production Identities

Having estimated equations for the number of cows and bulls, and heifers and steers slaughtered, as well as average carcass weights these can be brought together to create an identity for total farm supply. This identity is presented below:

Production of Beef (All Canada) = (Cow and Bull Slaughter (West and East) + Heifer and Steer Slaughter (All Canada)) * Average Carcass Weight (All Canada)

Production of Beef (U.S.) = (Cow and Bull Slaughter (U.S.) + Heifer and Steer Slaughter (U.S.)) * Average Carcass Weight (U.S.)

3.7.7 Hog Production Equations

Hog production is less complex than beef production and it is possible to estimate output using only one equation. The estimation of beef supply required separate treatment of the different types of animals comprising the slaughter and average carcass weights. This is not needed in the pork equations because the breeding inventory is relatively small and culled sows and boars make only minor contributions to total slaughter (3 percent). Furthermore, average carcass weights are much less variable and do not change dramatically with changes in hog and feed prices. Supply of pork can therefore be estimated in pounds instead of numbers thereby simplifying the modeling process.

Production depends largely on the price of output and the price of feed (which represents about 70 percent of variable costs). There are, however, time lags between price changes and production responses. An early explanation of the impact of time lags on agricultural production is the cobweb theorem (Ezekiel (1938)). This work, however, has been superceded by the adaptive expectations and partial adjustment models developed by Nerlove (1958).

The equation used to estimate pork production includes lagged (four quarters) deflated prices of hogs and feed, a lagged dependent variable, and seasonal dummy variables which is consistent with the specifications used by Robertson (1980) and Zwart and Martin (1974). The four quarter time lag is sufficient to allow for the breeding decision to be made, a four month gestation period and five to six months for the resultant offspring to be ready for slaughter. The lagged dependent variable is included on the assumption that expected prices are based upon a geometrically declining weighted average of past prices. In section 2.3.1 it was noted how production in Ontario and Quebec has increased in recent years while it has remained stable in other regions. To capture this trend a dummy variable is added to the Eastern Canadian specification. This variable equals zero up until the second quarter of 1977 and one in the third quarter of 1977. Between the third quarter of 1977 and the first quarter of 1980 the variable increases by one unit each quarter. For the second quarter of 1980 and beyond the variable equals 11.0. Finally, a dummy variable for the third quarter of 1973 is used in the U.S. to capture the effect of the Canadian imposition of export controls on pork.

The estimated equations are presented in table 3.17. All variables are significant and the equations display high explanatory power. The coefficient on feed in Eastern Canada is constrained to yield an elasticity of -0.05. This is because the OLS estimate provided a coefficient with the "wrong" sign probably resulting from the structural changes that have occurred in that region. The restriction on the coefficient is therefore justified and the equation performs very well in the simulation. The elasticities for hogs and feed in Western Canada are found to equal 0.19 and -0.17, respectively. The direct price elasticity (0.10) in the Eastern Canadian equation is very small. It is consistent, however, with an industry in which specialization has made producers less responsive to changes in price levels. Elasticity estimates for the U.S. are similar to those found in Canada.

3.8 LIVESTOCK PRICE LINKAGE EQUATIONS

It was argued in section 2.6 that price linkage equations can be used to join the various regions in a non-spatial equilibrium model. In a world of perfect arbitrage (i.e. in which prices in different countries differ only by the exchange rate and transportation costs) the price linkages can be entered as:

3.1 $$P_A = P_B * ER +/- \text{Transport Costs},$$

+ if country A is an importer,
- if country A is an exporter.

In the real world this identity may not hold due to the many imperfections that exist within international trade (ie. trade barriers and agreements, location, political preferences) and it is necessary to estimate an equation linking the price in Canada with the price in the U.S.

Other researchers (Robertson (1980) and Agriculture Canada (1983)) have specified price linkage equations differently. In these studies the exchange rate and U.S. price are used as separate regressors and therefore no constraints are imposed on the elasticities. In this study, the Canadian price is specified to depend on seasonal dummy variables, the U.S. price, net trade and a lagged dependent variable.

Table 3.17: Pork Production, Western and Eastern Canada, United States, 1968(1)-1980(4)

Region	Dependent Variable	Intercept	Lagged Deflated Price of Hogs (PHG1/WPI3)	Lagged Deflated Price of Barley (OPBA3/WPI3)	Lagged Dependent Variable		R^2	D.W.	h-stat	Rho
Western Canada	Pork Production (QPK1)	I 30.10 II 23.08 III 6.59 IV 22.41	182.99 (4.12) [0.19]	-134.39 (-7.07) [-0.17]	0.86 (23.31)		.94	2.08	0.30	-0.27
	Dependent Variable	Intercept	Lagged Deflated Price of Hogs (PHG2/WPI3)	Lagged Deflated Price of Corn (FPCO2/WPI3)	Lagged Dependent Variable	Dummy for Increased Production in Quebec (DQUE)	R^2	D.W.	h-stat	Rho
Eastern Canada	Pork Production (QPK2)	I 53.65 II 45.86 III 40.22 IV 61.22	165.12 (3.21) [0.10]	-50.26 Constrained [-0.05]	0.64 (8.44)	5.39 (5.60)	.99	1.81	0.00	
	Dependent Variable	Intercept	Lagged Deflated Price of Hogs (PHG4/WPI4)	Lagged Deflated Price of Corn (PCO4/WPI4)	Lagged Dependent Variable	Dummy for 1973 3rd (D19733)	R^2	D.W.	h-stat	Rho
U.S.A.	Pork Production (QPK4)	I 291.27 II 483.24 III 278.30 IV 910.84	1958.11 (3.52) [0.12]	-900.87 (-3.94) [-0.13]	0.87 (14.45)	-392.03 (-2.60)	.90	1.81	0.80	

All price variables are lagged four quarters.

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets [ ].

The U.S. price is included in Canadian dollars (ie. the U.S. price multiplied by the exchange rate), and this constrains the elasticity of the Canadian price, with respect to the U.S. price, to equal the elasticity of Canadian price with respect to the exchange rate. Also, included in the specification is net trade between the U.S. and Canada. This variable is included to capture the effect of switching trade in which Canada is sometimes a net importer and sometimes a net exporter. Also, net trade is included to capture the absence of perfect arbitrage between Canada and the U.S.

The estimated equations (tables 3.18) perform well. All have very high explanatory power and all variables have large t-values apart from net trade in beef. A dummy variable for the second, third and fourth quarters of 1974 is included in the beef equations to correct for autocorrelation which was apparent in earlier estimates by Coleman (1984). The price and exchange rate transmission elasticities range between 0.75 and 0.81 in the short-run and 0.86 and 1.01 in the long-run. Although the long-run elasticity of Western hog prices is slightly larger than one, the discrepancy is not large enough to justify constraining it to equal one.

Having obtained regional beef and pork prices they are then weighted by average slaughter in the East and West (3.2 and 3.3) to calculate an average Canadian price which is used to explain Canadian retail prices.

3.2 PSS3 = 0.582 PSS1 + 0.418 PSS2

3.3 PHG3 = 0.379 PHG1 + 0.621 PHG2

3.9 FEED PRICE LINKAGES EQUATIONS

3.9.1 Soybean Meal and Rapeseed Meal Price Linkage Equations

The prices of soybean meal and rapeseed meal which appear in the enterprise budgets are determined largely in the United States. Consequently, it is necessary to link the Canadian prices to the U.S. price via the exchange rate. Table 3.19 contains the estimates for the protein price linkages. The Eastern and Western prices of soybean meal and the Western price of rapeseed meal are shown to depend upon the U.S. price multiplied by the exchange rate, a time variable and a dummy for the third quarter of 1973. A time variable is included to model the steadily increasing difference between U.S. and Canadian prices throughout the time period, while the dummy variable is employed to capture the volatile changes in protein meal prices during the U.S. soybean embargo. The exchange rate transmission elasticities are all less than unity. The equations perform well displaying high explanatory power and the coefficients are correctly signed and have high t-values. Since there were problems in obtaining data prior to 1971, the regression is extended to the end of 1981 to increase the degrees of

Table 3.18: International Price Linkage for Beef, United States to Canada, 1970(1)-1980(4)

Linkage	Dependent Variable	Estimator	Intercept	U.S. Price of Steers in Canadian Dollars (PSS4*ER34)	Net Trade in Beef Canada/U.S. (NT3BF4)	Lagged Price of Steers	Dummy for 742+743+744	R^2	D.W.	h-stat	Rho
Western Canada	Price of Steers (PSS1)	OLS[a/]	I 1.65 II 1.67 III 0.83 IV 2.24	0.77 (14.13) [0.77]	-0.05 (-1.85) [-0.02]	0.21 (3.52)	6.58 (5.43)	.99	1.64	1.29	
Eastern Canada	Price of Steers (PSS2)	OLS[a/]	I 2.03 II 0.62 III 1.01 IV 2.32	0.80 (16.84) [0.75]	-0.01 (-0.51) [-0.00]	0.22 (4.48)	6.71 (6.52)	.99	1.84	0.56	

International Price Linkage for Pork, United States to Canada, 1970(1)-1980(4)

Linkage	Dependent Variable	Estimator	Intercept	U.S. Price of Hogs in Canadian Dollars (PHG4*ER34)	Net Trade in Pork Canada/U.S. (NT3PK4)	Lagged Price of Hogs	R^2	D.W.	h-stat	Rho
Western Canada	Price of Hogs (PHG1)	OLS[a/]	I -1.56 II -2.14 III -0.43 IV -0.11	1.03 (22.97) [0.80]	-0.05 (-4.00) [-0.00]	0.21 (5.97)	.99	1.80	0.68	
Eastern Canada	Price of Hogs (PHG2)	OLS[a/]	I 1.38 II 1.32 III 2.59 IV 2.44	1.03 (18.73) [0.75]	-0.08 (-3.26) [-0.01]	0.13 (2.59)	.99	2.20	0.70	0.63

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

a/ See Coleman (1984) for a comparison of OLS and 2SLS estimates for a slightly different specification of this equation.

Table 3.19 Soybean Meal and Rapeseed Meal Price Linkages, Western and Eastern Canada to United States, 1971(1)-1981(4).

Linkage	Dependent Variable	Intercept	U.S. Price of Soybean Meal in Canadian Dollars (PSM4*ER34)	Time	Dummy for 1973 3rd Quarter (D19733)	R^2	D.W.	h-stat	Rho
Western Canada to U.S.A.	Price of Soybean Meal (PSM1)	15.80	1.18 (30.91) [0.84]	1.26 (1.57)	69.01 (5.43)	.98	1.46		
Eastern Canada to U.S.A.	Price of Soybean Meal (PSM2)	-2.53	0.99 (63.04) [0.88]	1.69 (5.11)	64.72 (12.34)	.99	1.65		
Western Canada to U.S.A.	Price of Rapeseed Meal (PRM1)	-23.54	0.60 (12.51) [0.75]	3.72 (3.70)	43.74 (2.75)	.94	1.41		

Coefficients given without brackets.
t-values given in parentheses, ( ).
Short-run elasticities given in square brackets, [ ].

freedom.

3.9.2 Corn and Barley Price Linkage Equations

The second set of feed price linkages concern the prices of corn and barley. The corn and barley price equations are specified to be linear in logarithms and the long-run elasticity of price transmission has been constrained to equal 1.0. This constraint is imposed by forcing the coefficient on the price variable to equal one, minus the coefficient on the lagged dependent variable, thus insuring that the long-run elasticity of price and exchange rate transmission is one.

Corn prices in Eastern Canada are linked to corn prices in the United States, while Western Canadian barley prices are linked to Ontario corn prices. This approach is taken because trade in barley does not generally take place between Canada and the United States. End of crop year barley stocks (IBA3) are also included in the barley equation to account for price differentials between corn and barley, as is a zero-one variable (D78) to account for a period (1978(2) to 1979(1)) when barley prices diverged greatly from corn prices because of lack of arbitrage between the domestic and export barley markets (Carter (1984)). A zero-one variable (D733) is also included to account for a large outlier in 1973(3). Estimates of the corn and barley equations are shown in table 3.20. Although the barley equation indicates the need for an autocorrelation correction the uncorrected equation simulated better than the corrected equation.

The Eastern corn price and Western barley prices are combined to form a feed price variable, used in estimating Canadian beef supply, which is a weighted sum of the two regional prices. The weights are identical to those used in forming the Canadian steer price from Eastern and Western steer prices.

3.9.3 Silage Value and Hay Price Linkage Equations

In addition to grain and protein supplements, silage and hay are also fed to cattle in most beef feedlot and cow-calf operations. Silage is particularly important in the budget for Eastern Canada where 4.22 pounds of silage are fed for every one pound of corn. In the budget for Western Canada however, only 0.36 pound of silage is fed for every one pound of barley. Grain and silage are to some extent substitutes within a typical ration for feeding and fattening livestock. Given this substitutability, changes in the price of grain are reflected in changes in the value of silage.1/ Hence, changes in the exchange rate may cause

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1/ The commercial market for silage in Canada is almost non-existent, although there is evidence of silage moving between neighbouring those imputed by farm management specialists (Ontario Ministry of Agriculture and Food).

Table 3.20: Corn and Barley Price Linkages, Western and Eastern Canada, 1972(1)-1981(4)

Linkage	Dependent Variable	Intercept	U.S. Price of Corn in Canadian Dollars	Lagged Price of Corn	Ln(Time)	R^2	D.W.	h-stat	Rho
Eastern Corn Price to U.S. Corn Price	Price of Corn Ln(FPCO2)	I 0.08 II 0.10 III 0.12 IV 0.07	(1 - 0.08) (constrained) [0.92]	0.08 (1.98)	-0.16 (-0.85)	.99	1.75	0.82	0.81

Linkage	Dependent Variable	Intercept	Price of Corn Eastern Canada Ln(FPCO2)	Stocks of Barley Western Canada Ln(IBA3)	D733	Lagged Dependent Variable	D78	R^2	D.W.	h-stat	Rho
Western Barley Price to Eastern Corn Price	Price of Barley Ln(OPBA3)	I 0.49 II 0.48 III 0.44 IV 0.48	(1 - 0.61) (constrained) [0.39]	-0.06 (-2.09)	0.26 (5.05)	0.61 (16.15)	-0.12 (-4.31)	.99	1.08	3.00	

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

changes in the value of silage via changes in grain prices. To capture this relationship equations are specified which link silage values to farms. Consequently, the values for silage used in this study are grain prices for both Eastern and Western Canada. Moreover, if silage values are not linked to the exchange rate it is expected that Western producers will fair relatively worse than those in the East (since grain is relatively more important in the budget for Western Canada than Eastern Canada).

The estimated equations are presented in table 3.21. The coefficient on grain prices in both equations have large t-values and the equations display considerable explanatory power. Both equations require an adjustment for autocorrelation. The elasticities for the price of silage with respect to the price of grain are 0.42 and 0.65 for Western and Eastern Canada, respectively.

The price of hay is included in the gross margin for beef feedlot and cow-calf operations in Eastern Canada and is linked to the Eastern corn price in the model. The need to link these prices follows an identical argument used to justify linking silage values (ie. hay and corn are to some extent substitutes within a typical ration and therefore their prices should be linked). The estimated equation is presented in table 3.22. An autocorrelation adjustment is required and gives an Rho value of 0.98. After, this correction the coefficient on the price of corn has a high t-value and the equation displays considerable explanatory power. The elasticity of the price of hay with respect to the price of corn is 0.13.

3.10 FEEDER STEER AND COW PRICE EQUATIONS

3.10.1 Feeder Steer Equations

The enterprise budgets for feedlot operations in Eastern and Western Canada contain regional prices of feeder steers among the set of traded cash costs. Since the model does not include the demand and supply of feeder steers explicitly, it is necessary to obtain regional prices using reduced form equations similar to those used in section 3.7.1.

The price of feeder steers used in the West is the Calgary price and it depends on the price of barley and finished steers. These are the major variables that determine demand for feeder steers by feedlot operators. A lagged dependent variable is included to capture expectations and dummy variables are used to accommodate seasonality. The estimated equation is given in table 3.23. All variables are significant and the explanatory power of the equation is very high. The coefficient on the lagged dependent variable implies rapid adjustment to price changes and an increase in the steer price results in a more than proportionate increase in feeder steer prices.

For Eastern Canada the Toronto feeder steer price is not

Table 3.21: Silage Value Linkages, Western and Eastern Canada, 1971(1)-1981(4)

Linkage	Dependent Variable	Estimator	Intercept	Western Price of Barley (OPBA3)		R^2	D.W.	h-stat	Rho
Value Silage Western Canada to Barley price Western Canada	Value of Silage (BF1SLGE)	OLS	I 0.73 II 0.71 III 0.65 IV 0.70	0.03 (19.44) [0.42]		.98	1.78		0.57
Linkage	**Dependent Variable**	**Estimator**	**Intercept**	**Eastern Price of Corn (FPCO2)**	**Time**	**R^2**	**D.W.**	**h-stat**	**Rho**
Value Silage Eastern Canada to Corn Price Eastern Canada	Value of Silage (BF2SLGE)	OLS	I -0.29 II -0.26 III -0.24 IV -0.44	0.12 (39.43) [0.65]	0.07 (2.32)	.99	1.98		0.29

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

Table 3.22: Hay Price Linkage, Eastern Canada, 1971(1)-1981(4).

Linkage	Dependent Variable	Estimator	Intercept	Eastern Price of Corn (FPCO2)	R^2	D.W.	h-stat	Rho
Price Hay Eastern Canada to Price Corn Eastern Canada	Price of Hay (PHAY2)	OLS	I 3.68 II 2.66 III 1.52 IV 1.28	0.06 (2.14) [0.13]	0.96	2.02		0.98

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

Table 3.23 Price of Feeder Steers, Western and Eastern Canada, 1971(1)-1981(4).

Region	Dependent Variable	Estimator	Intercept	Price of Barley (OPBA3)	Price of Steers (PSS1)	Lagged Dependent Variable	R^2	D.W.	h-stat	Rho
Western Canada	Feeder Steer Price (PFS1)	OLS	I -0.43 II -3.76 III -4.41 IV -5.41	-0.17 (-6.42) [-0.24]	1.09 (9.17) [1.01]	0.31 (3.88)	.97	1.88	0.47	
Linkage	**Dependent Variable**	**Estimator**	**Intercept**	**Price of Feeder Steers Western Canada (PFS2)**			**R^2**	**D.W.**	**h-stat**	**Rho**
Feeder Price West to Feeder Price East	Feeder Steer Price (PFS2)	OLS	-2.56	1.00 (107.15) [1.04]			.99	1.63		

Coefficients given without brackets.
t
t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

appropriate. Substantial numbers of feeder steers move East from the Prairies into Eastern feedlots so that Eastern prices are largely set in the West. Thus, a price linkage equation is estimated in which the price in Saskatoon is given as a function of the price in Edmonton. The Saskatoon price is then used in the Eastern beef feedlot enterprise budgets. The transportation costs incurred in moving cattle to the East are contained within the enterprise budget under the transport and marketing category. The estimated equation is given in table 3.24 and indicates that the prices between regions are very similar.

3.10.2 Cow Price Equations

Cull cows and bulls represent an important source of revenue for cow-calf operators. It has been argued that livestock prices in Canada are largely determined in the U.S. market with adjustments for exchange rates and transportation costs. Changes in the exchange rate therefore can be expected to affect cow-calf operators through changes in cow prices. Cow prices in Eastern Canada and Western Canada are estimated using reduced form equations, similar to those used in sections 3.7.1 and 3.10.1.

The equations are specified to incorporate factors influencing both the demand and supply of cows. The demand is derived from consumers' demand for low quality beef. This is captured by per capita disposable income and the prices of pork and steers (the price of steers represents the price of high quality beef). The supply factors include the price of feed and is included to capture profitability in the feedlot sector as it affects feeder calf prices and thereby the culling rate of the breeding herd.

The estimated equations are reported in table 3.24. The equations have high explanatory power and most coefficients have high t-values. The negative sign on the income variable is consistent with the demand for a low quality product and the sign on the price of steers suggests that low and high quality beef are to some extent substitutable (this result is inconclusive however, because the influence of supply also causes this sign to be positive).

3.11 TREATMENT OF MACROECONOMIC VARIABLES

In section 2.7 the importance of linking certain macroeconomic variables between the U.S. and Canada was stressed. This section presents the methods by which these variables are linked in the model. Linkage equations, based on the PPP theorem, are employed for the CPI and WPI. The wage rate, interest rate and disposable income cannot be treated in this way and are dealt with using the methods described below.

Table 3.24 Cow and Bull Price, Western and Eastern Canada, 1966(1)-1980(4).

Region	Dependent Variable	Estimator	Intercept	Current Price of Steers (PSS1)	Current Price of Barley (OPBA3)	Lagged Dependent Variable	Current Price of Hogs (PHG1)	Disposable Income (PCDY3)	R^2	D.W.	h-stat	Rho
Western Canada	Price of Cows and Bulls (PBW1)	OLS	I 0.20 II 0.42 III -2.75 Iv -3.78	0.48 (5.27) [0.72]	-0.09 (-6.04) [-0.20]	0.52 (5.59)	0.09 (2.53) [0.14]	-0.003 (-1.79) [-0.11]	.97	1.74	1.43	
Region	Dependent Variable	Estimator	Intercept	Current Price of Steers (PSS2)	Current Price of Corn (FPCO2)	Lagged Dependent Variable	Current Price of Hogs (PHG2)	Disposable Income (PCDY3)	R^2	D.W.	h-stat	Rho
Eastern Canada	Price of Cows and Bulls (PBW2)	OLS	I -0.60 II -0.53 III -2.42 IV -4.38	0.49 (6.20) [0.72]	-0.11 (-6.45) [-0.29]	0.67 (8.38)	0.12 (3.05) [0.19]	-0.006 (-3.53) [-0.21]	.98	1.73	1.28	

Coefficients given without brackets.

t-values given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

3.11.1 The WPI Linkage Equation

A brief review of the Purchasing Power Parity Theorem (PPP) was given in section 2.7.2. This provides the theoretical framework within which the WPI linkage equation is treated. The PPP theorem says that exchange rate changes are ultimately derived from divergent inflation rates so that a systematic relationship can be identified between the U.S. and Canadian WPIs and the exchange rate.

The relative PPP (see 2.6.2.1) suggests that an appropriate regression equation can be estimated as

$$\dot{P}_{can} = a_0 + a_1 * \dot{ER} + a_2 * \dot{P}_{us}$$

where, $\dot{P}_{can}$ and $\dot{P}_{us}$ are changes in the Canadian and United States wholesale prices, respectively and $\dot{ER}$ is the change in the exchange rate.

This equation was successfully estimated by Lee (1976) between 1914 and 1950 using current and lagged values of $\dot{ER}$ and $\dot{P}_{us}$. However, attempts to use this specification failed to provide satisfactory results unless the variables were transformed from rates of change to absolute levels. This is primarily due to the time trend that accompanies the untransformed data.

The specification used shows the Canadian WPI as a function of the United States WPI, the exchange rate, and a lagged dependent variable. A log-log functional form is used so that the coefficients are the elasticities. As well as being more convenient, this functional form performed better than when a linear equation was estimated. Autocorrelation proved to be a problem with an estimated autocorrelation coefficient of 0.96. The coefficient on the exchange rate has a small t-value but otherwise the equation performs well. The estimated coefficients are presented in table 3.25. The long-run elasticity between the Canadian and United States WPIs suggests that almost half the increases in the United States WPI are felt in the Canadian market.

3.11.2 The CPI Linkage Equation

Typically changes in the CPI are felt earlier in changes in the WPI as firms pass changes in the cost of production on to consumers. As a result, the equation is specified as a mark-up equation from the WPI to the CPI. In addition to the WPI, the United States CPI and exchange rate are included in the specification to capture the influence of imports within the Canadian CPI. The unemployment rate is also included to incorporate a Philips relationship as well as a lagged dependent variable.[1/]

1/ The Philips curve purports to describe the relationship between price levels and unemployment. Its downward slope reflects booms and troughs within the economic cycle.

Table 3.25: Macro Variable Linkages -- Canada to United States, 1971(1) - 1981(4)

Linkage	Dependent Variable	Estimator	Intercept	Canadian Wholesale Price Index Ln (WPI3)	Exchange Rate Ln (ER34)	Unemployment Rate Ln (UNEMPLT)	Lagged Dependent Variable	U.S. Consumer Price Index Ln (CPI4)	R^2	D.W.	h-stat	Rho
Canadian CPI to U.S. CPI	Consumer Price Index Ln (CPI3)	OLS	-0.09	0.06 (5.03)	0.03 (1.24)	-0.01 (-1.56)	0.85 (20.00)	0.10 (2.71)	.99	1.81	0.65	

Linkage	Dependent Variable	Estimator	Intercept	U.S. Wholesale Price Index Ln (WPI4)	Lagged Dependent Variable	Exchange Rate Ln (ER34)	R^2	D.W.	h-stat	Rho
Canadian WPI to U.S. WPI	Wholesale Price Index Ln (WPI3)	OLS	0.10	0.42 (1.88)	0.29 (2.50)	0.27 (1.75)	.99	1.84		0.96

Table 3.25 continued

Canadian Interest Rate and Forward Exchange Rate Equations, 1973(1)- 1982(4).

Dependent Variable	Intercept	Rate of Interest U.S. (RTB4)	Forward Premium (AVSPREAD*4/ER34)	Lagged Dependent Variable (RTB3(-1))	Real Disposable Income (DY3/CPI3)	Dummy Variable 1980 3rd Quarter (D19803)	R^2	D.W.	Rho
Canadian Interest Rate (RTB3)	-3.73 (-4.47)	0.88 (10.55) [0.74]	59.04 (5.10) [0.04]	0.15 (2.04)	0.03 (4.32) [0.59]	-2.27 (-3.74)	.98	1.90	0.27

Dependent Variable	Intercept	Exchange Rate (ER34)	Consumer Price Index, Canada (CPI3)	Consumer Price Index, U.S. (CPI4)	R^2	D.W.	Rho
Forward Exchange Rate (AVFOER34)	0.07 (5.58)	0.92 (60.27) [0.91]	0.00058 (4.37) [0.09]	-0.00038 (-3.17) [-0.07]	.99	1.45	

t-statistics given in parentheses, ( ).

Short-run elasticities given in square brackets, [ ].

Coefficients given without brackets.

Despite small t-values on the exchange rate and unemployment rate all coefficients carry the appropriate signs. There is no autocorrelation and the explanatory power of the equation is exceptionally high.

3.11.3 The Rate of Interest Equation

A theoretical framework, based on interest rate parity, within which to estimate the impact of a change in the exchange rate on the rate of interest, was developed in section 2.6.3. It states that the Canadian interest rate is equal to the U.S. interest rate plus the forward premium. Since this is a long-run relationship two variables representing the supply and demand for money, ie. disposable income and the money supply were included in this equation to capture the short-run influences on the interest rate.

The theoretical framework for the forward exchange rate equation is again based on the purchasing power parity of exchange rate determination. This theory implies that a bilateral exchange rate is determined by the relative inflation rates of the countries involved. Thus the forward exchange rate is expected to depend upon the consumer price indices in Canada and the United States. The spot exchange rate is also included to capture the naive expectation that the future exchange rate will be unchanged from current levels.

The estimated equations are presented in table 3.25. The final specification for the interest rate equation includes the U.S. rate of interest, the forward premium, real disposable income, a dummy variable for the 3rd quarter of 1980 and a lagged dependent variable. All variables have the correct signs and large t-values. The equation indicates a high level of explanatory power (R-squared = 0.98) following an autocorrelation adjustment (Rho = 0.27). The coefficient on the lagged dependent variable (0.15) suggests that Canadian interest rates adjust quickly to changes in U.S. interest rates for which the short-run and long-run elasticities are 0.74 and 0.87, respectively. The dummy variable (D19803) is included to capture the decline in the interest rate in the middle of 1980, which came as a sudden departure from the steady upward trend experienced throughout most of the regression period. The money supply was included in the initial specifications but entered with the wrong sign (positive) and does not appear in the final equation.

The equation for the forward exchange rate is also presented in table 3.25. Regressors include the spot exchange rate and the consumer price index for both Canada and the U.S., all of which are correctly signed and have high t-values. The equation has a high level of explanatory power and no autocorrelation adjustment is needed. A change in the spot exchange rate is transmitted through to the forward rate slightly less than proportionately (0.92 and 0.91 for the coefficient and elasticity, respectively). Both the Canadian and the United States CPIs have small impacts on the forward exchange rate, with elasticities of 0.09 and -0.07, respectively.

3.11.4 Disposable Income

The linking of disposable income in Canada to that of the U.S. presents a major problem. The purchasing power parity theorem, while providing the theoretical framework within which to link price indices, does not justify similar treatment of disposable income. Moreover, Canadian disposable income is determined by a multitude of different domestic and international factors and it would be naive to explain it using just the U.S. disposable income and the exchange rate.

The purpose of estimating a linkage between the disposable incomes is to obtain a multiplier, or elasticity, which gives the change in Canadian disposable income for a given change in the exchange rate. If such a multipler could be found from a model that included all the complexities of the macroeconomy, and which was supported by a theoretical framework, it could then be employed directly. This would avoid the use of a linkage equation that is difficult to justify and which can not be relied upon to provide accurate results.

This possible solution led to an investigation of existing macroeconomic models to see if such multipliers were available. The RDFX model of the Bank of Canada is a large model of the Canadian economy which is used for policy analysis and forecasting. The Bank has published the results of responses to selected policy shocks, one of which reports the effects of an autonomous 10 percent depreciation of the exchange rate (O'Reilly et al. (1983)). Multipliers for the CPI, the rate of interest and disposable income were reported for ten years following a permanent 10 percent depreciation. These multipliers for income are incorporated into our beef and pork model (BFPK) in the following way.

The BFPK model uses a real income variable in which per capita disposable income is deflated by the CPI. Taking the RDFX multipliers for per capita income and BFPK multipliers for CPI gives values for real per capita income that are very large (ie. long-run multipliers of 8 percent). This is because the BFPK multipliers for the CPI are much smaller than those for the RDFX (ie. long-run multipliers are 3 percent for BFPK and are 8 percent for RDFX).

To resolve this problem, RDFX multipliers for CPI are subtracted from those for nominal per capita disposable income to give values for real income. These are then used as per capita disposable income multipliers in the BFPK model. In this way, the changes in real per capita disposable income between the BFPK model and RDFX model are identical. Table 3.26 may clarify the procedure.

Table 3.26: Calculation of Nominal Income in the BFPK Model

	RDFX			BFPK	
Year	Nominal Income (a)	CPI (b)	Real Income (a)-(b)=(c)	CPI (d)	Nominal Income (c)+(d)
0	0.91	1.50	-0.59	0.39	-0.20
1	3.35	3.39	-0.04	1.62	1.38
2	4.45	4.42	0.13	2.28	2.41
3	4.96	5.04	-0.08	2.63	2.55
4	5.78	5.87	-0.09	2.81	2.72
5	6.57	6.39	0.18	2.90	3.08
6	7.38	6.80	0.58	2.95	3.55
7	8.25	7.24	1.01	2.97	3.98
8	9.00	7.63	1.37	2.99	4.36
9	9.93	7.94	1.79	3.00	4.79

The large difference existing between the CPI multipliers for the BFPK and RDFX models may cause some concern. Comparisons, however, between multipliers across a number of models indicate large differences and it is not clear which is the most accurate. It is not possible to compare deflated per capita disposable income because it is only reported for the RDFX, however, nominal gross national expenditures between the RDFX and the Data Resources (DRI) model are particularly close. Thus it is expected that per capita disposable income is also quite similar. Moreover, the value generated for the CPI by the BFPK model is so close to that of the DRI model that the differences between the CPI values for the BFPK and RDFX models are of little importance.

Finally, having used multipliers for income, perhaps those for the CPI and the rate of interest should also be employed to maintain consistency. Two major reasons suggest that this is not appropriate. First, nowhere are multipliers reported in the RDFX for WPI, and to obtain these would require a mark-up equation or perhaps some adjustment to the multiplier on the CPI. Second, PPP provides a theoretical framework which justifies the linking of price indices that can not be applied to disposable income. Consequently, whatever method was chosen to overcome these problems would always contain some element of inconsistency.

3.11.5 The Wage Rate

The final macro variable to be dealt with is the wage rate. This variable appears only in the farm to retail price mark-up equations (section 3.6.2) and enters with a very small coefficient. Thus, there seems little point in providing a sophisticated method to link wages in

the U.S. and Canada.

For this reason the multiplier on the Canadian wage rate is constrained to equal that on the CPI so that real wages do not change following a devaluation. This simplification is justified because wage rates are relatively unimportant and an unchanged real wage rate is supported by the RDFX.

3.11.6 A Summary of the Macroeconomic Linkages

The authors would be the first to admit that the methods used to endogenize the macroeconomic variables in this study are rather crude. However, it is felt that the multipliers are not inconsistent with those obtained from sophisticated models of the Canadian economy (O'Reilly et al. 1983). Table 3.27 shows the estimated multipliers for the Canadian macroeconomic variables obtained by simulating the six equations which explain the macroeconomic variables in the model.

It should also be noted that the reason why the exchange rate depreciates is important in determining its influence on the interest rate. In these simulations it is assumed that the Bank of Canada "leans against the wind" by increasing the interest rate to moderate the depreciation of the Canadian dollar. This appears to be consistent with the Bank's policies at least during the 1980's. Consequently, a depreciation of the dollar, with the U.S. interest rate constant, allows the Bank to lower Canadian interest rates.

Table 3.27: Estimated Multipliers for the Macroeconomic Variables Given a Ten Percent Devaluation of the Canadian Dollar

	Impact	Average	Final
		(percentage changes)	
Variable			
Canadian Interest Rate[1/]	-1.72	-1.54	-1.23
Forward Exchange Rate	9.23	9.40	9.50
Canadian CPI	0.39	2.72	3.00
Canadian WPI	2.63	3.70	3.73
Disposable Income (nominal)	-0.02	3.69	4.79
Wage Rate (nominal)	0.39	2.72	3.00
Spot Exchange Rate	10.00	10.00	10.00

1/ Percentage points.

3.12 SUMMARY

In this chapter the estimation results for the behavioral equations in the model have been presented. Although difficulties were encountered in the specification and estimation of some equations, in general, the results conformed with economic theory and the evidence provided by other researchers. In the next chapter the results of validating a dynamic historical simulation of the model are presented.

CHAPTER FOUR

VALIDATION OF THE MODEL

The single equations estimated in Chapter 3 were accepted or rejected on the basis of a set of statistical tests (eg. t-statistics, R^2, SER, etc.). The decision to accept or reject an equation is often not easy and ultimately depends upon the purpose for which the equation is being estimated. For example, models estimated for forecasting should have small standard errors, while those used for evaluating alternative policy scenarios or calculating structural elasticities should be specified to be consistent with economic theory. Once these equations have been put together to form a multi-equation model, a similar evaluation procedure is necessary to test the properties of the entire model. This chapter presents a number of different statistics which cover various aspects of model evaluation.

A major problem in validating a multi-equation model is that no specific criteria or benchmarks exist with which to accept or reject a validation statistic. The criteria are left to the modeler and therefore can be quite arbitrary. As in single equation estimation, the decision to accept a model as satisfactory depends upon the intended use of the model. Models designed for ex-ante forecasting are typically put through more rigorous tests than those developed for evaluating alternative policy scenarios.

In this chapter seven sets of validation statistics are presented. These cover various aspects of the model's ability to reproduce actual data and to respond to economic stimuli in a manner consistent with both economic theory and empirical observation. The validation statistics include;

1. Root Mean Square Percentage Error (RMSPE).
2. Mean Squared Error (MSE).
3. Theil's U-statistic.
4. The regression of actual data on simulated data.
5. Validation through turning point analysis.
6. Graphical validation.
7. Validation through exogenous shocks.

The validation statistics presented below are based on a simulation period from the 1st quarter of 1972 through the 4th quarter of 1980. This nine year dynamic simulation provides a stringent test of the model's ability to track cyclical behaviour. The model that is validated contains both the macro linkages and the grain price linkages, and is therefore more comprehensive than most other agricultural models. Coleman (1984) has shown that endogenizing these additional variables has little impact on the validation results of the model. However, in making comparisons with models developed in previous research the more comprehensive nature of this model should be kept in mind.

4.1 VALIDATION USING THE ROOT MEAN SQUARE PERCENTAGE ERROR

The root mean square percentage error (RMSPE) statistic shows how well simulated values of endogenous variables correspond to their actual historical values. The RMSPE is defined as,

$$\text{RMSPE} = \sqrt{1/n \sum_{t=1}^{n} \left(\frac{A_t - P_t}{A_t} \right)^2}$$

where, A_t = the actual value of an endogenous variable;

P_t = the simulated value of an endogenous variable; and,

n = the number of periods in the simulation.

This statistic is useful in that it provides a single figure which measures the variation of the predicted value around the actual values of the endogenous variables. The statistic does however have two drawbacks. First, the RMSPE is an average which as a measure of central tendency can mask the true nature of the series which it represents. For example, a few very large errors can raise the RMSPE of a series that otherwise tracks very well. Second, in cases where the actual values are small (eg. net trade), small errors in absolute terms give rise to substantial errors in percentage terms. Here again, the RMSPE can misrepresent the performance of the model. The RMSPEs for all important endogenous variables are presented in table 4.1. The results for quantity variables tend to be better than to those for prices. This can be explained by the inelasticity of the supply and demand curves in which inaccuracies have a greater effect upon prices than quantities. The huge values for net trade (230.9 and 861.3 for beef and pork, respectively) reflect the fact that these variables are close to zero throughout much of the simulation period. Despite these values, the model performs reasonably well on the RMSPE criterion, with only four of the 44 RMSPEs exceeding 20 percent.

4.2 VALIDATION USING MEAN SQUARE ERROR

The mean square error (MSE) is similar to the RMSPE in that it

Table 4.1: Root-Mean Square Percentage Errors for a Dynamic Simulation 1972(1) to 1980(4)

Variable		RMSPE	Variable		RMSPE
Carcass Weight Beef	Can.	2.79	Feeder Calf Price	West	20.50
	U.S.	2.24		East	18.18
				U.S.	21.57
Disappearance of Beef	Can.	5.10	Price of Hogs	West	14.57
	U.S.	3.78		East	12.10
				Can.	12.90
				U.S.	16.60
Disappearance of Pork	Can.	4.85	Price of Steers	West	13.57
	U.S.	6.31		East	11.59
				Can.	12.64
				U.S.	12.75
Cow and Bull Slaughter	West	15.08	Retail Price of Beef	Can.	14.33
	East	14.98		U.S.	10.43
	U.S.	16.49			
Heifer and Steer Slaughter	Can.	7.73	Retail Price of Pork	Can.	6.12
	U.S.	4.13		U.S.	8.94
Cow and Bull Inventory[a/]	West	5.76	Production of Beef	Can.	6.44
	East	2.68		U.S.	4.10
	U.S.	3.42			
Closing Stocks of Beef	Can.	10.49	Production of Pork	West	7.23
	U.S.	14.36		East	3.53
				U.S.	6.34
Closing Stocks of Pork	Can.	15.24	Consumer Price Index	Can.	1.57
	U.S.	13.19			
Net Trade Beef (Canada/U.S.)		230.91	Wholesale Price Index	Can.	4.50
Net Trade Pork (Canada/U.S.)		861.28	Price of Corn	Can.	6.46
			Price of Barley	Can.	9.08

a/ Based on annual data.

measures the mean of the squared difference between actual and simulated variables. It can be defined in terms of differences in the levels of variables (equation 4.1) or in terms of differences in percentage changes (equation 4.2).

4.1 $$MSEL = 1/n \sum_{t=1}^{n} (P_t - A_t)^2$$

4.2 $$MSEP = 1/n \sum_{t=1}^{n} (p_t - a_t)^2 \quad \text{where,}$$

$$p_t = \frac{P_t - A_{t-1}}{A_{t-1}} \quad \text{and} \quad a_t = \frac{A_t - A_{t-1}}{A_{t-1}}$$

Since the MSEL will depend on the units in which the variable is measured the MSEP is more useful in providing comparisons of forecasting accuracy for variables measured in different units. The major usefulness of this statistic is that it can be broken down into separate components to reveal the sources of discrepancy between actual and simulated values. Two methods in which the MSE can be decomposed have been described.

Theil (1966) suggests that the MSE should be broken down into its bias, variance and covariance components and these are derived as follows,

$$\begin{aligned} MSE &= (\bar{P} - \bar{A})^2 + S_{p-a}^2 , \\ &= (\bar{P} - \bar{A})^2 + S_p^2 + S_a^2 - 2rS_pS_a , \\ &= (\bar{P} - \bar{A})^2 + (S_p - S_a)^2 + 2(1-r)S_pS_a , \\ 1 &= \frac{(\bar{P} - \bar{A})^2}{MSE} + \frac{(S_p - S_a)^2}{MSE} + \frac{2(1-r)S_pS_a}{MSE} . \end{aligned}$$

where, $\bar{P}$ = the mean of the simulated data,

$\bar{A}$ = the mean of the actual data,

S_p = the variance of the simulated data,

S_a = the variance of the actual data,

r = the correlation coefficient between the simulated and actual data.

Theil defines $\frac{(\bar{P} - \bar{A})^2}{MSE}$ as the bias component (U^b),

$\frac{(S_p - S_a)^2}{MSE}$ as the variance component (U^v), and

$\frac{2(1-r)S_pS_a}{MSE}$ as the covariance component (U^c).

Note that $U^b + U^v + U^c = 1$.

The bias component shows whether the simulated values tend to be higher or lower than the actual values, while the variance component indicates to what extent the MSE is influenced by the variance of the actual and simulated values. The covariance component measures the unsystematic error (ie. that which remains after errors in average values and average variabilities have been accounted for).

Maddala (1977) argues however, that there is no a priori reason to insist that the variances of actual and simulated data should be equal and suggests that a decomposition into bias, regression and disturbance terms is more illuminating. These are derived as follows,

$$\begin{aligned} MSE &= (\bar{P} - \bar{A})^2 + S_{p-a}^2 , \\ &= (\bar{P} - \bar{A})^2 + S_p^2 + S_a^2 - 2rS_pS_a , \\ &= (\bar{P} - \bar{A})^2 + (S_p - rS_a)^2 + (1-r^2)S_a^2 , \\ &= (\bar{P} - \bar{A})^2 + (S_p - rS_a)^2 + (1-r^2)S_a^2 . \end{aligned}$$

Maddala defines $\frac{(\bar{P} - \bar{A})^2}{MSE}$ as the bias component (U^b),

$\frac{(S_p - rS_a)^2}{MSE}$ as the regression component (U^r), and

$\frac{(1-r^2)S_a^2}{MSE}$ as the disturbance component (U^d).

Note again that $U^b + U^r + U^d = 1$

Maddala describes the benefits of this approach using the regression of actual on simulated values as follows,

$$A_t = a + b * P_t$$

A perfect forecast yields a = 0 (U^b = 0) and b = 1 (U^r = 0). Figure 4.1 shows a regression line between actual and simulated values in which the 45° line represents a perfect forecast ($A_t = P_t$). The error in the intercept (a = 0) is accounted for by U^b while the error in the slope is accounted for by U^r. The U^d represents unsystematic errors, derived from random disturbances that are contained within the actual data series. Since they are random and cannot be explained or modeled, the forecast cannot be expected to capture these disturbances. Given that a perfect forecast yields U^b = 0 and U^r = 0 the validation statistics presented in table 4.2 improve as,

$U^b \rightarrow 0$

$U^v \rightarrow 0$ $U^r \rightarrow 0$

$U^c \rightarrow 1$ $U^d \rightarrow 1$

The results suggest that the model performs satisfactorily on the MSE criterion. The results for the beef variables include an average for U^b equal to 10.7 percent (5.1 percent excluding the three cow and bull inventory equations), U^v equal to 8.9 percent and U^c equal to 80.1 percent. Corresponding results in MacAulay (1976) are 1.96, 10.22 and 87.78 percent and in Haack (1978) 13.50, 10.62 and 75.88 percent. This suggests that on the mean square error criterion the model outlined in this study performs less well than MacAulay's and equally as well as Haack's. The results for the pork variables include an average U^b equal to 2.9 percent, U^v equal to 8.7 percent and U^c equal to 89.4 percent. These are very similar to the 1.9, 10.0 and 88.0 percent obtained by Zwart (1974).

4.3 VALIDATION USING THEIL'S U-STATISTIC

A useful statistic related to both RMSPE and the MSE is Theil's inequality coefficient. Theil's inequality statistic has been defined in numerous ways by different analysts. In this study the definition favored by Leuthold (1975) is used (equation 4.3).

$$4.3 \qquad \sqrt{\frac{1/n \sum_{t=1}^{n} ((P_t - A_{t-1}) - (A_t - A_{t-1}))^2}{1/n \sum_{t=1}^{n} (A_t - A_{t-1})^2}}$$

Figure 4.1: The Regression of Actual Against Simulated Values

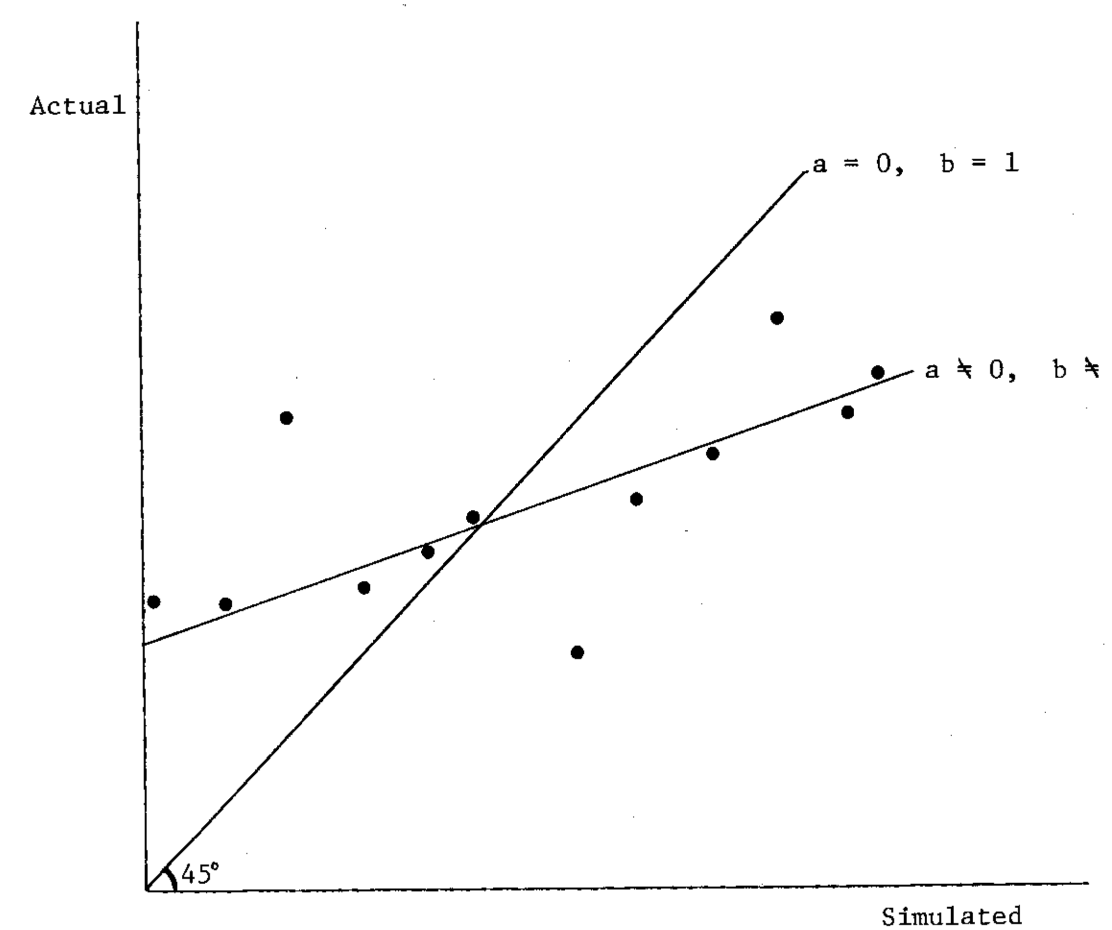


Table 4.2: Mean-Square Error and its Decompositions for a Dynamic Simulation 1972(1) to 1980(4)

		MSEP	MSEL a/	U_b	U_r	U_c	U_r	U_d
Carcass Weight	Can.	0.1	267.0	0.21	0.11	0.68	0.49	0.30
	U.S.	*	196.6	0.08	0.12	0.79	0.50	0.41
Disappearance of Beef	Can.	0.3	707.8	0.07	0.03	0.90	0.33	0.60
	U.S.	0.1	61234.3	0.12	0.03	0.84	0.26	0.62
Disappearance of Pork	Can.	0.2	254.8	0.01	0.00	0.98	0.22	0.77
	U.S.	0.4	45943.3	0.00	0.07	0.93	0.34	0.66
Cow and Bull Slaughter	West	2.3	196.5	0.00	0.00	0.99	0.08	0.91
	East	2.3	140.6	0.00	0.08	0.91	0.32	0.68
	U.S.	2.8	146201.0	0.02	0.18	0.80	0.50	0.47
Heifer and Steer Slaughter	Can.	0.6	2358.2	0.00	0.03	0.96	0.44	0.56
	U.S.	0.2	87827.9	0.01	0.00	0.98	0.21	0.78
Cow and Bull Inventory b/	West	0.3	42059.4	0.39	0.04	0.57	0.02	0.59
	East	0.1	3309.3	0.18	0.00	0.82	0.06	0.76
	U.S.	7.2	1.27E08	0.98	0.00	0.02	0.01	0.01
Closing Stocks of Beef	Can.	1.1	54.2	0.08	0.00	0.92	0.08	0.84
	U.S.	1.7	1973.4	0.01	0.07	0.92	0.27	0.71
Closing Stocks of Pork	Can.	2.7	17.4	0.00	0.01	0.99	0.17	0.83
	U.S.	1.9	1018.4	0.02	0.03	0.95	0.16	0.82
Net Trade Beef (Canada/U.S.)		560.5	371.8	0.00	0.32	0.67	0.77	0.23
Net Trade Pork (Canada/U.S.)		11035.7	461.6	0.02	0.31	0.66	0.72	0.26
Price of Feeder Calves	West	4.3	112.7	0.05	0.09	0.85	0.51	0.44
	East	3.5	96.9	0.02	0.15	0.82	0.60	0.37
	U.S.	5.0	121.6	0.02	0.28	0.70	0.71	0.27
Price of Hogs	West	2.2	61.3	0.03	0.10	0.87	0.44	0.53
	East	1.5	46.4	0.04	0.07	0.89	0.38	0.58
	U.S.	2.7	40.7	0.02	0.08	0.90	0.42	0.56
Price of Steers	West	2.0	37.5	0.03	0.10	0.87	0.52	0.45
	East	1.4	31.1	0.03	0.07	0.90	0.46	0.51
	U.S.	1.7	29.8	0.04	0.04	0.92	0.39	0.57

Table 4.2 continued

		MSEP	MSEL a/	U_b	U_r	U_c	U_r	U_d
Retail Price of Beef	Can.	2.1	403.2	0.09	0.17	0.74	0.64	0.27
	U.S.	1.1	224.1	0.07	0.14	0.79	0.60	0.33
Retail Price of Pork	Can.	0.4	149.9	0.02	0.09	0.89	0.42	0.56
	U.S.	0.8	130.8	0.03	0.11	0.86	0.51	0.46
Production of Beef	Can.	0.4	959.7	0.05	0.12	0.83	0.58	0.37
	U.S.	0.2	62988.5	0.12	0.06	0.83	0.31	0.57
Production of Pork	West	0.5	62.6	0.00	0.05	0.95	0.25	0.75
	East	0.1	45.8	0.07	0.03	0.90	0.14	0.79
	U.S.	0.4	46893.7	0.00	0.03	0.97	0.21	0.79
Consumer Price Index	Can.	0.0	6.4	0.62	0.04	0.33	0.20	0.18
Wholesale Price Index	Can.	0.2	579.5	0.68	0.05	0.27	0.19	0.13
Price of Corn	East	0.4	35.7	0.00	0.03	0.97	0.01	0.99
Price of Barley	West	0.9	59.0	0.02	0.00	0.97	0.18	0.79

a/ The decompositions are for MSEL.
b/ Based on annual data.

$$\sqrt{\frac{1/n \sum_{t=1}^{n} (P_t - A_t)^2}{1/n \sum_{t=1}^{n} (A_t - A_{t-1})^2}}$$

With this definition of U a value of zero indicates a perfect forecast while U=1 indicates a prediction performance the same as no-change extrapolation.

U statistics are provided in table 4.3 for the endogenous variables in the validation model. It is not clear whether these results indicate that the model validates well since there is no upper limit or benchmark for this statistic to aid in the interpretation of the values obtained. It is possible however, to compare the results with Theil-U statistics reported in previous studies. These do not provide benchmarks with which to accept or reject the current model, but do indicate whether the model performs better or worse than models deemed acceptable elsewhere. In the current study 64 percent of the beef variables have a Theil-U greater than one which can be compared with the 65 percent obtained by MacAulay. This result suggests that the model validates about the same on the Theil-U criterion. However, when many variables show strong trends rather than cyclical patterns a no-change estimate may often predict better than one generated by a model. For the pork variables in the model, 30.8 percent are greater than one, which can be compared with the 41 percent reported by Pieri, Meilke and MacAulay (1977).

4.4 VALIDATION BY REGRESSING ACTUAL VALUES ON SIMULATED VALUES

A further validation measure can be obtained by regressing the actual values of the endogenous variables against the simulated values. The regression takes the form:

$$\text{Actual value} = a + b * \text{Simulated value}$$

For a perfect forecast in which actual values are identical to simulated values, $a = 0$, $b = 1$ and the $R^2 = 1$. In table 4.4 the F-statistic to test the joint hypothesis of $a = 0$ and $b = 1$, as well as the individual t-tests of $a = 0$ and $b = 1$ are presented along with the R^2. The results show that 16 out of the 25 (or 65.0 percent) beef variables have an R^2 of more than 0.70. This can be compared to the 76 percent and 62 percent reported by MacAulay and Haack, respectively. The hypothesis, $b = 1$ is accepted for 72 percent of the beef variables. Similar tests reported by MacAulay and Haack show the hypothesis is accepted for 34 and 62 percent of variables, respectively. Meanwhile, the hypothesis $a = 0$, is accepted for 76 percent of beef variables in this study, for 34 percent of variables in MacAulay and for 57 percent of variables in

Table 4.3: Theil U-Statistics for a Dynamic Simulation 1972(1) to 1980(4)

Carcass Weight Beef	Can.	1.66	Feeder Calf Price	West	1.32
	U.S.	1.31		East	1.45
				U.S.	1.66
Disappearance of Beef	Can.	1.06	Price of Hogs	West	1.06
	U.S.	0.90		East	0.97
				Can.	1.00
				U.S.	1.05
Disappearance of Pork	Can.	0.86	Price of Steers	West	1.27
	U.S.	0.85		East	1.16
				Can.	1.23
				U.S.	1.10
Cow and Bull Slaughter	West	0.48	Retail Price of Beef	Can.	1.65
	East	0.73		U.S.	1.50
	U.S.	1.04			
Heifer and Steer Slaughter	Can.	1.21	Retail Price of Pork	Can.	0.94
	U.S.	0.85		U.S.	1.22
Cow and Bull Inventory[a/]	West	0.99	Production of Beef	Can.	1.52
	East	0.53		U.S.	0.94
	U.S.	5.25			
Closing Stocks of Pork	Can.	0.64	Production of Pork	West	0.66
	U.S.	0.53		East	0.46
				U.S.	0.65
Net Trade Beef (Canada/U.S.)		1.87	Consumer Price Index	Can.	0.72
Net Trade Pork (Canada/U.S.)		1.66	Wholeale Price Index	Can.	1.53
			Corn Price	East	0.46
			Barley Price	West	0.89

a/ Based on annual data.

Table 4.4: Regression of Actual Values on Simulated Values from a Dynamic Validation 1972(1) to 1980(4)

		R^2	t-values[a/] b=1	t-values[a/] a=0	F-value[b/] a=0 and b=1
Carcass Weight	Can.	0.42	0.84	0.92	4.92
	U.S.	0.53	0.41	-0.37	1.58
Disappearance of Beef	Can.	0.81	4.41	-4.29	11.79
	U.S.	0.75	2.39	-2.28	5.58
Disappearance of Pork	Can.	0.91	4.39	-4.44	9.89
	U.S.	0.74	-2.13	2.14	2.29
Cow and Bull Slaughter	West	0.75	1.41	-1.30	1.06
	East	0.45	-0.93	0.89	0.45
	U.S.	0.63	0.42	-0.23	0.48
Heifer and Steer Slaughter	Can.	0.45	-1.83	1.83	1.68
	U.S.	0.57	0.33	0.36	0.27
Cow and Bull Inventory[c/]	West	0.83	2.63	-2.73	7.84
	East	0.98	2.88	-3.02	5.82
	U.S.	0.71	1.04	-1.68	169.0
Closing Stocks of Beef	Can.	0.82	2.18	-1.83	3.97
	U.S.	0.57	1.16	-1.23	0.90
Closing Stocks of Pork	Can.	0.48	-0.63	0.60	0.21
	U.S.	0.64	-0.88	0.71	0.76
Net Trade Beef (Canada/U.S.)		0.04	-10.06	6.20	50.75
Net Trade Pork (Canada/U.S.)		0.70	7.07	-0.72	25.88
Price of Feeder Calves	West	0.85	1.45	-1.83	2.02
	East	0.79	-0.06	-0.21	0.42
	U.S.	0.74	-0.09	-0.17	0.36
Price of Hogs	West	0.72	-3.30	2.89	6.27
	East	0.75	-3.55	3.18	7.21
	U.S.	0.54	-3.40	3.12	6.27

Table 4.4 continued

		R^2	t-values[a/] b=1	t-values[a/] a=0	F-value[b/] a=0 and b=1
Price of Steers	West	0.84	-0.21	-0.04	0.50
	East	0.88	0.06	-0.32	0.53
	U.S.	0.78	-0.39	0.13	0.74
Retail Price of Beef	Can.	0.90	0.52	-1.04	1.75
	U.S.	0.88	-0.16	-0.20	1.23
Retail Price of Pork	Can.	0.94	-3.40	3.08	6.26
	U.S.	0.81	-3.94	3.62	8.48
Production of Beef	Can.	0.53	-0.08	0.18	0.85
	U.S.	0.75	2.43	-2.31	5.58
Production of Pork	West	0.88	0.13	0.10	0.02
	East	0.99	-2.23	2.61	3.98
	U.S.	0.75	1.64	1.64	1.35
Consumer Price Index	Can.	0.99	1.21	0.51	30.35
Wholesale Price Index	Can.	0.99	1.36	0.76	39.04
Corn Price	East	0.95	0.93	-0.95	0.45
Barley Price	West	0.92	2.19	-1.86	2.89

a/ The critical value for the t-test at a five percent level of significance is 2.04.

b/ The critical value for the F-test at a five percent level of significance is 3.28.

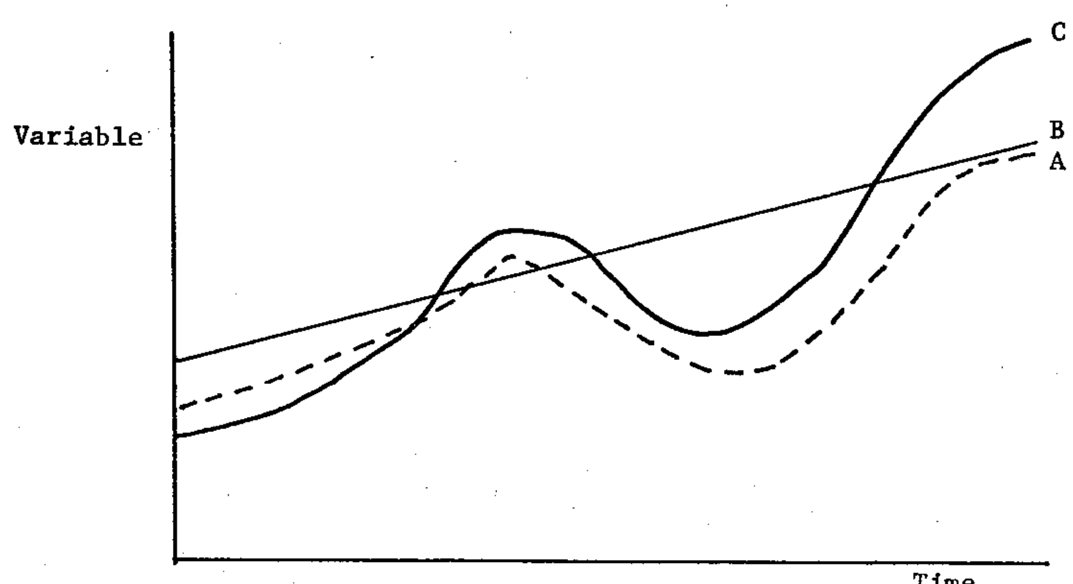
c/ Based on annual data.

Haack. The joint hypothesis that a = 0 and b = 1 is accepted for 64 percent of the beef variables. These results suggest that the model presented in this study performs better than some other beef models when validated by regressing actual on simulated values. The results for the pork variables are less acceptable than for the beef. They show that 70 percent of the variables have an R^2 greater than 0.70. However, the hypothesis b = 1 and a = 0 is accepted for only 38 percent of the variables. This method of validation appears in Pieri, Meilke and MacAulay but in their regression of actual on simulated values the intercept is constrained to equal zero and therefore does not permit a useful comparison for the current model.

4.5 VALIDATION THROUGH TURNING POINT ANALYSIS

The validation statistics so far have concentrated on the closeness of actual and simulated values. From these nothing can be said about the model's ability to capture turning points in the historical data. Consider figure 4.2 in which line A represents the actual values and lines B and C two sets of simulated values. Although B displays a lower RMSPE, most modelers would choose C because it is able to predict turning points in the historical data.

Figure 4.2: Validation Through Turning Point Analysis



Source: Pindyck and Rubinfeld, p. 364.

Cicarelli (1983) describes a statistic using probability analysis with which to quantify how well simulated values capture turning points in the historical data. The procedure is described below.

The simulated data are divided into instances where values increased between t-1 and t, (F+), and where they decreased (F-). The same process is carried out on the actual data giving (A+) and (A-), respectively. From these the number of directional changes correctly forecast (ie. (A+ | F+) plus (A- | F-)), can be determined as well as the number of directional errors (ie. (A- | F+) plus (A+ | F-)). These are referred to as conditional outcomes. Next, the number of forecasted increases (F+), and the number of forecasted decreases (F-), are divided by the total number of forecasts, (F+) + (F-). This gives the unconditional probability that a model predicted an increase P(F+), or a decrease P(F-). Next, each of the conditional outcomes is divided by the appropriate number of forecasts to give the conditional probability of an outcome. For example, (A+ | F+) divided by (F+) to give P(A+ | P+). The P(A+ | F+) therefore is the probability that a forecast increase actually occurred. Similarly, P(A- | F-) is the probability that a forecast decrease actually occurred while P(A+ | F-) and P(A- | F+) are the conditional probabilities of directional errors. The final step multiplies the conditional probabilities by the appropriate unconditional probability and their summation provides, P*, the probability that the model correctly predicted the directional change.

$$P^* = P(F+) * P(A+ \mid F+) + P(F-) * P(A- \mid F-)$$

Hence, P^* is the probability of correctly forecasting a directional change, while $1-P^*$ is the probability of directional error. Values for P* are presented for most endogenous variables in table 4.5. Again it is not clear whether these results are satisfactory as there is no benchmark with which to compare these probabilities. However, of the 38 beef and pork variables listed, 1 variable is between 50 and 59 percent; 11 variables are between 60 and 69 percent; 12 between 70 and 79 pecent; and, 13 between 80 and 89 percent. These suggest that[1/] the model captures turning points in the actual data reasonably well.

4.6 GRAPHICAL VALIDATION

A common method of validation involves examining plots of both actual and simulated values against time. Graphs for some of the endogenous variables are presented in figures 4.3 to 4.11. This provides visual evidence of how well the model tracks. It also may indi-

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1/ Turning point errors were also calculated using fourth-differences to eliminate seasonality from the data. The results of this analysis were similar to those obtained using first-differences.

Table 4.5: Probabilities of Correctly Forecasting Turning Points in a Dynamic Simulation 1972(1) to 1980(4)

Variable		P^*	Variable		P*
Carcass Weight Beef	Can.	0.63	Feeder Calf Price	West	0.69
	U.S.	0.57		East	0.68
				U.S.	0.80
Disappearance of Beef	Can.	0.88	Price of Hogs	West	0.77
	U.S.	0.64		East	0.74
				U.S.	0.69
Disappearance of Pork	Can.	0.71	Price of Steers	West	0.71
	U.S.	0.71		East	0.77
				U.S.	0.69
Cow and Bull Slaughter	West	0.88	Retail Price of Beef	Can.	0.71
	East	0.88		U.S.	0.69
	U.S.	0.86			
Heifer and Steer Slaughter	Can.	0.71	Retail Price of Pork	Can.	0.83
	U.S.	0.71		U.S.	0.71
Cow and Bull Inventory a/	West	0.63	Production of Beef	Can.	0.62
	East	0.88		U.S.	0.69
	U.S.	0.88			
Closing Stocks of Beef	Can.	0.80	Production of Pork	West	0.86
	U.S.	0.83		East	0.89
				U.S.	0.75
Closing Stocks of Pork	Can.	0.88	Consumer Price Index	Can.	1.0
	U.S.	0.74			
Net Trade Beef (Canada/U.S.)		0.71	Wholesale Price Index	Can.	0.89
Net Trade Pork (Canada/U.S.)		0.66	Corn Price	East	0.94
			Barley Price	West	0.89

a/ Based on annual data.

Figure 4.3: Simulated and Actual Values of Beef Production in Canada and the United States

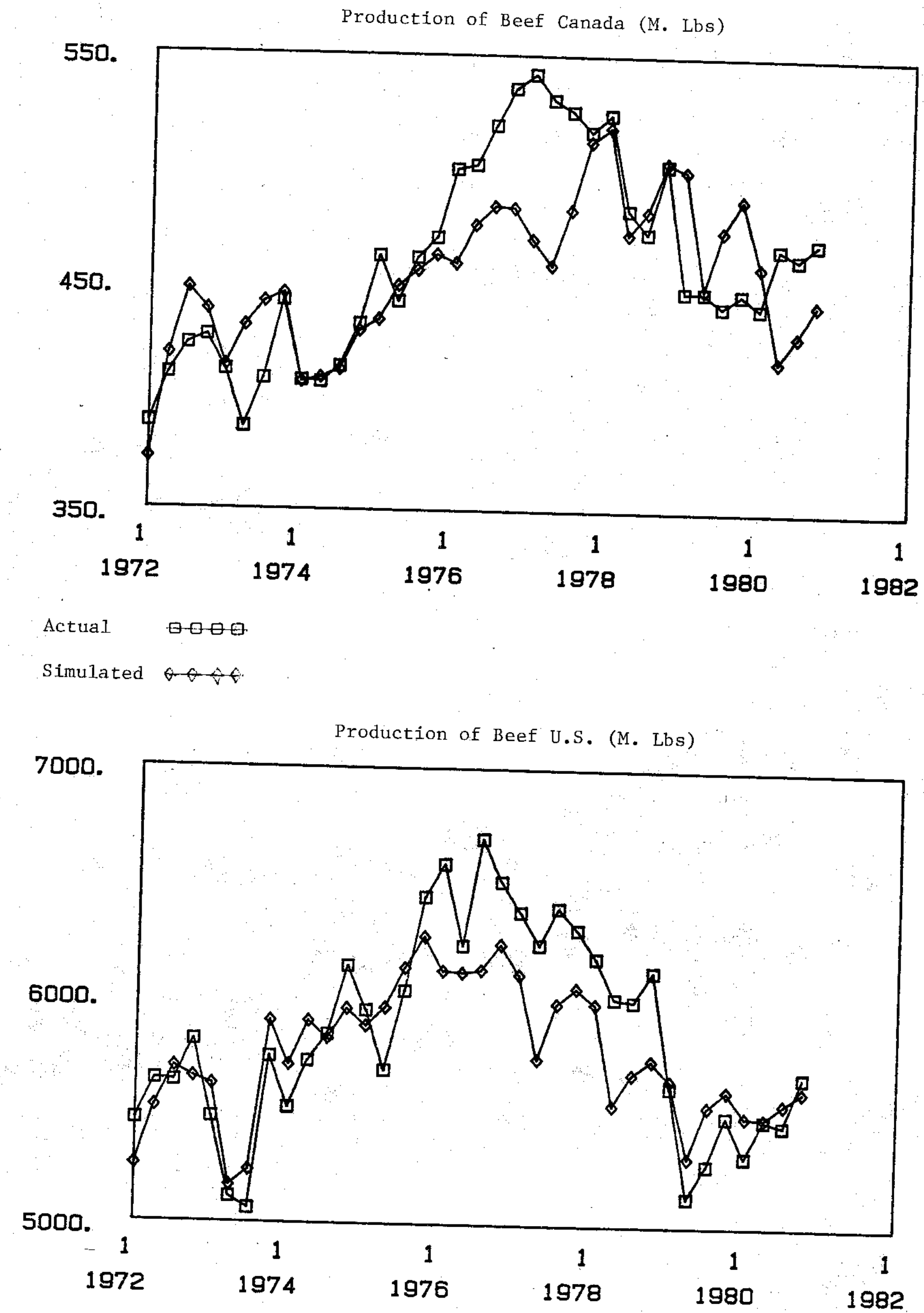


Figure 4.4 Simulated and Actual Values of Beef Disappearance in Canada and the United States

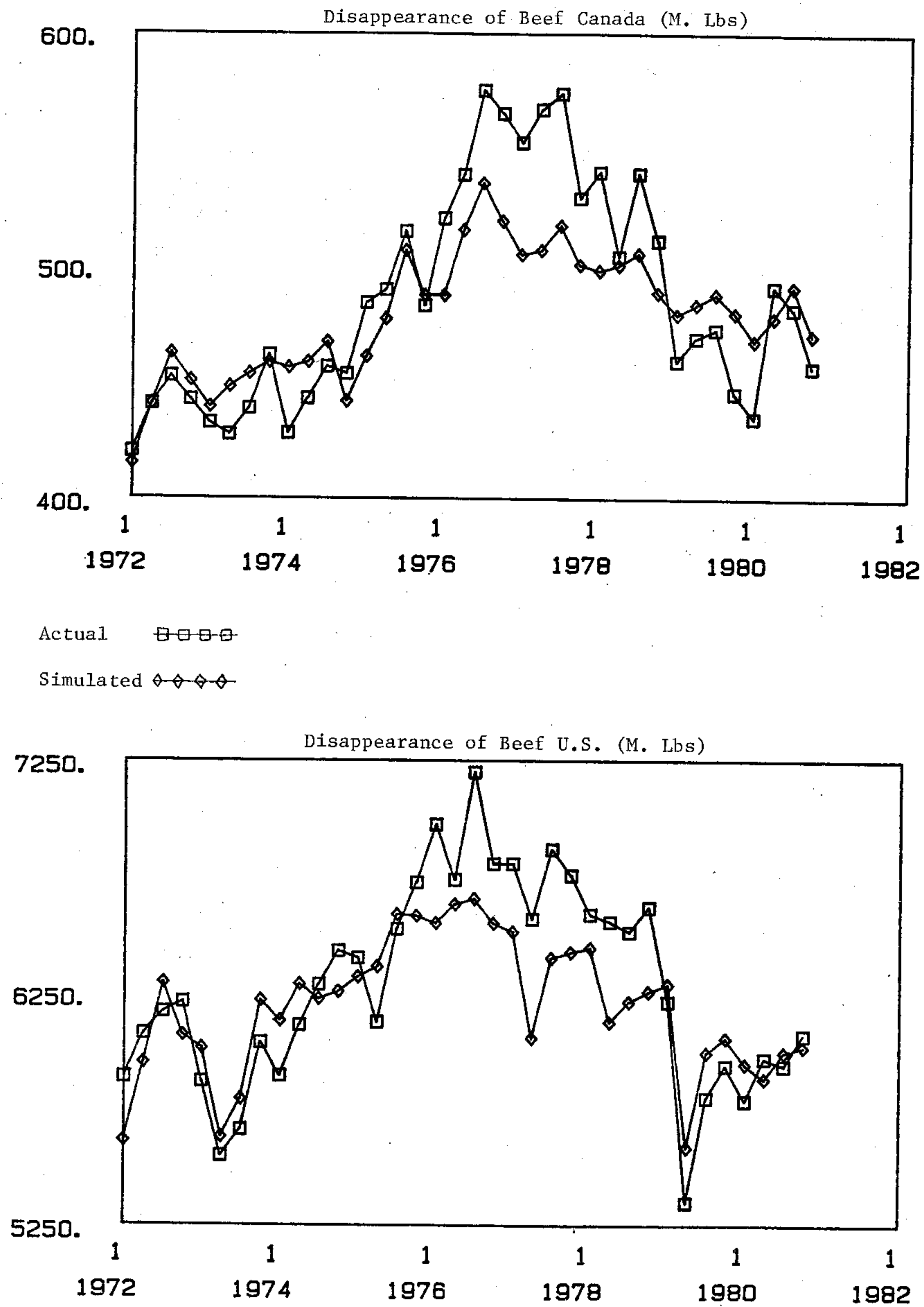


Figure 4.5: Simulated and Actual Values of Cow and Bull Inventories in Canada and the United States

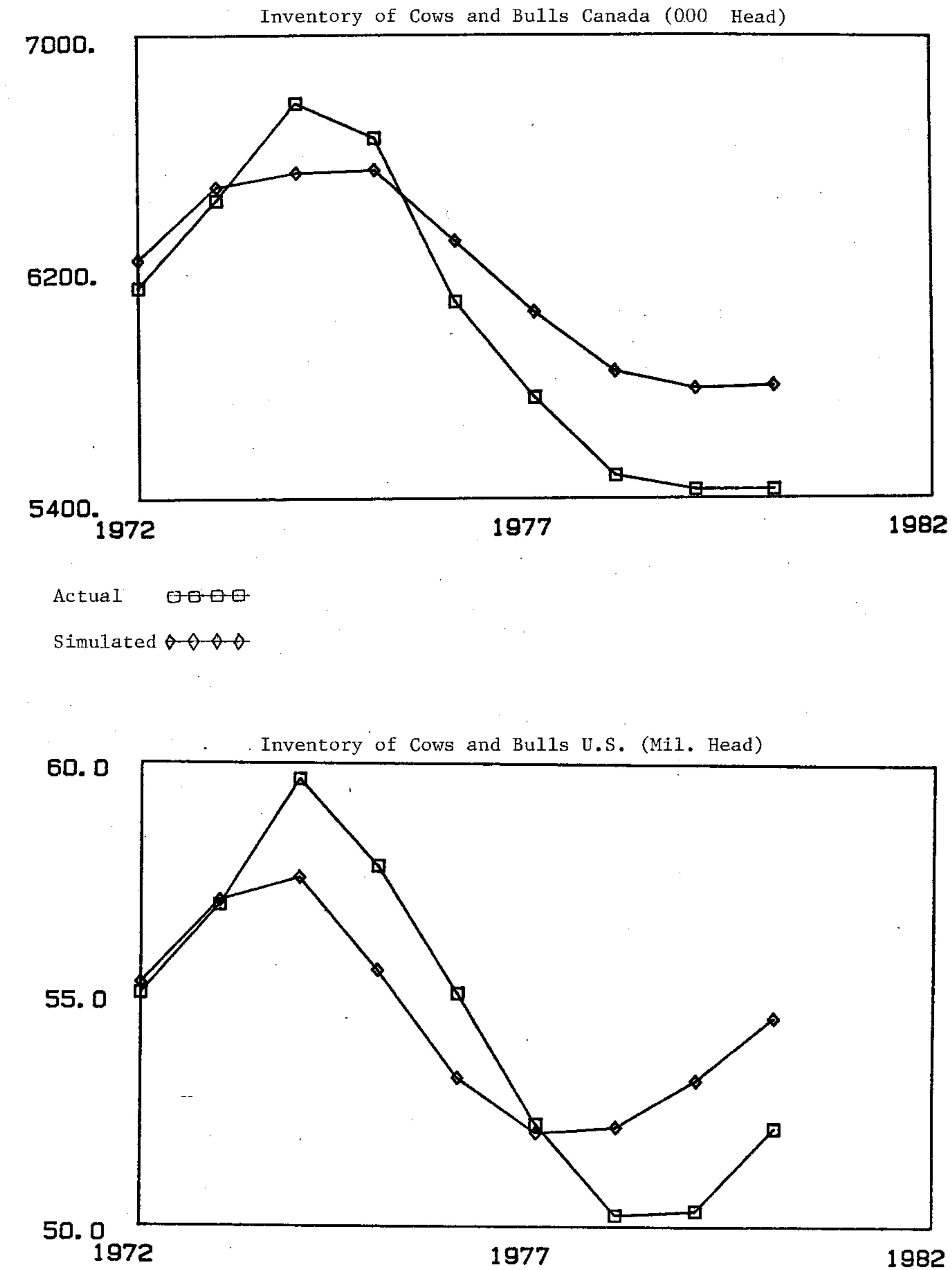


Figure 4.6: Simulated and Actual Values of Feeder Calf Prices in Western Canada and the United States

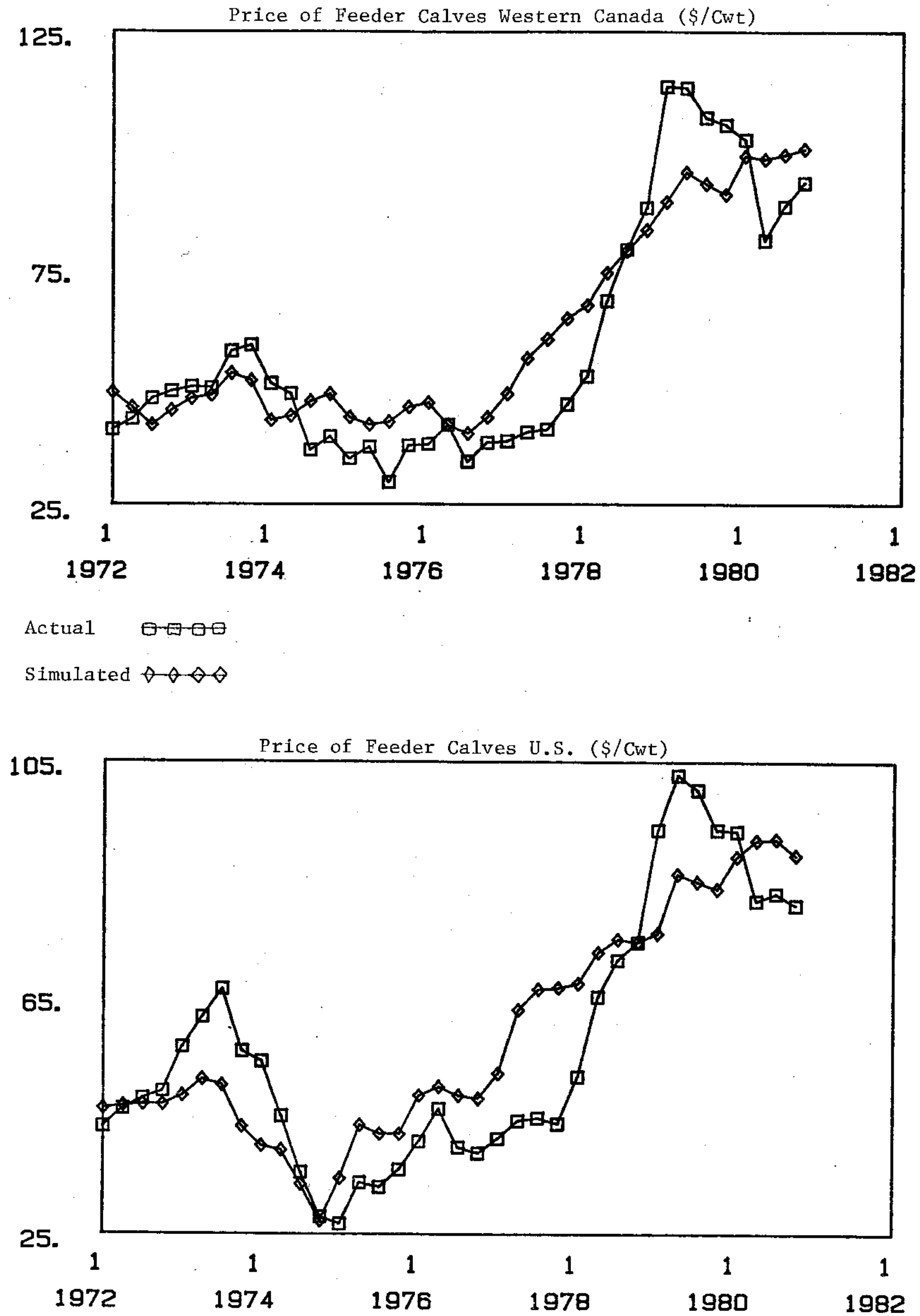


Figure 4.7: Simulated and Actual Values of Steer Prices in Canada and the United States

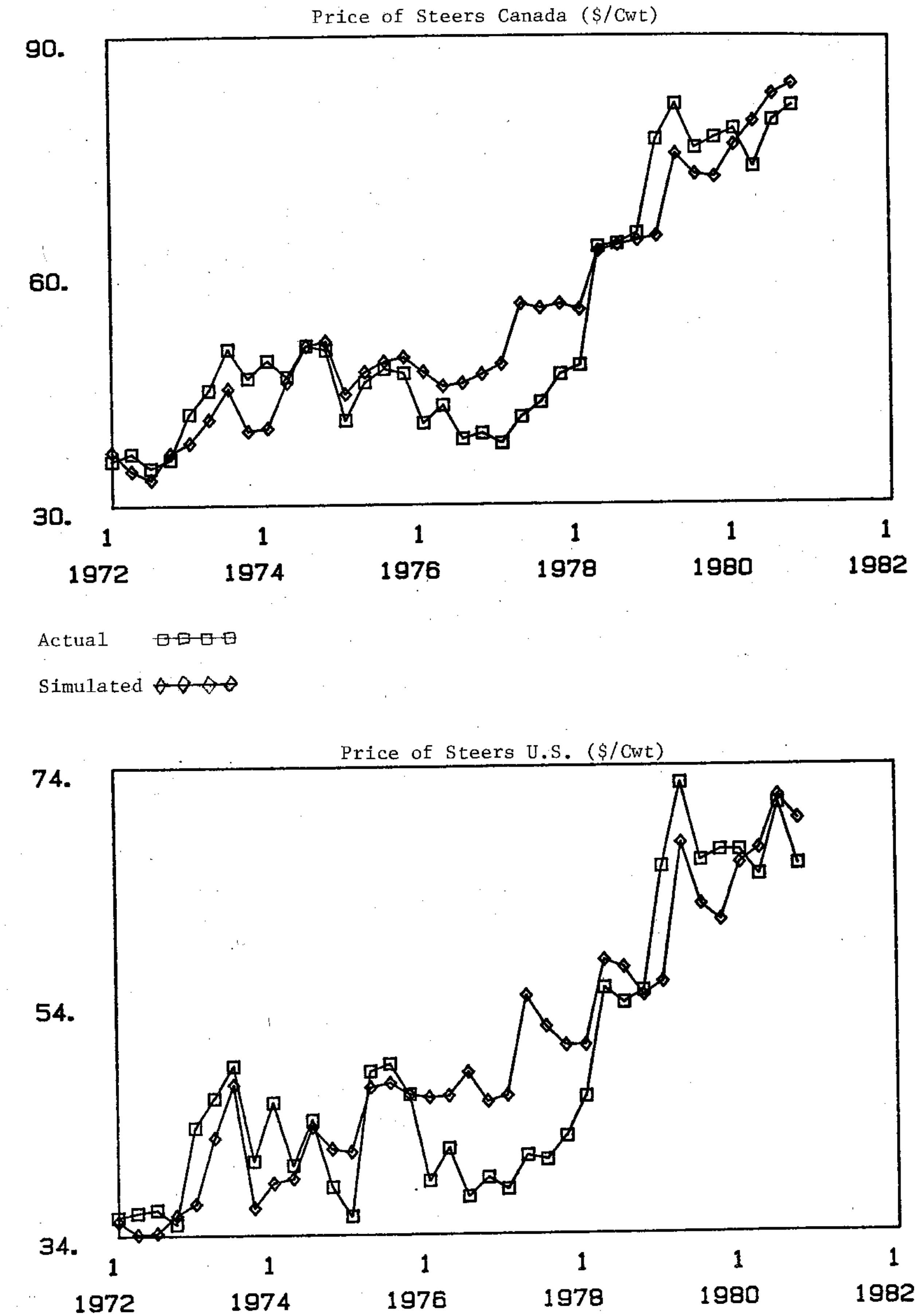
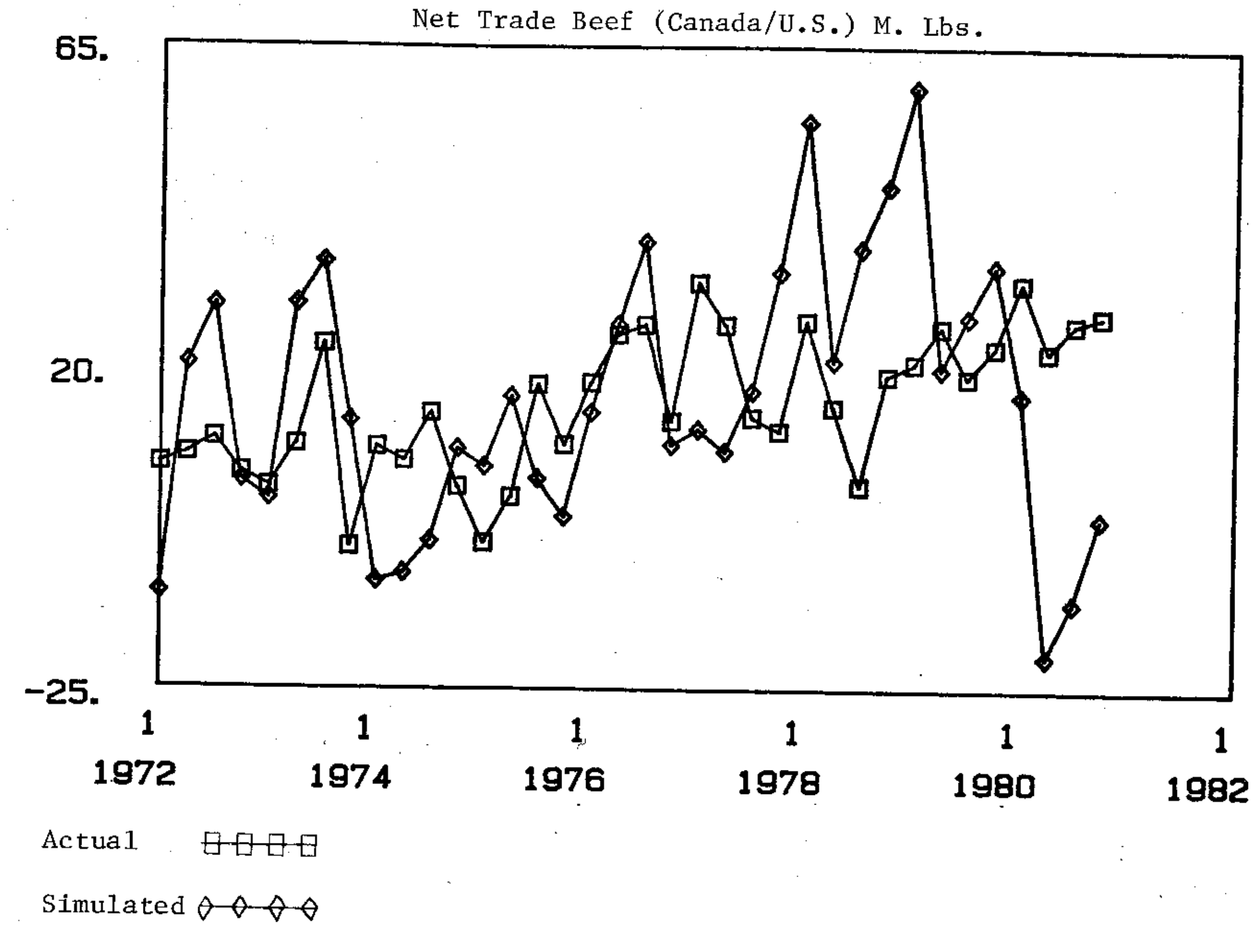


Figure 4.8: Simulated and Actual Values of Net Trade in Beef and Pork Between Canada and the United States



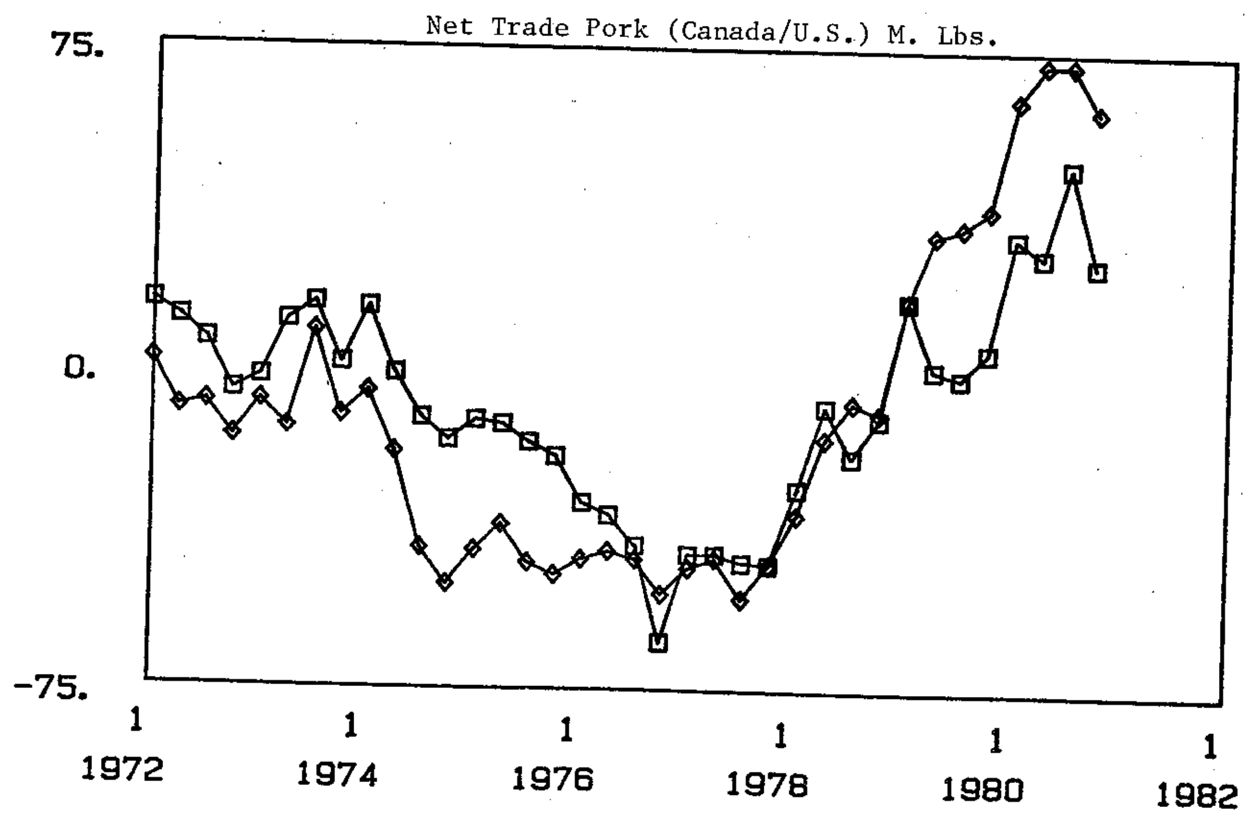
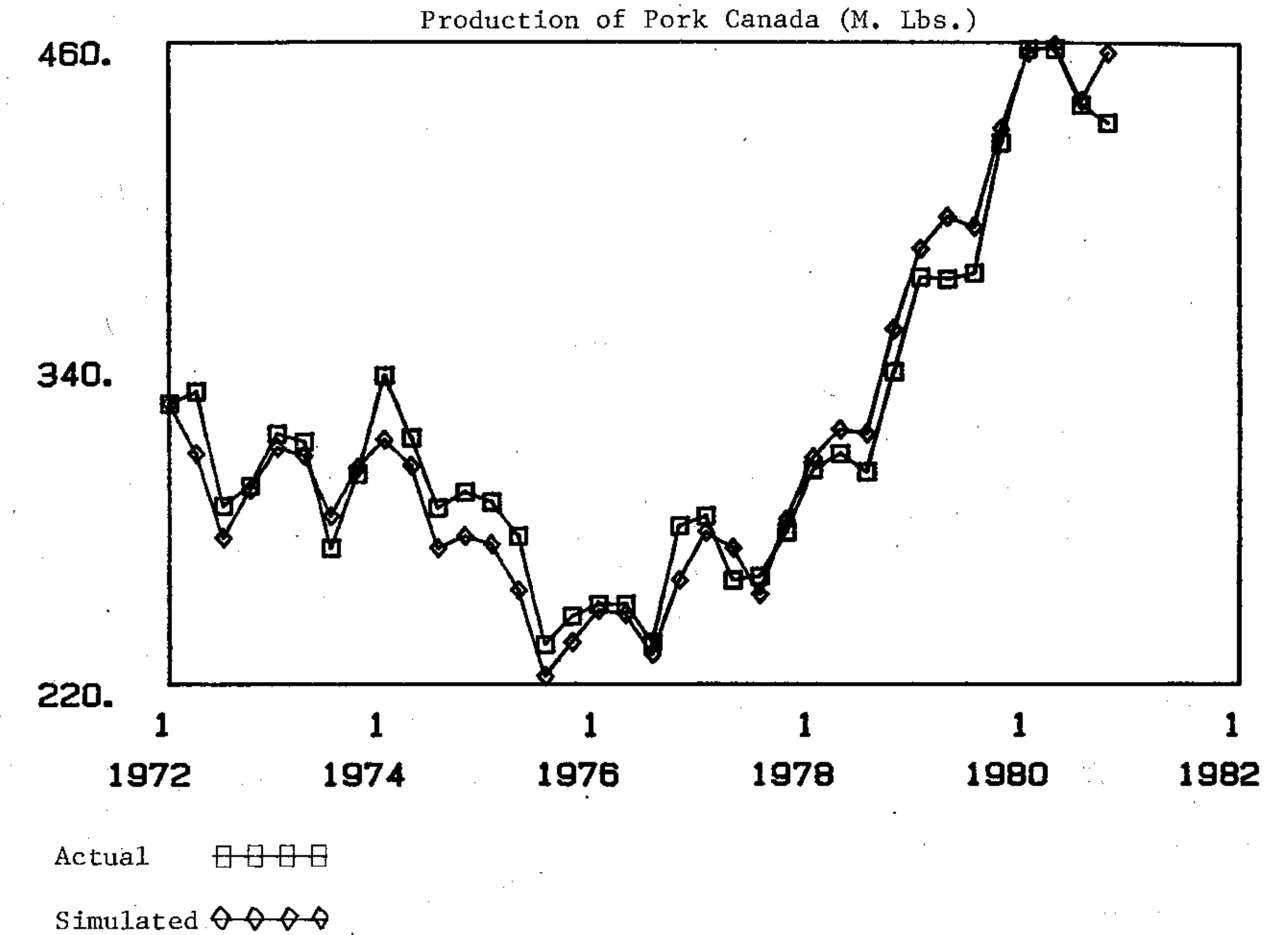


Figure 4.9: Simulated and Actual Values of Pork Production in Canada and the United States



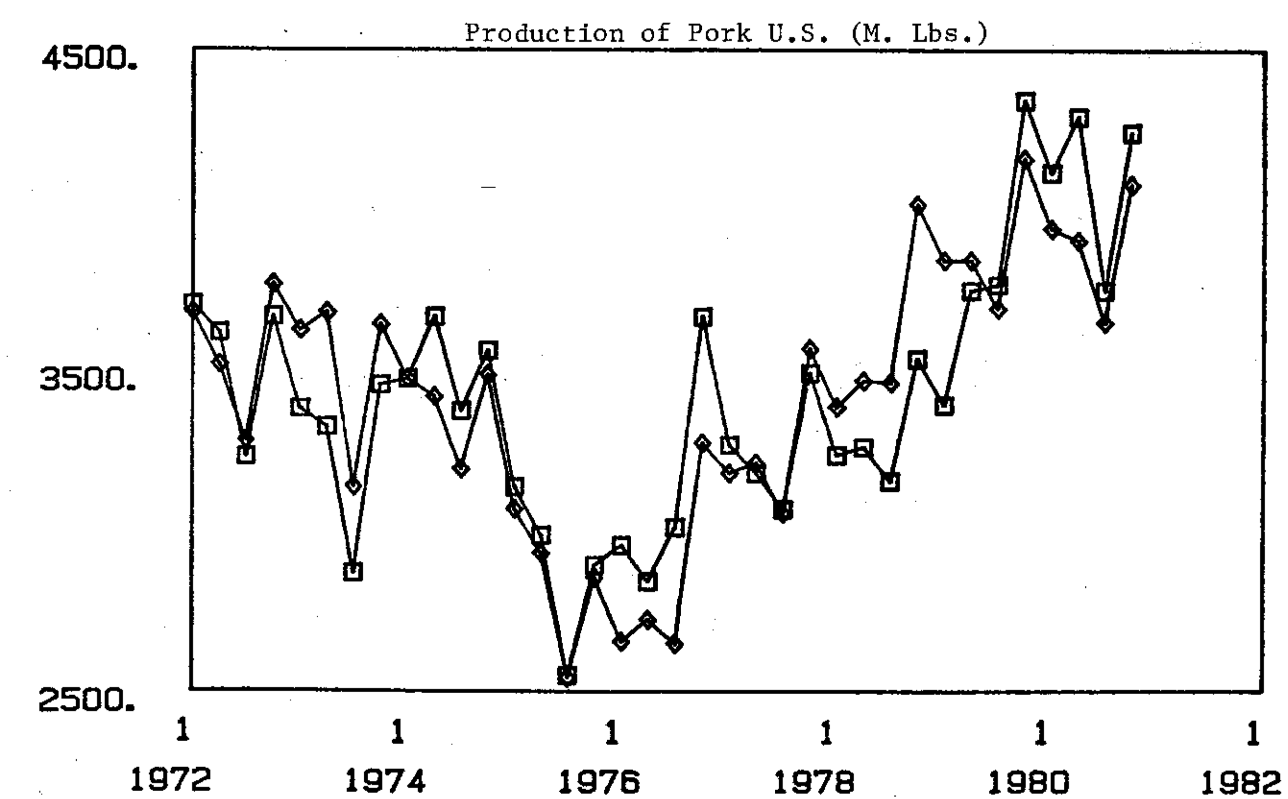


Figure 4.10: Simulated and Actual Values of Pork Disappearance in Canada and the United States

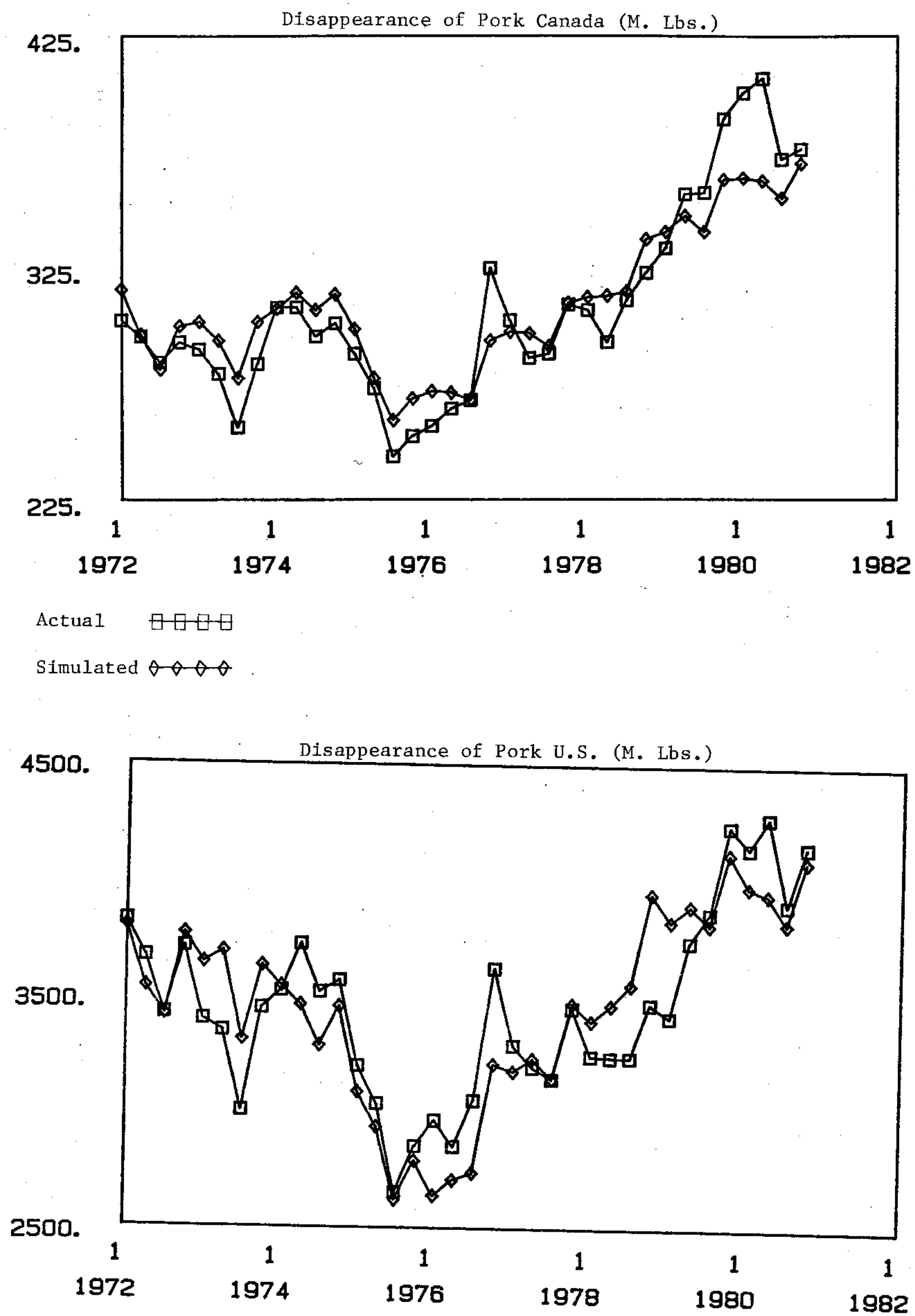
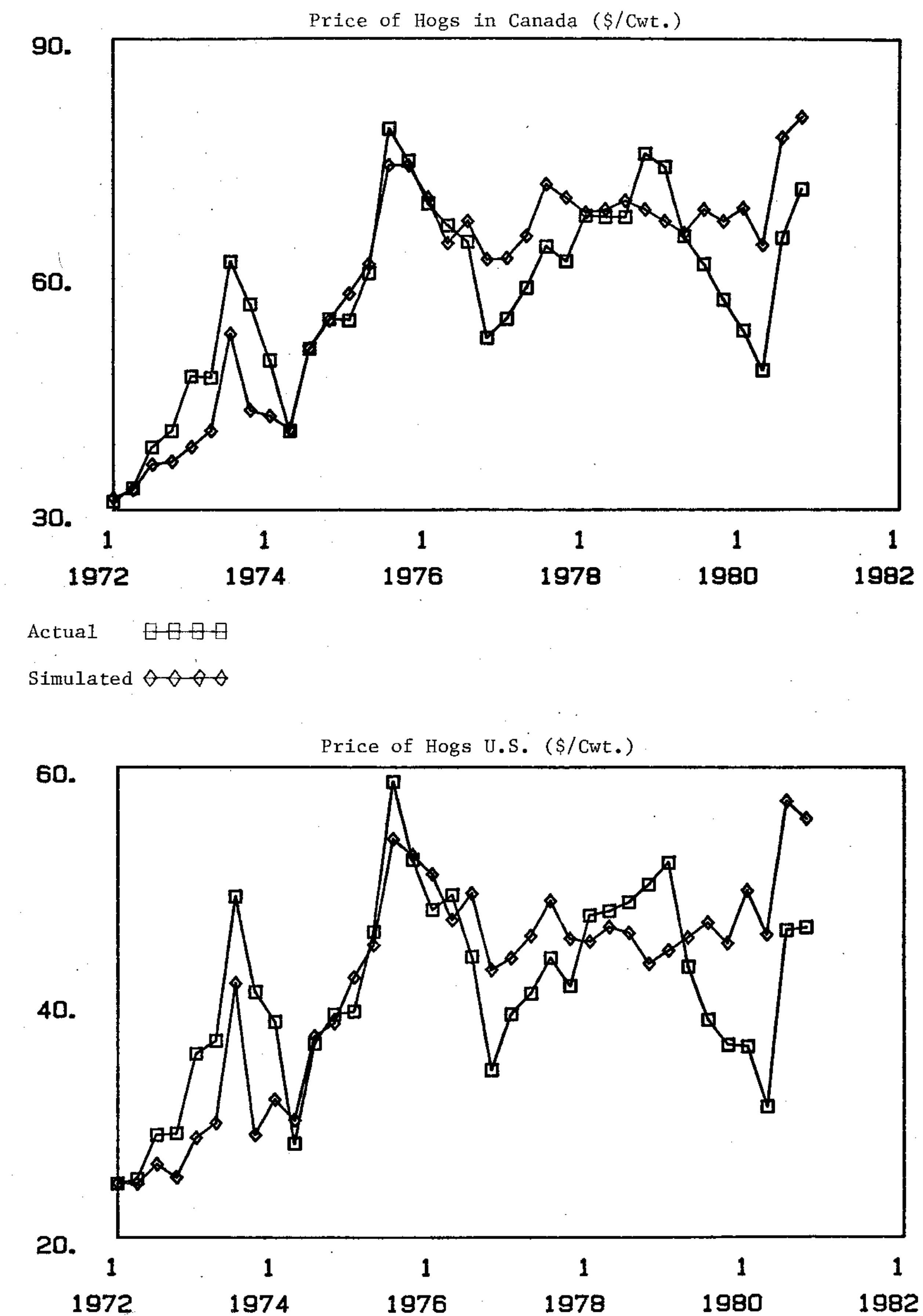


Figure 4.11: Simulated and Actual Values of Hog Prices in Canada and the United States



cate that some periods within the simulation track better than in others. For example, figure 4.8 shows the plots of actual and simulated values for net trade in beef. The figure indicates that the model fails to track in 1974 and at the end of the simulation period. This failure must be recognized, especially if the model is to be used for forecasting.

While providing an instantaneous and perhaps pleasing measure for the reader, graphical validation can be quite misleading. This is because the size of the difference between actual and simulated values, when portrayed graphically, depends entirely upon the scale of the graph. Hence the smaller the scale becomes the better the validations appear.

4.7 VALIDATION THROUGH EXOGENOUS SHOCKS

The model is primarily intended for the evaluation of various policy scenarios. These are evaluated against a base simulation and not actual values. Thus it can be argued that while the closeness of simulated to actual data is desirable, it is not of crucial importance. Perhaps more relevant to the purpose for which the model is constructed is to ensure that the model is stable and that the dynamics and responses to various shocks are consistent with both economic theory and prior knowledge of how the market operates.

In Coleman (1984) two types of shocks were applied, to an early version of this model, in order to observe the responses of the endogenous variables. The first type of shock involved a permanent increase in certain variables to see if the model responded in a manner consistent with economic theory and empirical observation. The second set of experiments involved a one period shock to certain variables in order to test for model stability in a situation where the effects of these shocks were expected to slowly diminish with time.

Since the results of Coleman's analysis showed that the model responded in a manner consistent with *a priori* expectations in all of the experiments conducted, a complete set of results are not given here. However, to give the reader some appreciation of the characteristics of the model the results of one experiment are presented. In this experiment (see figures 4.12 to 4.17) the U.S. beef cow and bull inventory equation is multiplied by ten percent. This results in an initial increase in U.S. inventories of ten percent, but since feedback is still allowed through the behavioral equation its value fluctuates throughout the simulation (see figure 4.12). The effects of increasing U.S. inventories are observed in both the U.S. and Canadian markets. The increase in U.S. inventories lowers the U.S. price and decreases Canadian exports of beef to the United States. Meanwhile Canadian prices follow the U.S. prices downward as determined by the price linkage equations. Lower Canadian steer prices produce lower feeder calf prices and inventory levels. The reductions in prices reduce Canadian

Figure 4.12: Impact of a 10 Percent Increase in Beef Cow and Bull Inventories in the U.S. on Canada and the United States

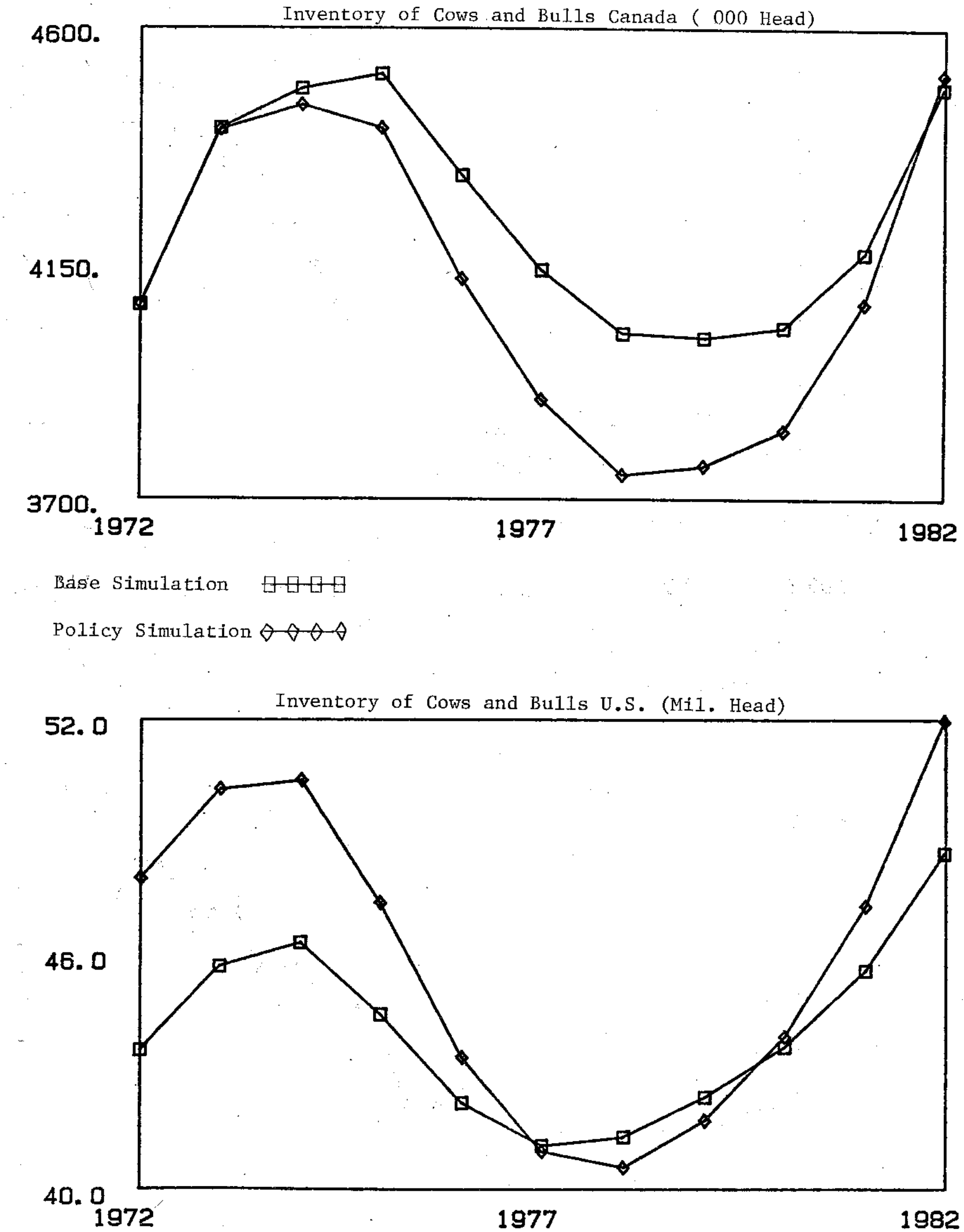
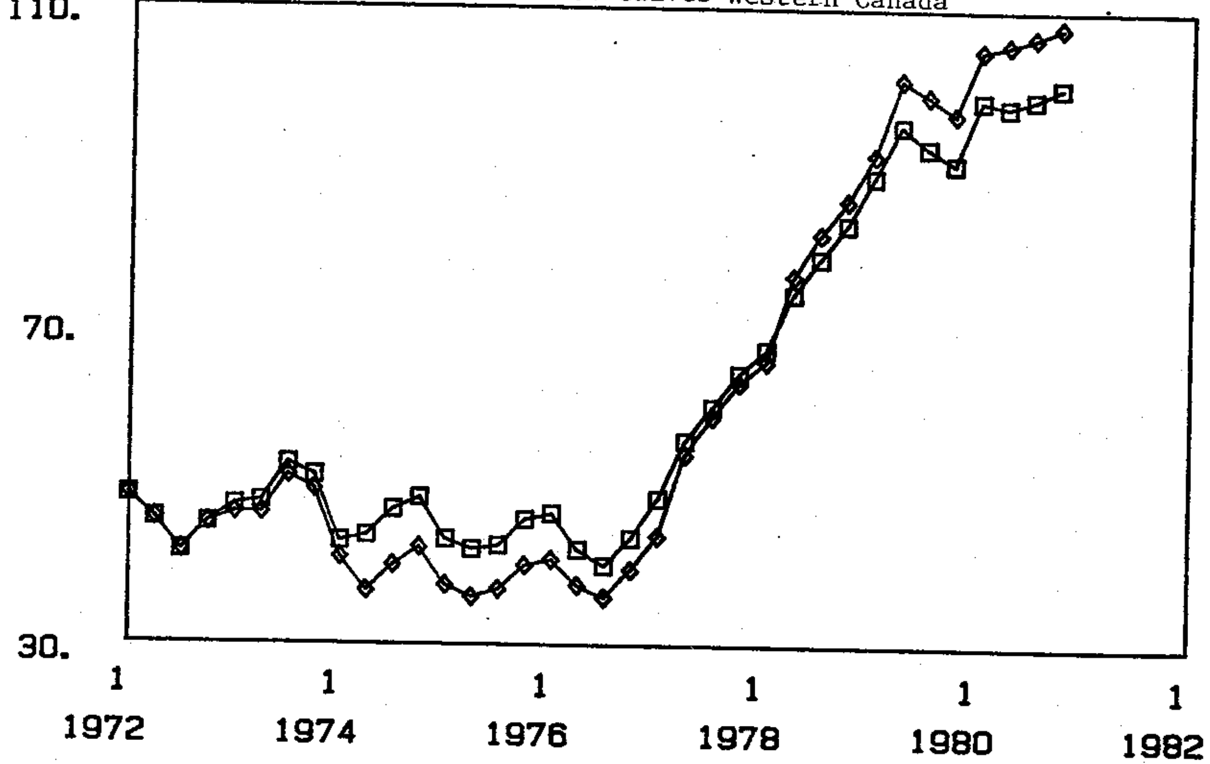


Figure 4.13: Impact of a 10 Percent Increase in Beef Cow and Bull Inventories in the U.S. on Feeder Calf Prices in Western Canada and the United States

Price of Feeder Calves Western Canada



Base Simulation

Policy Simulation

Price of Feeder Calves United States

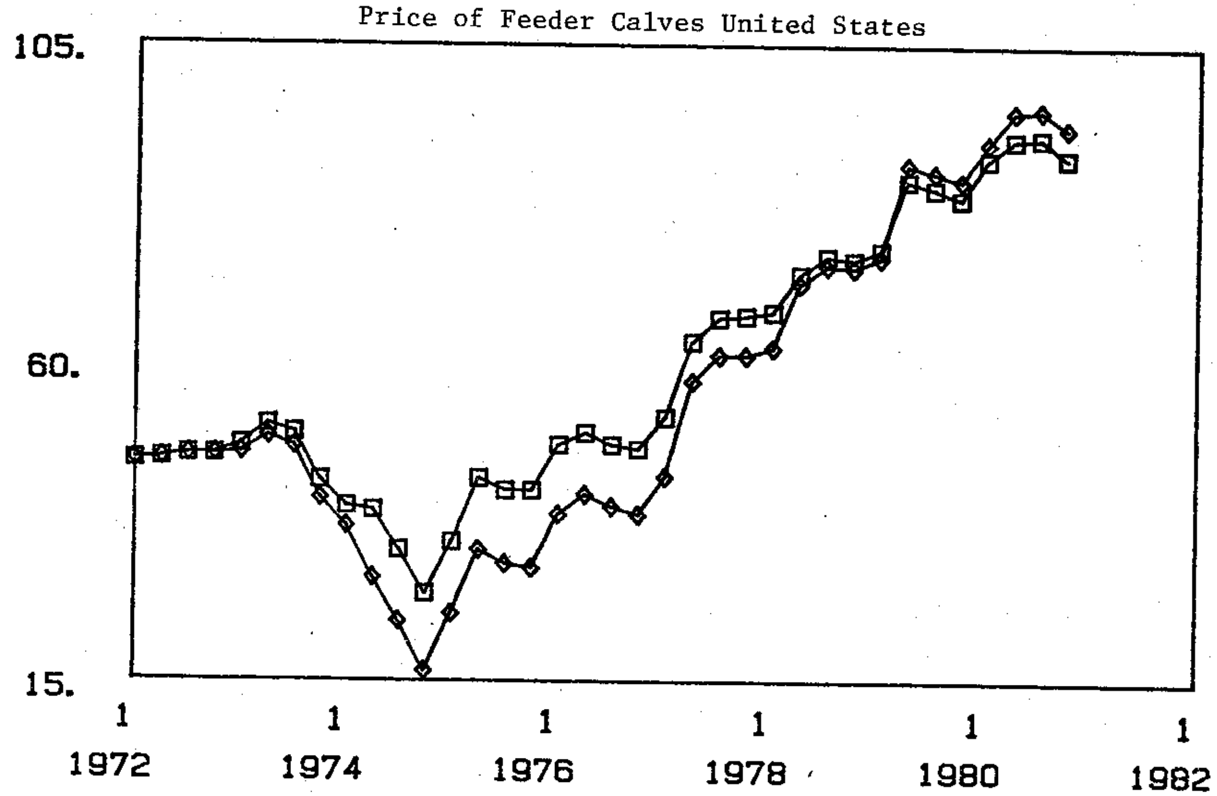
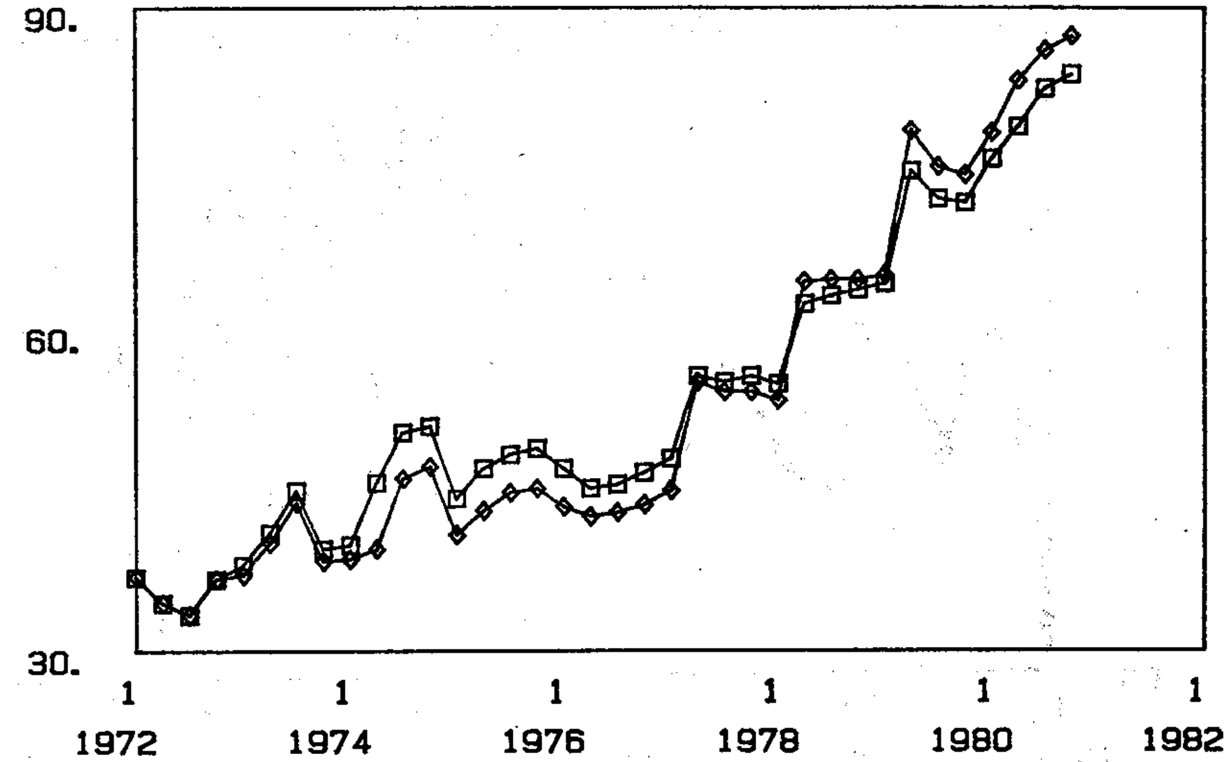


Figure 4.14: Impact of a 10 Percent Increase in Beef Cow and Bull Inventories in the U.S. on Steer Prices in Canada and the United States

Price of Steers Canada



Base Simulation

Policy Simulation

Price of Steers United States

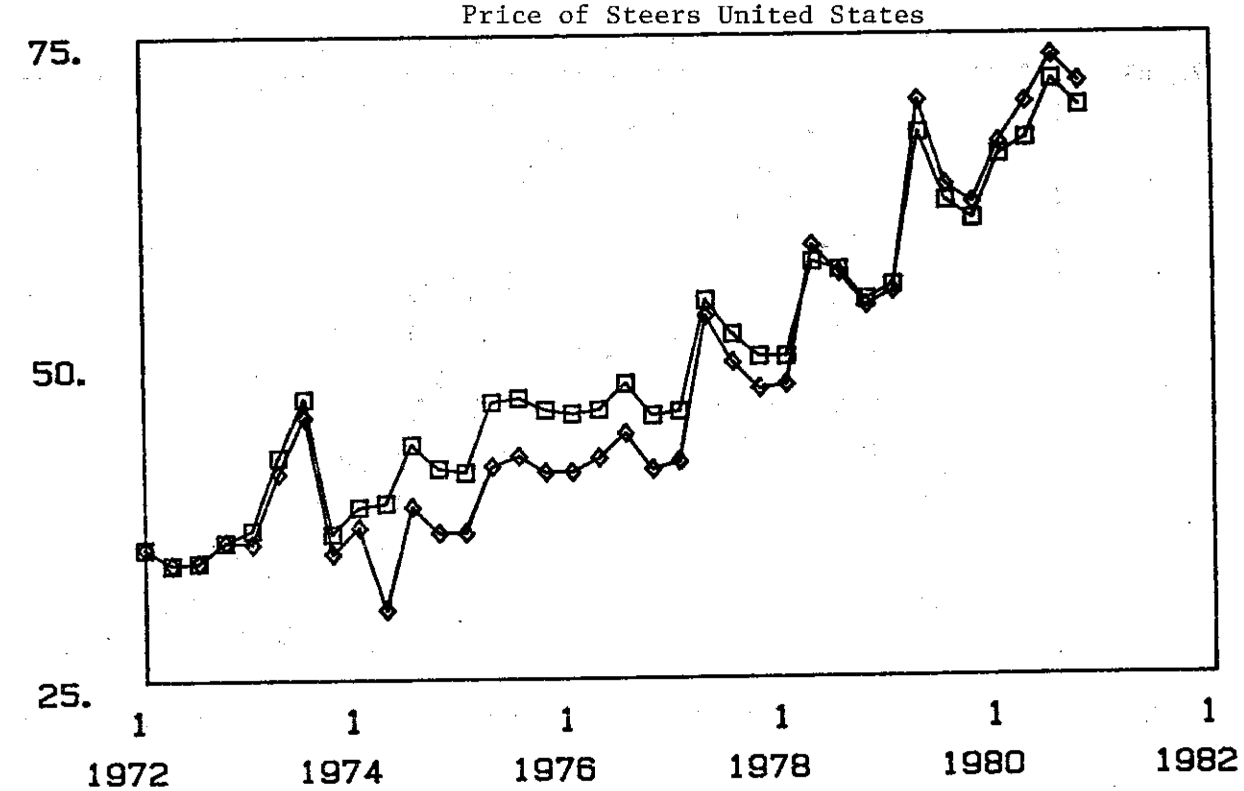


Figure 4.15: Impact of a 10 Percent Increase in Beef Cow and Bull Inventories in the U.S. on Production of Beef in Canada and the United States

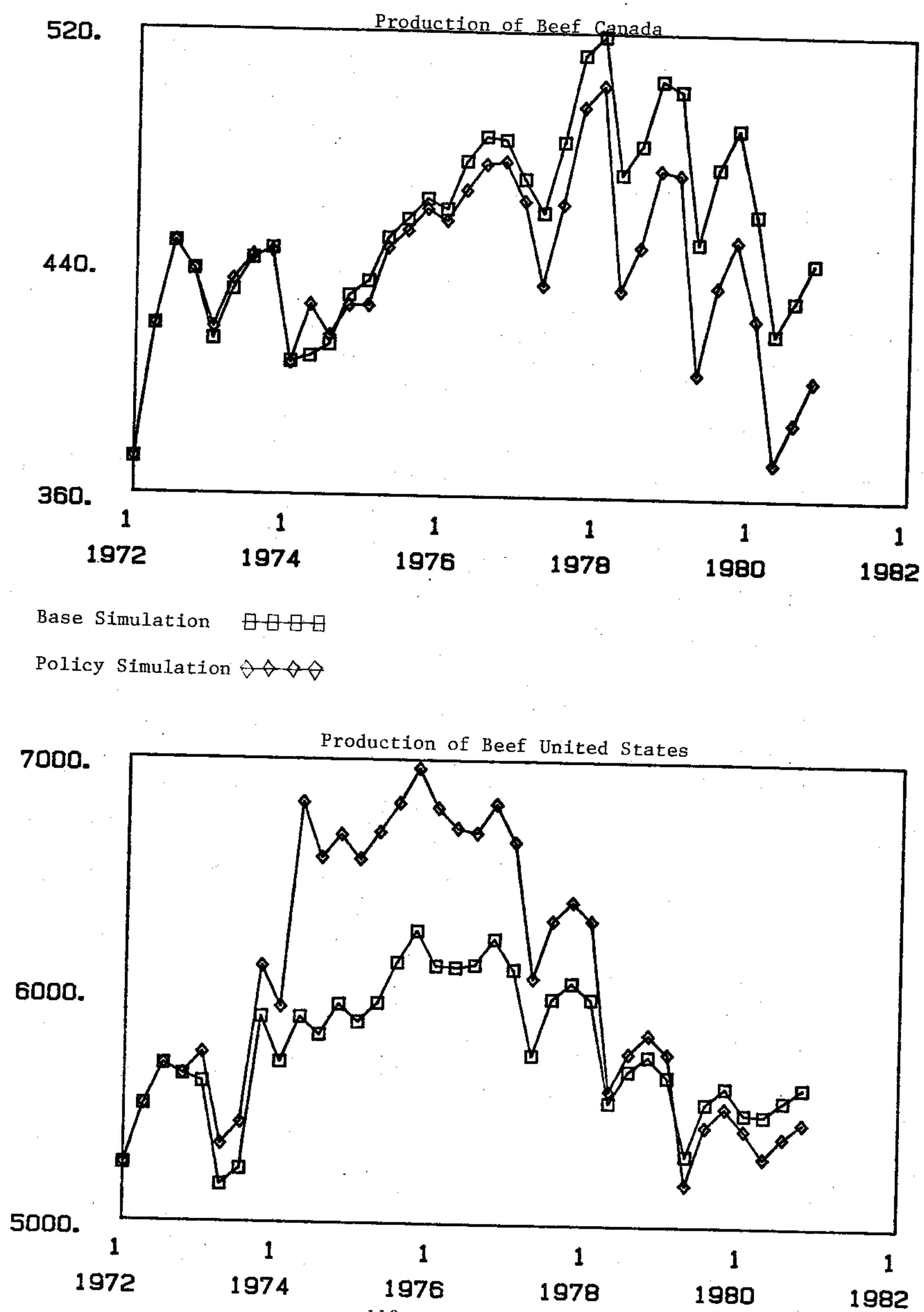


Figure 4.16: Impact of a 10 Percent Increase in Beef Cow and Bull Inventories in the U.S. on the Disappearance of Beef in Canada and the United States

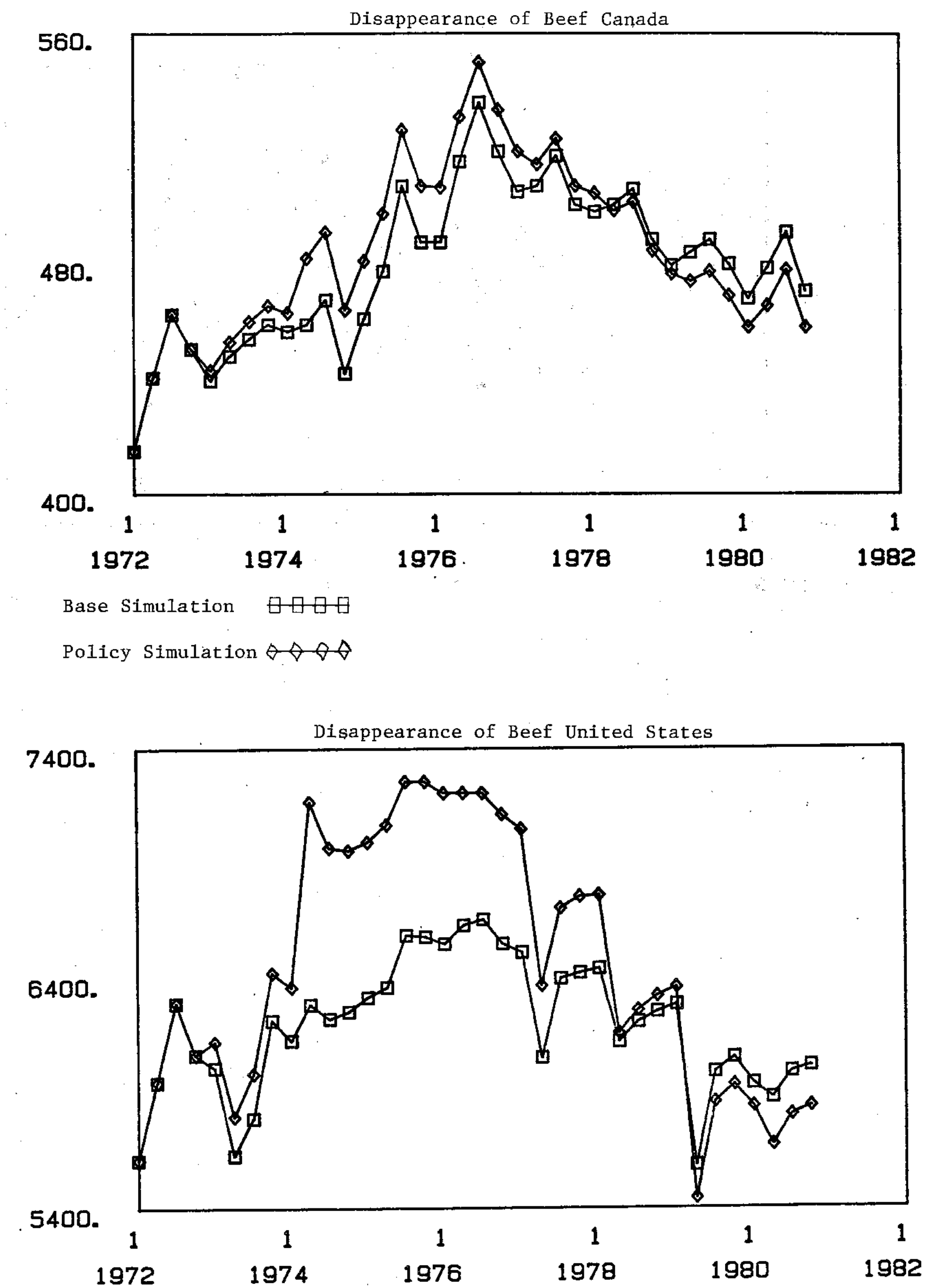
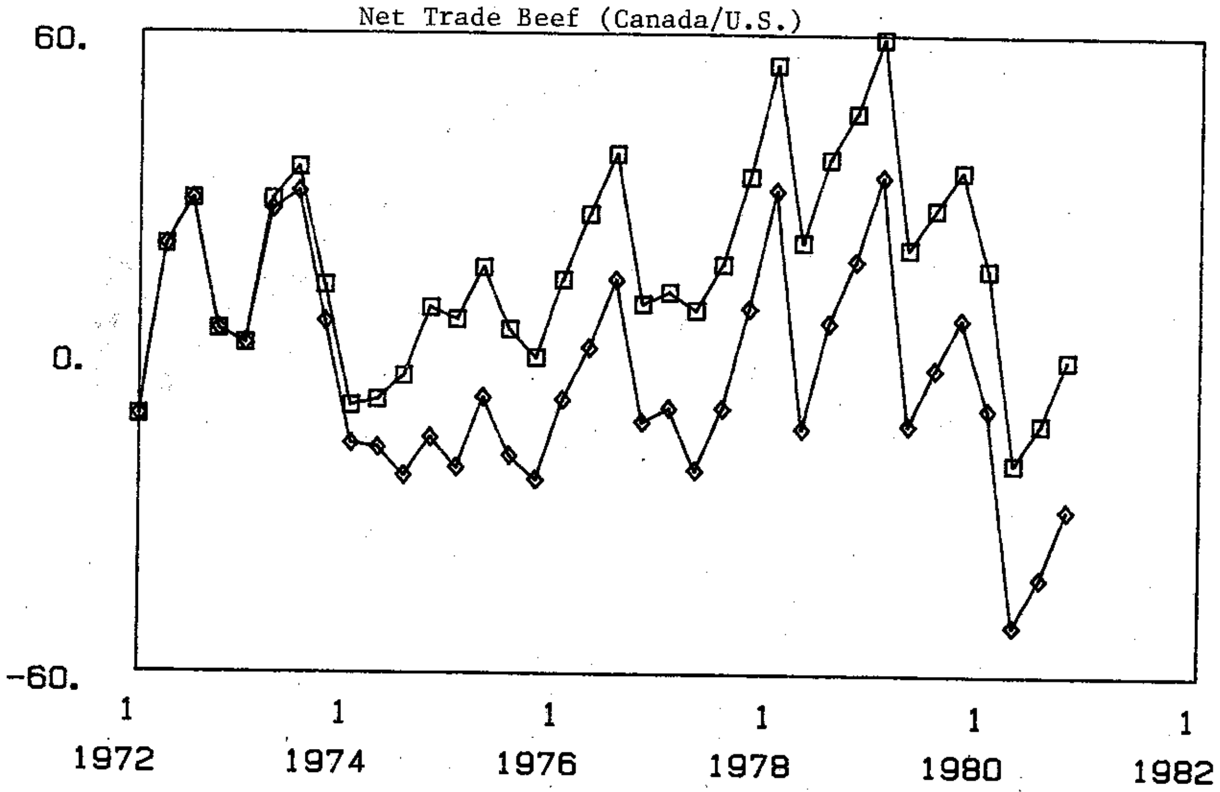


Figure 4.17: Impact of a 10 Percent Increase in Beef Cow and Bull Inventories in the U.S. on Net Trade in Beef Between Canada and the United States



production significantly.

4.8 SUMMARY

A number of validation statistics have been presented that cover various aspects of the model's ability to reproduce actual data. By comparing the current study with previous research it is possible to gauge how well the model validates. For the beef market, the model fairs favourably when validated by regressing actual on simulated values. On the Theil-U criterion however, the model performs relatively poorly. To some extent a comparison with previous studies is inappropriate when models are estimated and simulated over different time periods. For example, in this study the model has to capture both the peak (1974) and the trough (1978) in cattle inventories. The modeling of these turning points presented difficulties that did not exist for the models cited previously in this chapter because those models were estimated and simulated over the late 1960s and early 1970s when cow and bull inventories were consistently increasing.

The results for the beef variables are generally better than those for pork. Many validation statistics found in other pork studies were not comparable with the ones reported above, however, where comparisons are possible the model performs equally well (Zwart and Martin (1974) and Pieri, Meilke and MacAulay (1977)).

Most important is that the model behaves in a manner consistent with economic theory and empirical observation. Cases in which simulated values diverge substantially from actual values indicate weaknesses in the model. However, this is less critical when, policy shocks are evaluated against a base simulation and not against actual values.

CHAPTER FIVE

POLICY ANALYSIS

5.1 INTRODUCTION

Having constructed and validated a model of the North American red meat sector it is now used to answer the questions posed in Chapter one. These ask whether Canadian producers have benefitted from the depreciation of the Canadian dollar and whether the exchange rate is more or less important to the well-being of producers than other variables such as feed costs. Three experiments are presented below which cover various aspects of these issues.

However, before the results are described it is useful to make some general points about the operation of the model. The level of inventories appear to be the key variable in the beef market as it has the major influence on supply. Inventories are determined by feeder calf prices (and the wholesale price index) which depend upon steer and grain prices. Steer prices are set by supply and demand conditions within the market. Net trade flows are determined by both the relative Canadian/U.S. price level and by shifts in excess demand and excess supply functions following exchange-rate-induced price changes.

It should be remembered that the results for the West dominate the Canadian beef market, while those for the East dominate the pork market. Thus, where the regional results conflict, the dominant region largely determines the national outcome.

Throughout the descriptions presented below, the impacts of shocking the model on producer gross margins are dealt with explicitly, and tables are included showing the changes in gross margins both in absolute and percentage terms. The values which are reported must not be taken as exact measures but rather should be treated as general indications of direction and magnitude. This caution is necessary for three major reasons. First, the technical coefficients used in the budgets are fixed throughout the simulation period. Thus, changes in technology which alter these coefficients have been ignored. Second, changes in relative feed prices result in changes in the most profitable mix of feeds within the livestock ration. This substitution of feeds, however, is not accounted for in the model. The effect of understating this substitution is to overstate the impact of feed price changes on producer gross margins. Third, the categorization of inputs into traded and non-traded categories is somewhat arbitrary over the eleven year simulation period. To the extent that exchange rate fluctuations may have influenced the price or opportunity cost of inputs classified as non-traded the exchange rate impact has been understated.

As expected, Canadian/United States exchange rate variations have little impact on the U.S. market and these results are not reported. The period over which the model is simulated runs from the first quarter of 1972 through the fourth quarter of 1982.

5.2 MULTIPLIERS AND ELASTICITIES

The results of shocking the model can be expressed in terms of either multipliers or elasticities. Multipliers can be calculated using matrix manipulation (providing the model is linear) and show the change in an endogenous variable for a one unit change in an exogenous variable (Labys (1973)). Three types of multipliers are usually presented. First, an impact multiplier which shows the effect of a one unit change in an exogenous variable on an endogenous variable within the same time period. Second, a long-run multiplier which shows the effect of a sustained one unit change in an exogenous variable on an endogenous variable given a time period long enough for full adjustment to take place. Third, cumulative multipliers which show the effects on values of an endogenous variable, t-time periods ($t=2,3,\ldots,n$), following a sustained one unit change in an exogenous variable. Consequently, they show the adjustment between the impact and long-run multipliers. Elasticities show the percentage change in an endogenous variable for a one percent change in an exogenous variable. Again, three types of elasticity can be calculated to show the initial, cumulative and final effects of a sustained percentage change in an exogenous variable. In this study the results are presented chiefly in terms of elasticities and provide the basic tool for policy analysis. Multipliers are not employed because their values depend on the units in which the variables are measured making it difficult to tell whether the effects of policy changes are large or small. Elasticities, however, are insensitive to the units in which the data are measured.

In some cases, however, an elasticity can be meaningless and differences are reported in terms of unit changes. Such cases include net exports and gross margins whose values are close to zero and can show vast percentage changes for small absolute differences. Finally, the simulation results are analysed using a "shock minus control" format. To illustrate the changes that occur before and after a shock, the effects are often described as "increases", "decreases", "rise", "fall", "positive" or "negative". These terms refer to the changes occurring between the base and shock simulations and not to the actual absolute levels of any particular variable.

5.3 EXPERIMENT ONE: TEN PERCENT DEVALUATION OF THE CANADIAN DOLLAR

In this experiment the Canadian dollar is devalued by ten percent relative to the U.S. dollar. The results are presented below and include an explanation of how they are generated.

5.3.1 The Beef Market

The recursive nature of the model requires that the explanation be split into separate time periods. Three are identified and cover the impact or initial effects, the average effects and the long-run or final effects.

Following a 10 percent devaluation of the Canadian dollar the initial impact is an increase in all the Canadian prices in the model. A significant impact on feed prices is felt immediately, with prices rising by 9.13 percent for corn and 3.44 percent for barley (table 5.1). The prices of steers rise 6.71 and 7.13 percent in Western and Eastern Canada, respectively (table 5.3). These two price increases combine to induce increases in nominal feeder calf prices. The real price of feeder calves (ie. after calculating an annual average price and deflating by the wholesale price index) is positive in the West but negative in the East since the rise in wholesale prices exceeds the rise in feeder calf prices. This causes a small increase in Western inventories (0.17 percent) and a small decrease in Eastern inventories (-0.004 percent). Initially, the change in inventories is not felt in changes in the supply of beef because of the lags in production. In early periods supply depends only on changing price levels. The negative coefficient on current steer prices in the heifer and steer slaughter equation causes supply to fall and this is reinforced by decreases in cow and bull slaughter following movements in feeder calf prices and inventory levels. The increase in prices reduces disappearance by a greater amount than supply, causing imports to decrease by 4.27 million lbs.

During the interim period the prices of steers and corn remain fairly stable at the higher levels. There is a further increase in the price of feeder calves, however, such that the real price of feeder calves rises in both the East and West causing inventory levels to rise. Beef supplies are initially below those in the base simulation, and remain lower until the twenty-fourth quarter when they rise above the base. These supply increases are the result of the positive coefficient on the lagged steer price in the heifer and steer slaughter equation. Cow and bull slaughter declines but this has little effect on total production. Disappearance increases from its initial level but remains below that of the base simulation over the entire period. The supply and demand balance keeps exports well above their base level and the value of beef trade increases dramatically.

The long-run situation involves little change in steer and feed price elasticities. The real (deflated) prices of feeder calves for Eastern and Western Canada are, respectively 4.57 percent and 3.18 percent higher, which causes inventory levels in Eastern and Western Canada to increase by 5.74 and 3.41 percent above base levels by the end of the simulation period. Supplies are above pre-devaluation levels by 3.57 percent or 15.29 million pounds. Increases in production result in substantial increases in exports (26.70 million lbs). The results of this simulation are tabulated in tables 5.1 to 5.3 and graphically

Table 5.1: Percentage Change in Feed Variables for a Ten Percent Devaluation of the Canadian Dollar

Variable	Region	Impact	Average	Final
Price of Corn	East	9.13	9.98	10.00
Price of Barley	West	3.44	9.82	10.00
Price of Rapeseed Meal	West	7.30	7.48	7.08
Price of Soybean Meal	West	7.85	8.63	8.68
Price of Soybean Meal	East	8.42	8.80	8.73
Value of Silage	East	8.21	9.38	9.20
Value of Silage	West	2.81	9.18	9.48
Price of Hay	East	1.24	1.61	1.19

Table 5.2: Percentage Change in Macro Economic Variables for a Ten Percent Devaluation of the Canadian Dollar

Variable	Impact	Average	Final
CPI	0.39	2.72	3.00
WPI	2.63	3.71	3.73
Wages and Salaries	0.39	2.72	3.00
Interest Rate 1/	-1.72	-1.54	-1.23
Per Capita Disposable Income	-0.02	3.69	4.79

1/ Change in percentage interest rate.

Table 5.3: Percentage Change in Beef Variables for a Ten Percent Devaluation of the Canadian Dollar

Variable	Region	Impact	Average	Final
Carcass Weight	Can.	0.00	-0.31	-0.21
Disappearance	Can.	-2.35	-2.82	-2.42
Cow and Bull Slaughter	West	-1.39	-1.11	-0.69
	East	-0.04	-1.37	-2.11
Heifer and Steer Slaughter	Can.	-2.08	1.35	5.54
Closing Stocks of Beef	Can.	-2.36	0.47	4.68
Cow and Bull Inventory	West	0.17	2.16	3.41
	East	-0.00	2.68	5.74
Net Exports[1/] (Canada/U.S.)		4.27	15.48	26.70
Feeder Calf Price	West	5.43	7.08	7.02
	East	2.80	7.56	8.48
Steer Price	West	6.71	7.70	7.62
	East	7.13	9.03	9.09
Production	Can.	-1.78	0.46	3.57
Value of Trade[2/]	Can.	1.40	11.87	28.81

1/ Change in million pounds.
2/ Change in million dollars.

depicted in figures 5.1 and 5.3.

5.3.2 Gross Margins. Beef

Two types of gross margins are obtained for both the cow-calf and the beef feedlot enterprise. The results are displayed in table 5.4 and figures 5.4 and 5.5. The gross margins show that the beef feedlot operators in Western and Eastern Canada are better off following the devaluation of the dollar with gross margins increasing by 65 cents and 170 cents per cwt., respectively. These gains are the result of output prices rising by more, following the devaluation, than the weighted average of input prices.

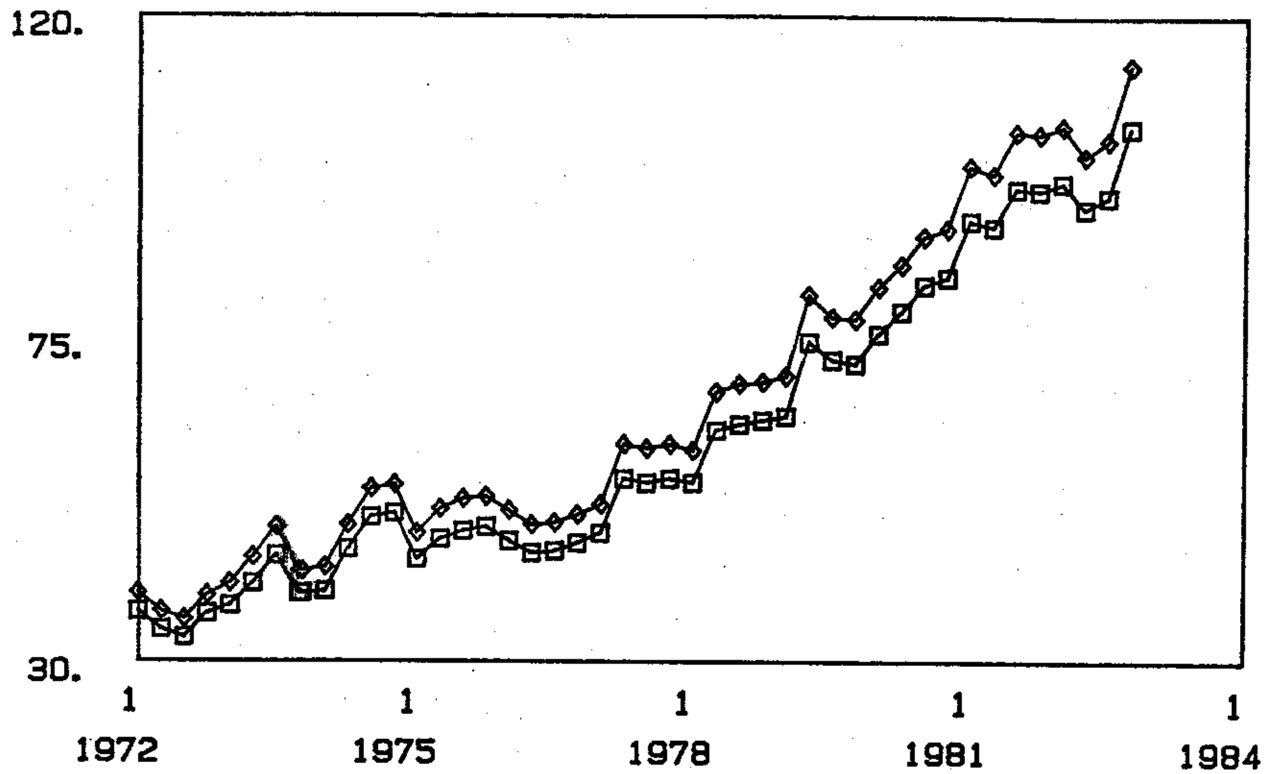
The gross margin over feed and livestock (which excludes the effect of interest rates) shows both Western and Eastern feedlot operators gaining less following the devaluation of the dollar (46 cents and 151 cents per cwt., respectively). These results show that the macro-economic impacts of the devaluation reinforced the sector specific impacts.

Table 5.4: Impact of a Ten Percent Devaluation on Beef Producer Gross Margins, ($/cwt.)

Enterprise	Region	Average G.M. Before	Average G.M. After	Change in G.M.	% Change in G.M.
Beef Feedlot	East	2.09	3.79	1.70	81.3
Beef Feedlot (after feed and livestock)	East	11.17	12.68	1.51	13.5
Beef Feedlot	West	1.82	2.47	0.65	35.7
Beef Feedlot (after feed and livestock)	West	8.57	9.03	0.46	5.4
Cow Calf	East	13.61	19.00	5.39	39.6
Cow Calf (after feed and livestock)	East	24.60	29.74	5.15	20.9
Cow Calf	West	12.41	16.79	4.38	35.3
Cow Calf (after feed and livestock)	West	21.41	25.50	4.09	19.10

Figure 5.1 Impact of a ten percent devaluation on the prices of steers and hogs in Canada.

Prices of Steers Canada (Dol./cwt.)



Base Simulation

10% Devaluation Canadian $

Price of Hogs Canada (Dol./cwt.)

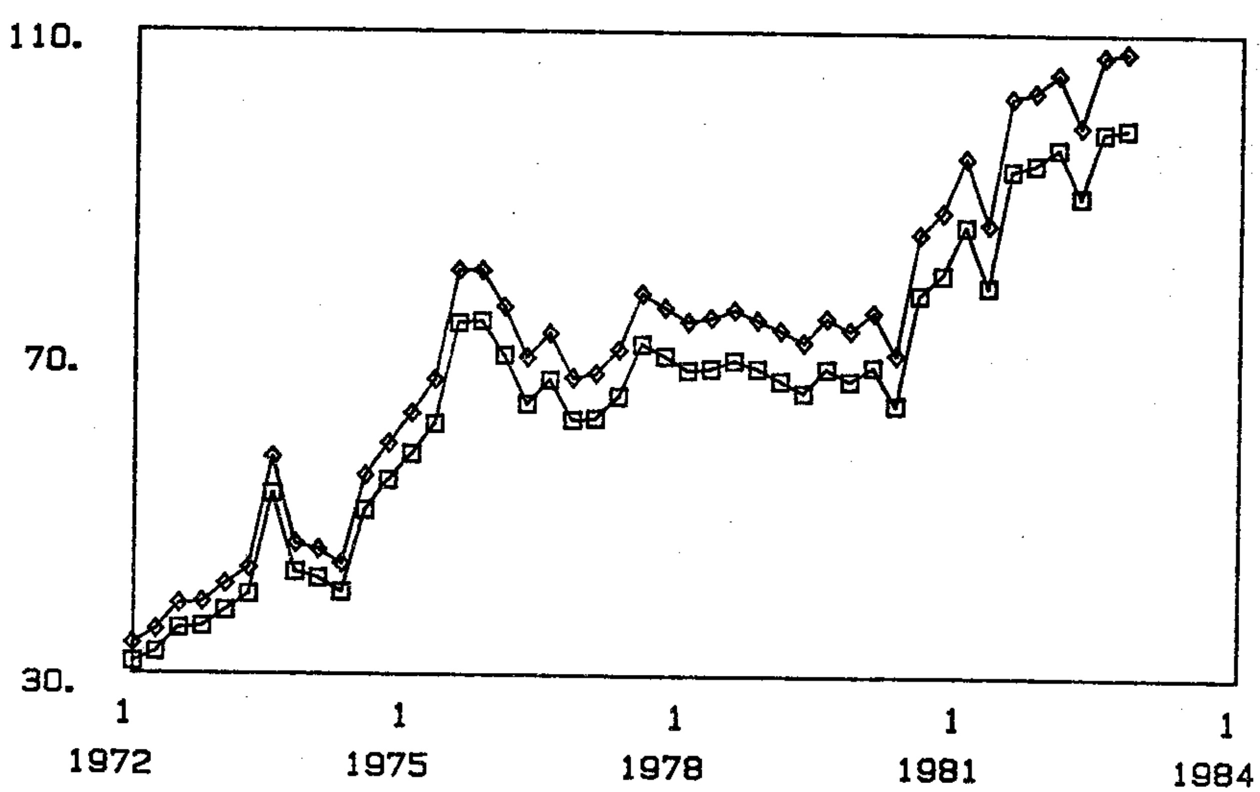
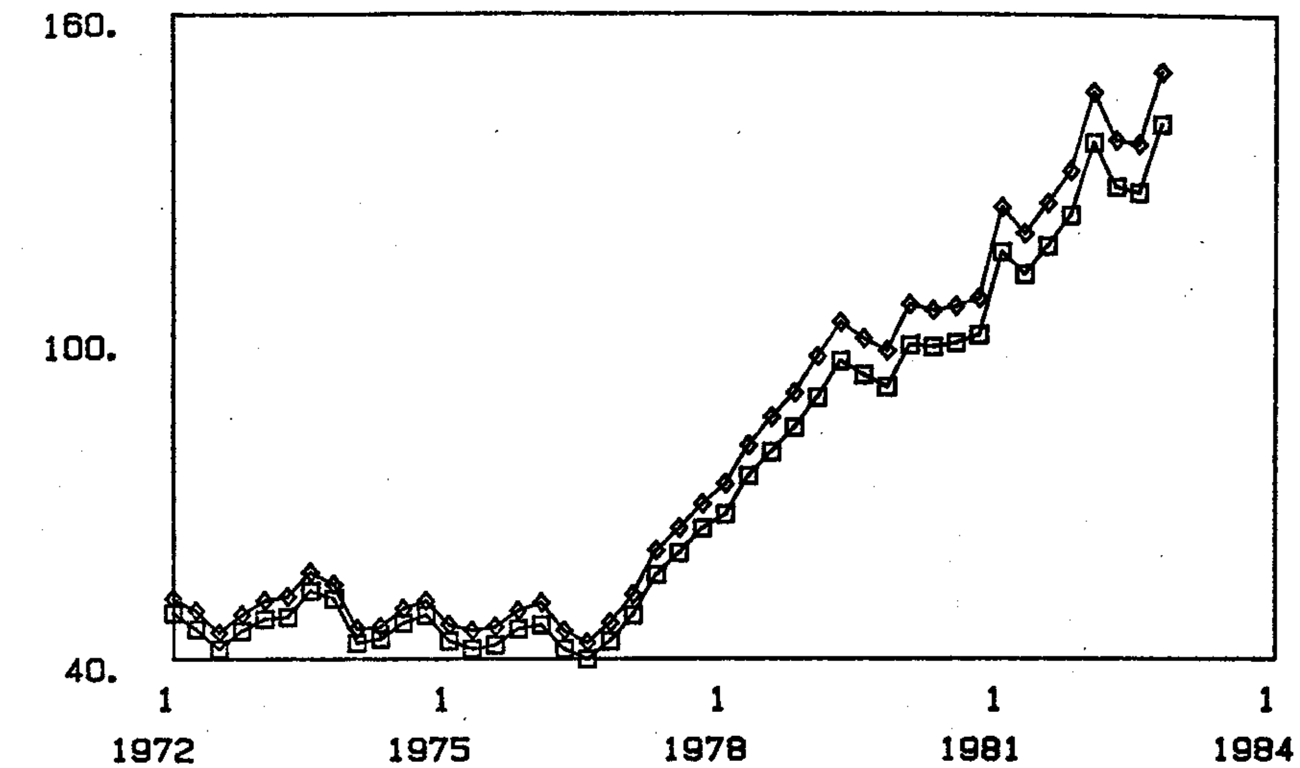


Figure 5.2: Impact of a ten percent devaluation on price of feeder calves in Western Canada and cow and bull inventories in Canada.

Price of Feeder Calves Western Canada (Dol./cwt)



Base Simulation

10% Devaluation Canadian $

Inventory of Cows and Bulls Canada ('000 Head)

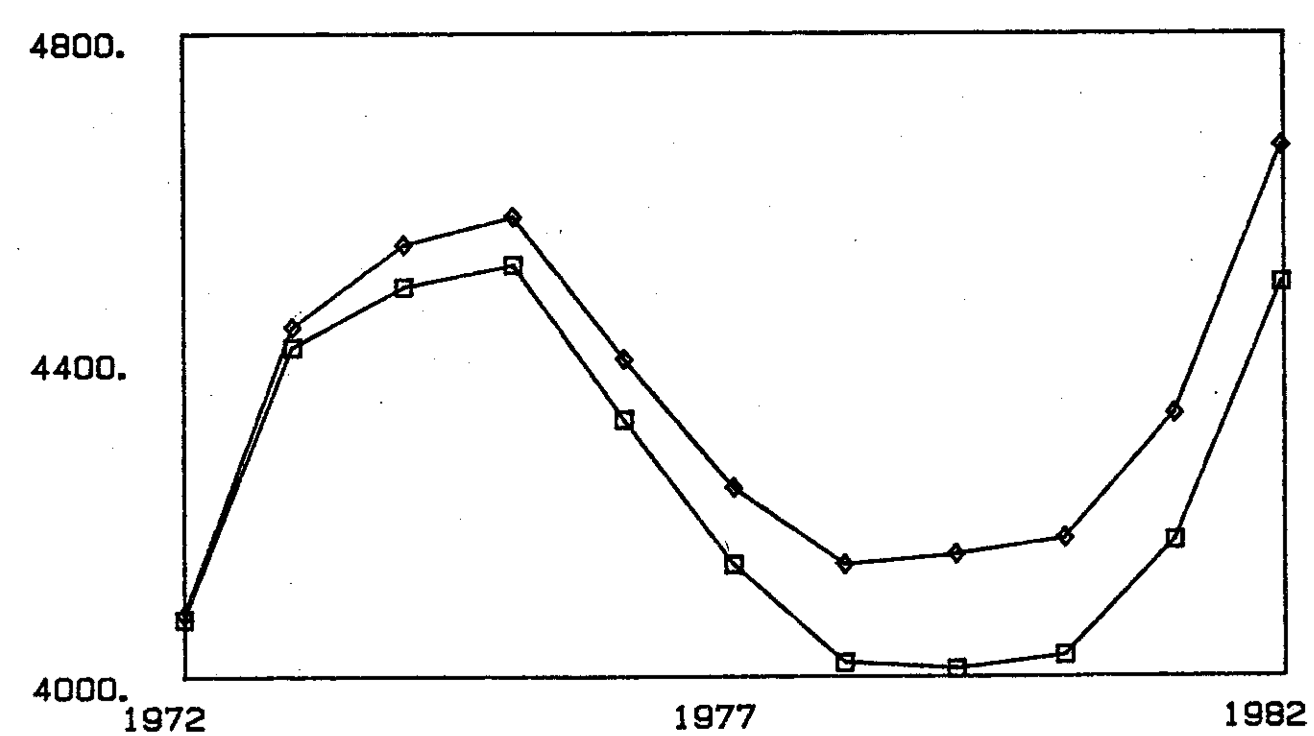
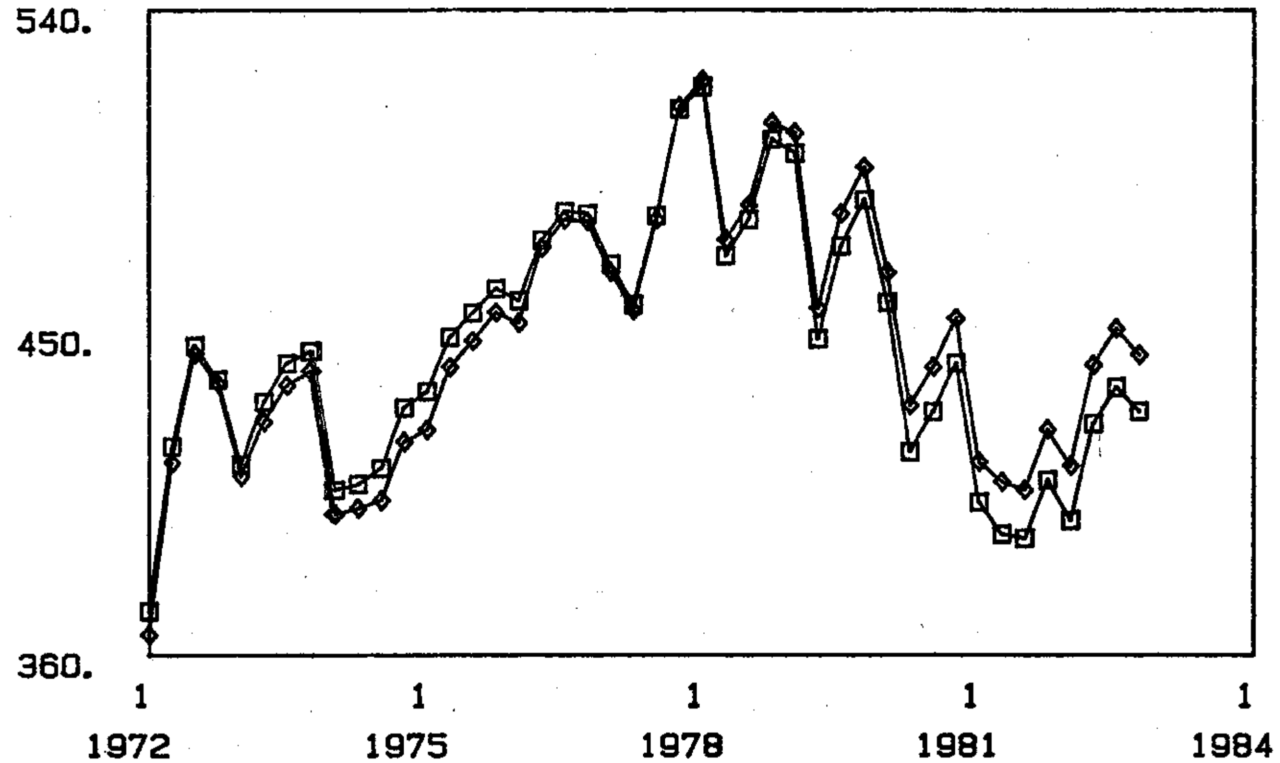


Figure 5.3: Impact of a ten percent devaluation on production and disappearance of beef.

Production of Beef All Canada (Mil. lbs.)



Base Simulation

10% Devaluation Canadian $

Disappearance of Beef All Canada (Mil. lbs.)

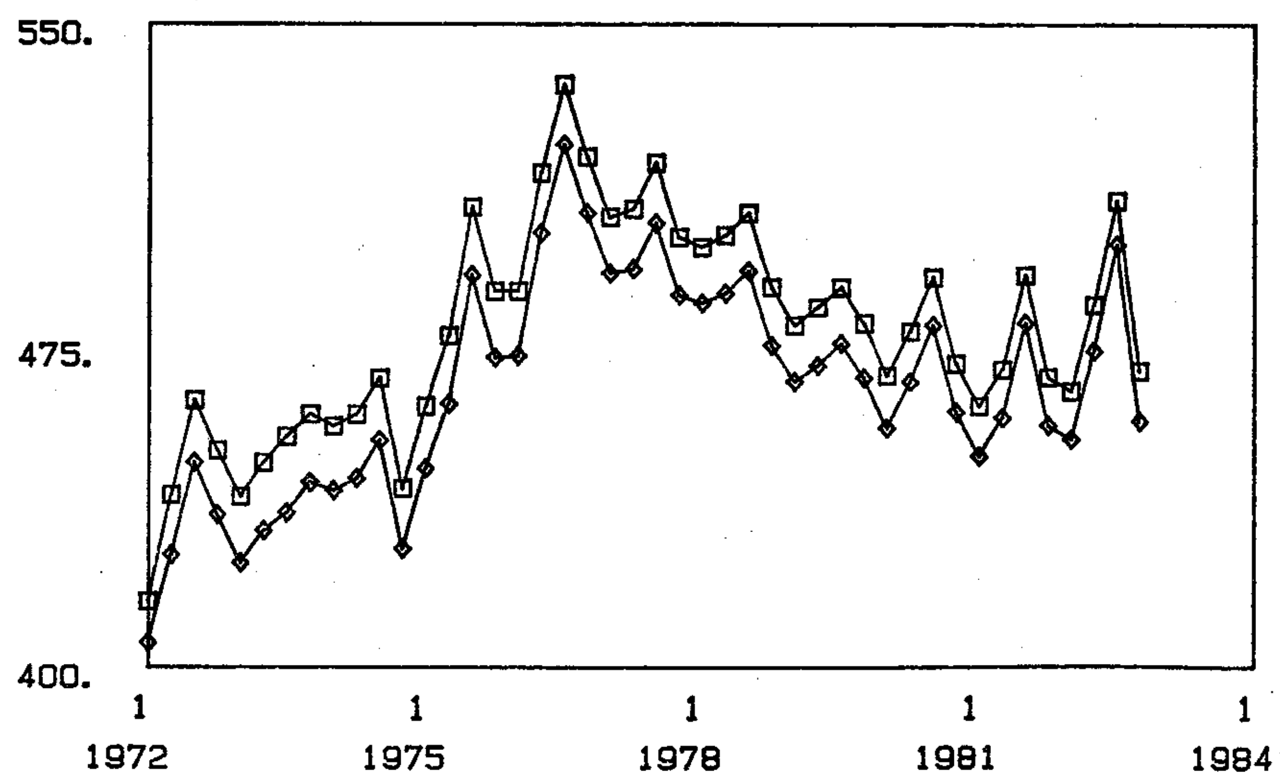
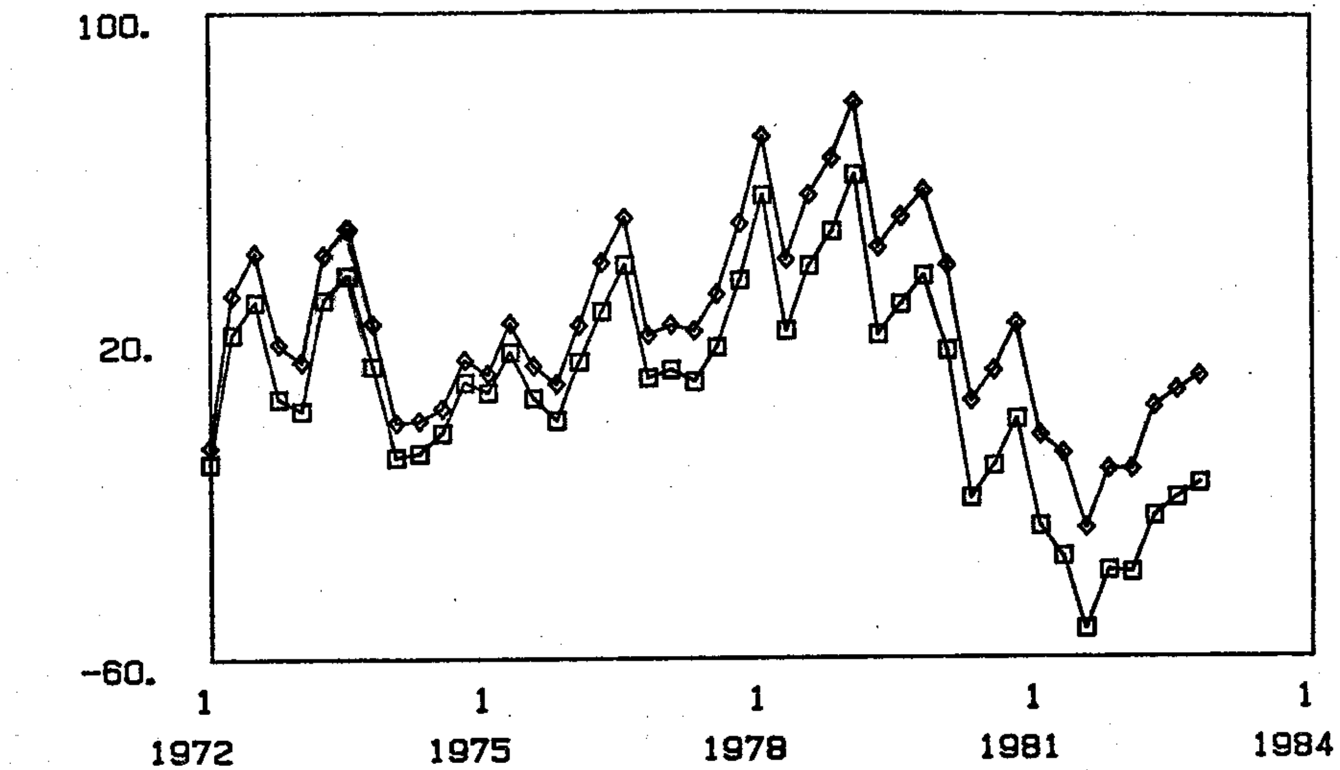


Figure 5.4: Impact of a ten percent devaluation on the net trade and value of beef trade

Net Trade In Beef Canada (Mil. lbs.)



Base Simulation

10% Devaluation Canadian $

Value of Net Beef Trade (Mil. Can. dol.)

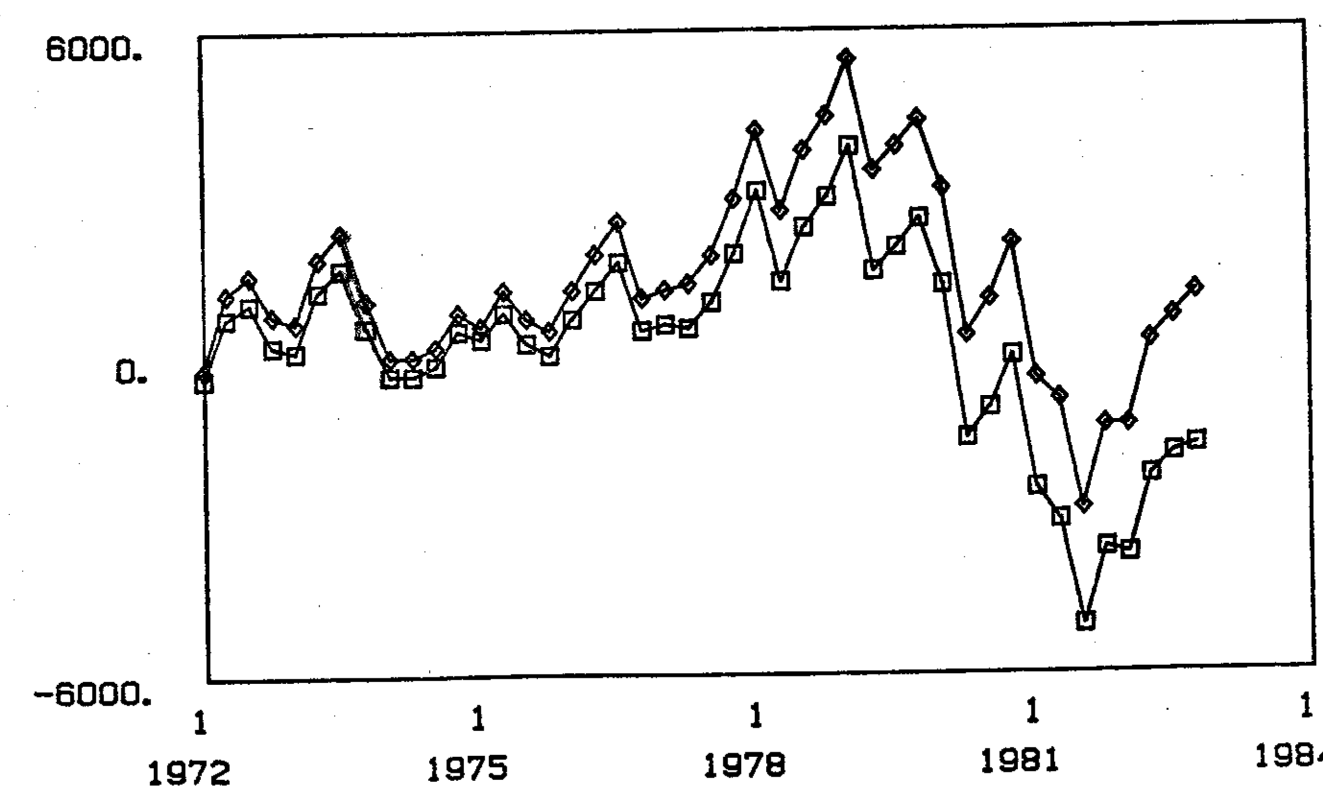
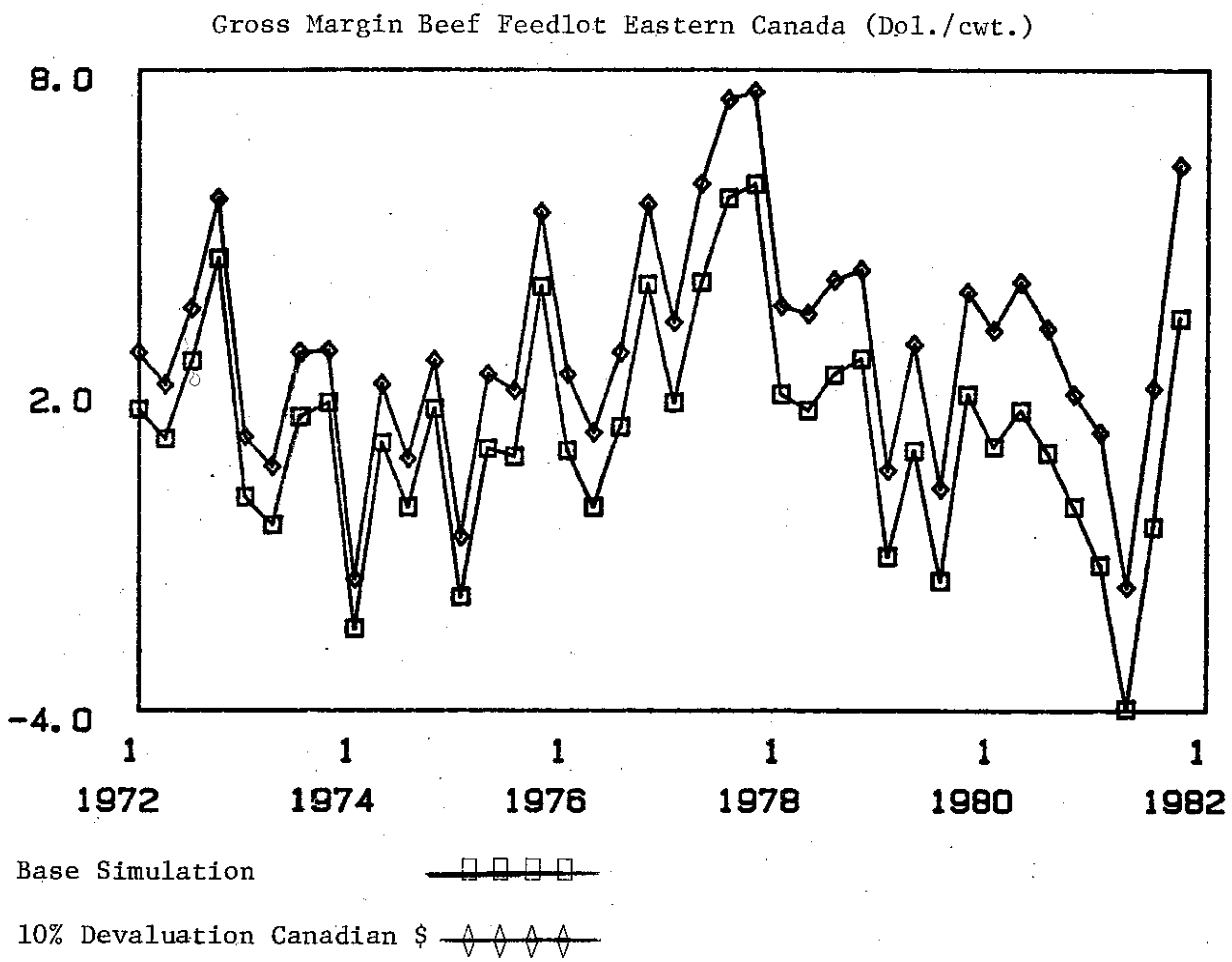
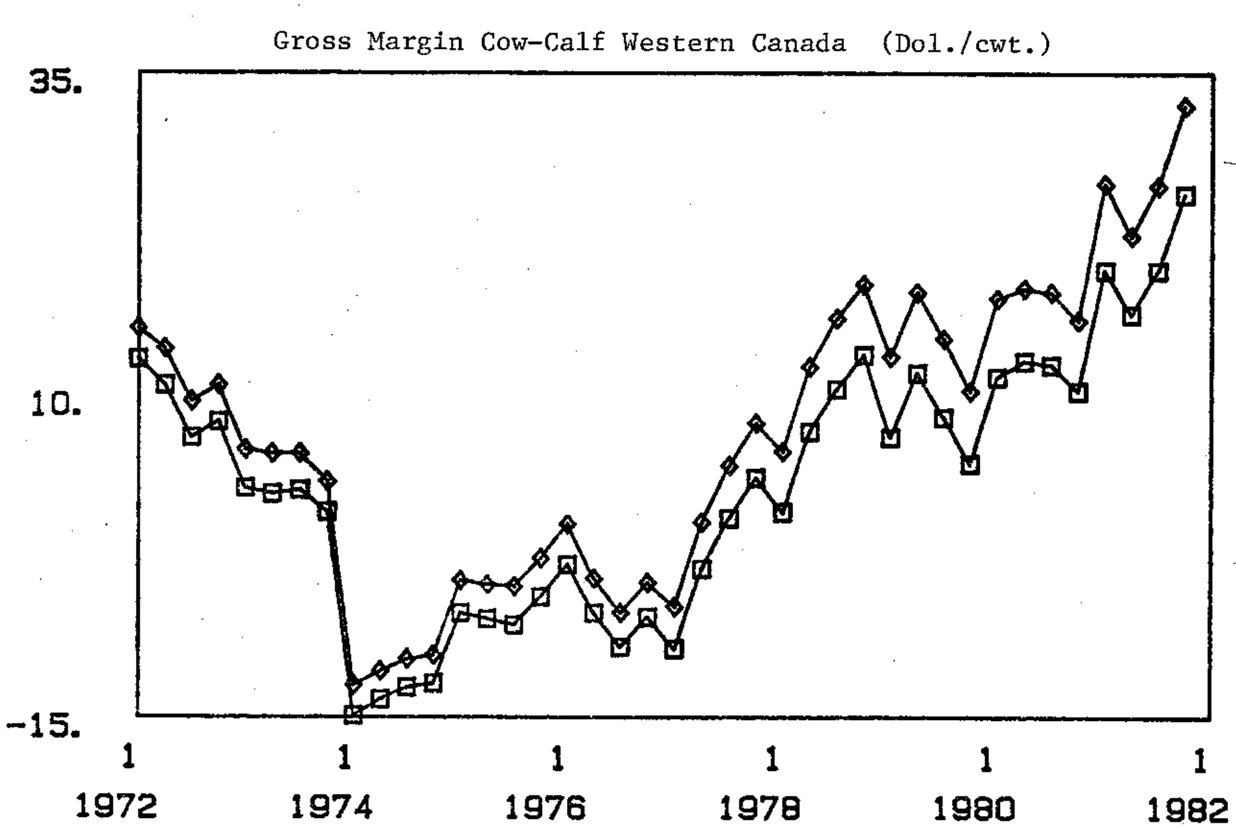


Figure 5.5: Impact of a ten percent devaluation on beef feedlot and cow-calf gross margins.





Cow-calf operators benefit from the devaluation and fair much better than those operating beef feedlots. This results from two major factors. First, the devaluation increases total revenues by increasing the price of calves and cows and bulls. Second, cow-calf operations in Western Canada tend to be extensive, relying on range land as a major feed input. This is treated as a non-traded cost of production and therefore is unaffected by movements in the exchange rate. In Eastern Canadian cow-calf operations cows are typically wintered on hay and supplements and put on pasture in the spring. Although the price of hay does increase following a devaluation, the impact is quite small (averaging 1.61 percent) while pasture is treated exogenously.

5.3.3 The Pork Market

The results for the pork market are shown in table 5.5 and figures 5.1, 5.6 and 5.7. The effects of the exchange rate on the pork market are easier to analyze than for the beef market because pork supply is described by only one equation and it does not contain the complicated recursive elements of beef. Nonetheless, it is perhaps useful to divide the simulation period into initial, average and long-run effects to better understand the dynamics of the results of the devaluation of the dollar.

The initial impact causes hog prices to rise by 8.31 percent in the West and 7.17 percent in the East. The price variables in the pork production equations are lagged four quarters so there is no initial change in production. Meanwhile, increases in pork prices reduce domestic disappearance. These factors result in additional excess supply such that exports to the U.S. increase by 1.47 million pounds.

The average impacts show hog prices rising slowly while feed prices remain unchanged at the higher level. The hog and feed price changes now influence supply which falls below the base level in Western Canada between the thirteenth and thirtieth quarters of the simulation. This is the result of larger percentage increases in feed prices than pork prices during these quarters and the nearly equal direct and cross price elasticities of supply. Production is above the base level for all but four quarters in Eastern Canada.

The increase in pork price keeps disappearance below base levels but nevertheless disappearance increases as incomes rise throughout the simulation period. The fall in the amount demanded and a small production increase results in pork exports rising by an additional 2.59 million pounds by the end of the simulation period.

5.3.4 Gross Margins. Pork

The devaluation of the Canadian dollar produces net benefits in terms of gross margins in both Eastern and Western Canada (table 5.6). Table 5.6 shows increases in the average gross margin of 3.76 and 3.11 dollars per cwt. in Western Canada and Eastern Canada, respectively.

Table 5.5: Percentage Change in Pork Variables for a Ten Percent Devaluation of the Canadian Dollar

Variable	Region	Impact	Average	Final
Disappearance	Can.	-0.33	-0.43	-0.20
Closing Stocks	Can.	-1.37	-0.05	0.14
Net Exports[1/] (Canada/U.S.)		1.47	1.89	2.59
Price of Hogs	West	8.31	9.92	10.08
	East	7.17	8.61	9.38
Production	West	0.00	-0.16	0.40
	East	0.00	0.30	0.41
	Can.	0.00	0.14	0.40
Value of Trade[2/]		0.54	1.91	7.96

1/ Change in million pounds.
2/ Change in million dollars.

Table 5.6: Impact of a Ten Percent Devaluation on Pork Producer Gross Margins, ($/cwt.)

Enterprise	Region	Average G.M. Before	Average G.M. After	Change in G.M.	% Change in G.M.
Farrow to Finish	East	29.99	33.10	3.11	10.4
Farrow to Finish (after feed and livestock)	East	36.50	39.50	2.99	8.2
Farrow to Finish	West	26.40	30.16	3.76	14.2
Farrow to Finish (after feed and livestock)	West	33.01	36.64	3.63	11.0

Figure 5.6: Impact of a ten percent devaluation on farrow to finish gross margins.

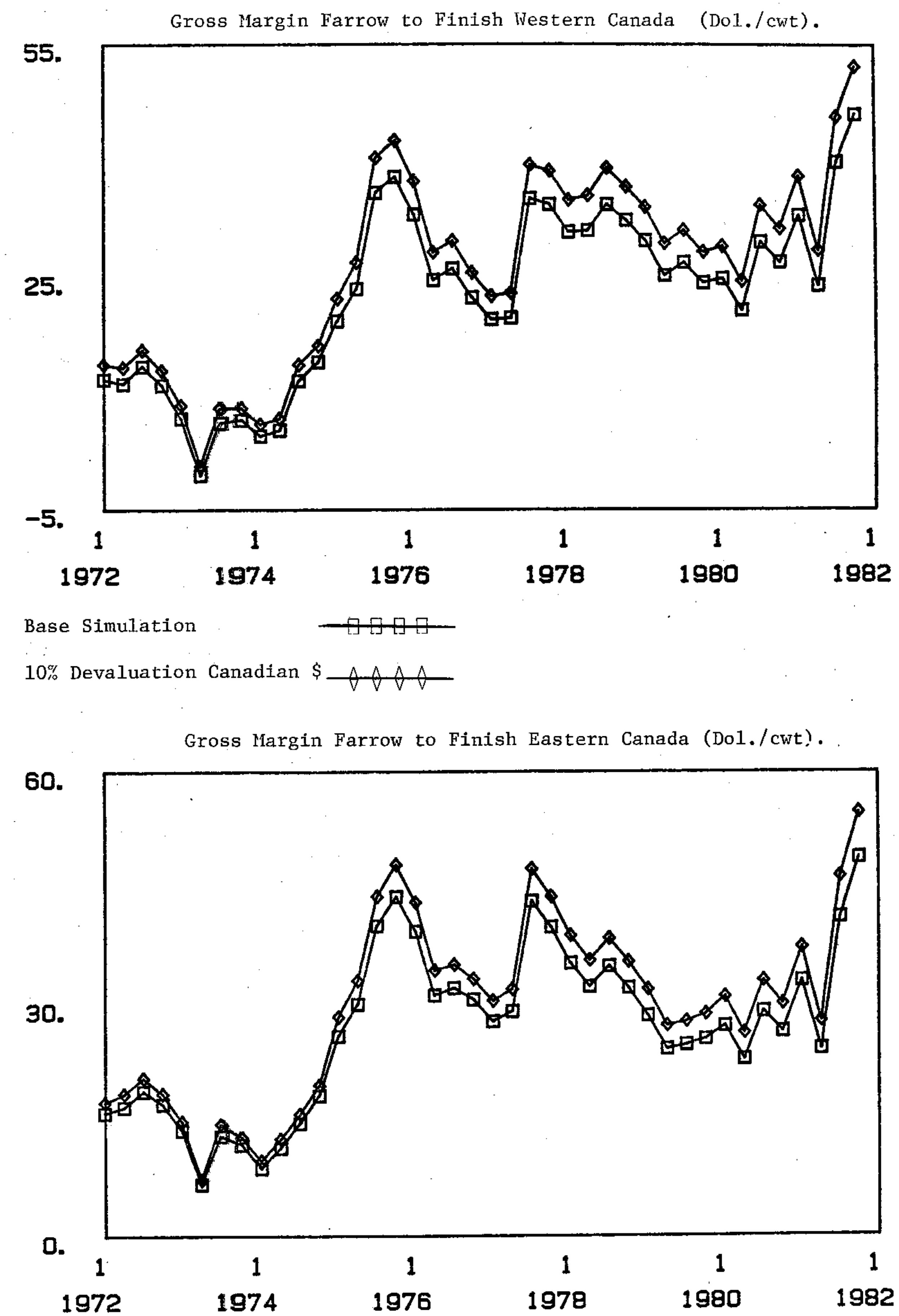
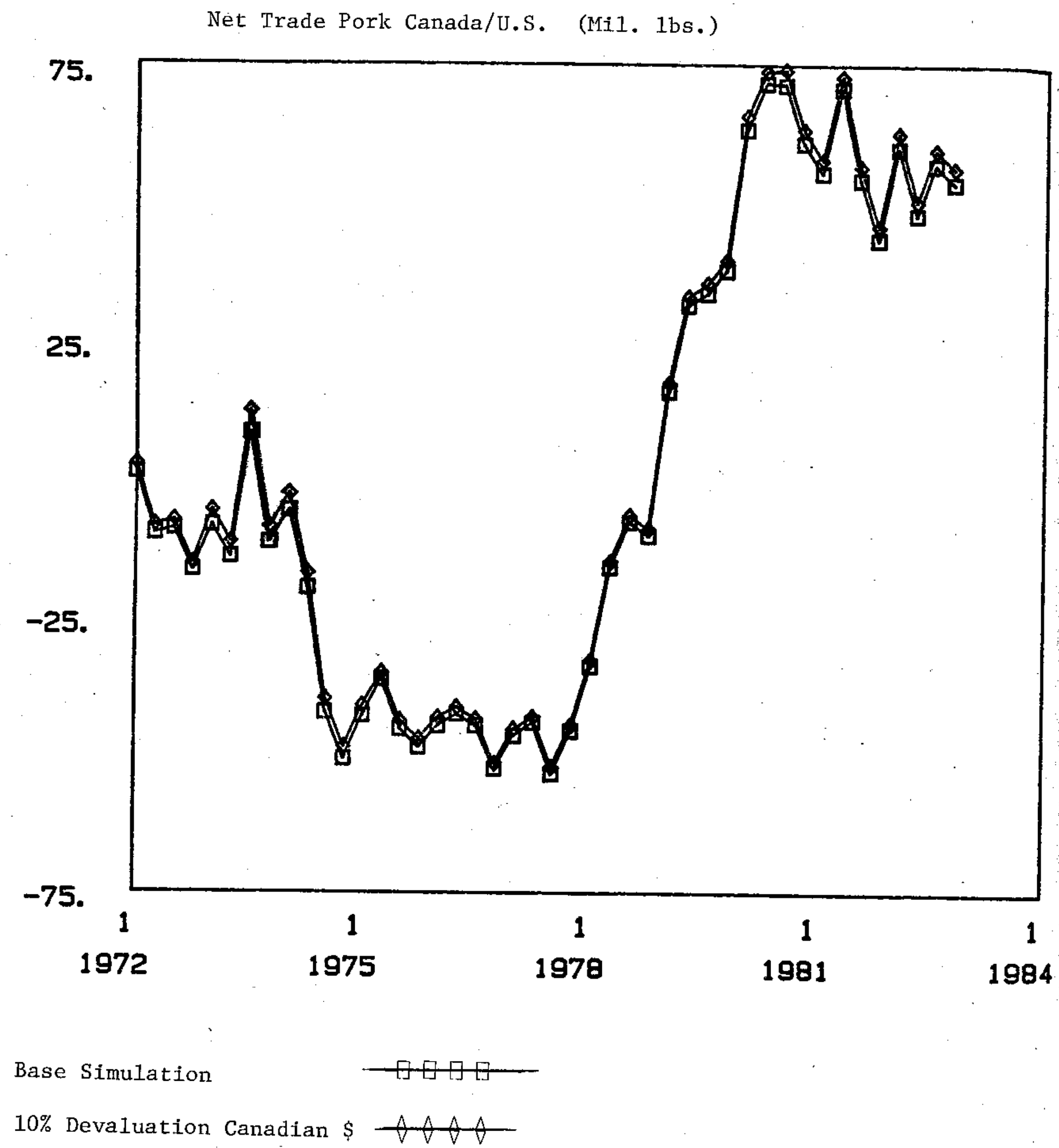


Figure 5.7: Impact of a ten percent devaluation on net trade in pork.



5.3.5 <u>Experiment One. Summary</u>

The results presented above show the effects of a 10 percent depreciation of the Canadian dollar on the red meat market. In general the devaluation is felt instantly and completely in feed prices while livestock prices move more slowly towards the full extent of the devaluation throughout the simulation period. Disappearance falls initially but thereafter slowly increases as incomes rise while net exports increase. The gross margins indicate that all red meat producers have gained from the devaluation, with cow-calf operators receiving the largest gains of the different types of producers considered.

5.4 <u>EXPERIMENT TWO: TEN PERCENT DECLINE IN THE CANADIAN PRICE OF CORN AND BARLEY</u>

To meet the second objective of this research it is necessary to illustrate the relative importance of changes in the exchange rate with changes resulting from variations in other factors which affect the industry. To this end the Canadian price of corn is lowered by ten percent from its base value, and because of the price link between corn and barley, the barley price also declines by ten percent. While this may appear to be an artificial situation the price of corn in Ontario has declined by 10 to 20 percent relative to the price in the United States since 1973/74 as Ontario became a surplus corn producing province (Coleman (1984), Meilke (1984)).

5.4.1 <u>The Beef Market</u>

As shown in table 5.7 the Canadian price of both corn and barley are reduced by ten percent over the entire simulation period. Corn prices in the U.S. are maintained at their base level and there are no changes in any U.S. variables large enough to report. In addition, this policy has no macroeconomic effects.

The decline in feed prices causes the production of beef to increase following a small decline in production in the first quarter of the simulation. Production is up by 6.64 percent by the end of the simulation and averages 5.44 percent more over the entire simulation.

The increase in the production of beef lowers steer prices, on average, by 2.42 percent in the West and 0.64 percent in the East. The difference in the percentage change in steer prices between the East and the West results from the impact that net exports have on prices in the two regions. The price linkage equations indicate that steer prices in the West will fall by about $0.80/cwt. more than prices in the East as the result of beef exports increasing by 20.00 million pounds. This difference in price response between the two regions may be larger than what would actually be expected.

Table 5.7: Percentage Change in Beef and Feed Variables for a Ten Percent Decline in Canadian Feed Grain Prices

Variable	Region	Impact	Average	Final
FEED				
Price of Corn	East	-10.0	-10.0	-10.0
Price of Barley	West	-10.0	-10.0	-10.0
BEEF				
Disappearance	Can.	-0.12	0.86	0.76
Cow and Bull Inventory	West East	0.12 -0.01	1.06 5.44	0.42 7.83
Net Exports 1/ (Canada/U.S.)		-2.70	20.01	24.95
Price of Feeder Calves	West East	1.95 1.98	0.89 5.10	0.39 2.77
Price of Steers	West East	0.48 0.16	-2.42 -0.64	-1.73 -0.43
Production	Can.	-0.96	5.44	6.64
Value of Trade 2/	Can.	-1.02	13.25	26.02

1/ Change in million pounds.
2/ Change in million dollars.

As a result of the steer price decline, disappearance increases, but by less than one percent. As mentioned above, net exports increase and the value of beef trade increases, on average by 13.25 million dollars.

5.4.2 Gross Margins: Beef

The results of a ten percent decrease in Canadian grain prices on gross margins of beef producers are shown in table 5.8. Gross margins for Eastern beef feedlot operators are up about $1.00/cwt. while the margin for Western feedlot operators declines marginally as a result of the larger decline in Western steer prices than in Eastern steer prices.

Cow calf producers in both the East ($3.34/cwt.) and the West ($0.97/cwt.) gain with the largest gains again occurring in the East.

5.4.3 The Pork Market

The impact of decreased grain prices is to increase pork production, primarily in the West, decrease pork prices by 1-2 percent and increase disappearance marginally (table 5.9). Net exports expand by 11.63 million pounds, on average, and the value of trade increases substantially.

5.4.4 Gross Margins: Pork

The gross margins for pork producers increase in both the East and the West (table 5.10). The increases are, however, quite small averaging 2.46 percent in the East and 3.41 percent in the West.

Table 5.8: Percentage Change in Beef Producer Gross Margins for a Ten Percent Decline in Canadian Feed Grain Prices, ($/cwt.)

Enterprise	Region	Average G.M. Before	Average G.M. After	Change in G.M.	% Change in G.M.
Beef Feedlot	East	2.09	3.10	1.01	48.3
Beef Feedlot (after feed and livestock)	East	11.17	12.11	0.94	8.4
Beef Feedlot	West	1.81	1.79	-0.02	-1.1
Beef Feedlot (after feed and livestock)	West	8.57	8.47	-0.10	-1.2
Cow Calf	East	13.61	16.96	3.34	24.5
Cow Calf (after feed and livestock)	East	24.59	27.93	3.33	13.5
Cow Calf	West	12.41	13.38	0.97	7.8
Cow Calf (after feed and livestock)	West	21.41	22.35	0.95	4.4

Table 5.9: Percentage Change in Pork Variables for a Ten Percent Decline in Canadian Feed Grain Prices

Variable	Region	Impact	Average	Final
Disappearance	Can.	0.04	0.15	0.10
Net Exports 1/ (Canada/U.S.)		-0.14	11.63	13.59
Price of Hogs	West	0.08	-1.35	-1.08
	East	0.09	-1.84	-1.53
Production of Hogs	West	0.00	9.41	11.07
	East	0.00	0.68	0.45
	Can.	0.00	3.57	3.08
Value of Trade 2/	Can.	-0.04	8.03	12.5

1/ Change in million pounds.
2/ Change in million dollars.

Table 5.10: Percentage Change in Pork Producer Gross Margins for a Ten Percent Decline in Canadian Feed Grain Prices, ($/cwt.)

Enterprise	Region	Average G.M. Before	Average G.M. After	Change in G.M.	% Change in G.M.
Farrow to Finish	East	29.99	30.72	0.74	2.46
Farrow to Finish (after feed and livestock)	East	36.51	37.14	0.64	1.75
Farrow to Finish	West	26.40	27.30	0.90	3.41
Farrow to Finish (after feed and livestock)	West	33.01	33.82	0.81	2.45

5.4.5 Experiment Two. Summary

This experiment isolates the effects of a decline in Canadian grain prices relative to those in the United States. The results show that the fall in grain prices increases beef and pork production, disappearance and net exports while Canadian prices drop slightly. All livestock producers, with the exception of Western beef feedlot operators are shown to benefit from the grain price declines.

5.5 EXPERIMENT THREE: TEN PERCENT DECREASE IN THE U.S. PRICE OF CORN

This experiment differs from experiment two in that the price of corn is assumed to decline in the United States which causes prices of corn and barley to decline in Canada. Unlike the previous experiment U.S. beef and pork producers will now be reacting to the decreased feed prices as well as their Canadian counterparts.

5.5.1 The Beef Market

The initial impact of the decreased U.S. corn price is to decrease the price of corn in Eastern Canada by 9.21 percent and the price of barley in Western Canada by 3.67 percent (table 5.11). The decreases in feed prices cause production in Canada to fall (resulting from the perverse sign of current feed prices in the heifer and steer slaughter equation) while disappearance is relatively unaffected. The reduced supply results in increased imports. Canadian steer prices decrease by 0.35 to 0.52 percent because of the increase in beef production in the United States (which results from the negative sign on the current price of feed in the heifer and steer slaughter equation). Despite small decreases in steer prices, feeder calf prices increase following the decrease in feed costs. Inventories of cows and bulls are unaffected at this early stage in the simulation period.

By the second quarter in the simulation period the decreases in feed prices start to cause beef production in Canada to increase and steer prices to decline. These price decreases increase consumption, but by less than the increase in supply. The resultant excess supply is exported to the United States. The decreases in steer prices cause feeder calf prices to fall below base levels during the middle of the simulation period. Meanwhile, inventories of cows and bulls increase as a result of higher feeder calf prices early in the simulation period. At the end of the simulation period production and Eastern inventories are above the base but Western inventories fall below the base level. The interaction of inventories, feeder calf and steer prices within the beef cycle are clearly observed in this simulation following the initial shock to the system.

Table 5.11: Percentage Change in Beef and Feed Variables for a Ten Percent Decrease in the U.S. Price of Corn

Variable	Region	Impact	Average	Final
FEED				
Price of Corn	East	-9.21	-9.99	-10.00
Price of Barley	West	-3.67	-9.83	-10.00
BEEF				
Disappearance	Can.	0.14	1.71	0.81
Cow and Bull Inventory	West	0.02	-0.75	-1.83
	East	-0.01	1.87	1.15
	U.S.	0.07	0.70	-0.25
Net Exports[1/] (Canada/U.S.)		-1.58	5.48	-0.06
Price of Feeder Calves	West	0.25	-1.00	0.74
	East	1.40	1.33	1.23
Price of Steers	West	-0.35	-3.58	-1.40
	East	-0.52	-3.07	-1.43
	U.S.	-0.78	-3.07	-1.41
Production	Can.	-0.28	3.07	0.85
	U.S.	0.65	1.81	0.39
Value of Trade[2/]	Can.	-0.57	2.60	-0.19

1/ Change in million pounds.
2/ Change in million dollars.

5.5.2 Gross Margins. Beef

The results of a 10 percent decrease in the U.S. price of corn on gross margins for beef feedlot and cow-calf operators are presented in table 5.12. The gross margins for beef feedlot operators show an average increase of 12 cents per cwt. for Eastern Canada and a decline of 9 cents per cwt. in the West. The decrease in feed prices increases the supply of beef and decreases steer prices. In addition, the feedlot sector adjusts its bid prices for feeder cattle to account for the lower cost of feed, and this is reflected in an increase in feeder calf prices over the first few years of the simulation. Consequently, the decrease in steer prices and the increase in feeder calf prices largely offsets the impact of lower feed prices for the feedlot industry.

Following the decreases in feed prices cow-calf operators in the East are made better off by $0.51/cwt. despite most of the feed costs appearing as non-traded variables. Cow-calf operators in the West are slightly worse off by an estimated $0.40/cwt. The difference stems from slightly larger steer and feeder calf price declines in the West in comparison with the East.

5.12: Impact of a Ten Percent Decrease in the U.S. Price of Corn on Beef Producer Gross Margins, ($/cwt.)

Enterprise	Region	Average G.M. Before	Average G.M. After	Change in G.M.	% Change in G.M.
Beef Feedlot	East	2.09	2.22	0.12	5.74
Beef Feedlot (after feed and livestock)	East	11.17	11.20	0.03	0.27
Beef Feedlot	West	1.82	1.72	-0.09	-4.94
Beef Feedlot (after feed and livestock)	West	8.57	8.38	-0.19	-2.21
Cow Calf	East	13.61	14.12	0.51	3.75
Cow Calf (after feed and livestock)	East	24.59	25.09	0.50	2.03
Cow Calf	West	12.41	12.00	-0.40	-3.22
Cow Calf (after feed and livestock)	West	21.41	20.98	-0.43	-2.00

5.5.3 The Pork Market

The initial impact of the increased U.S. price of corn is minimal (table 5.13). Feed variables in the production equations are lagged four quarters so production is initially unaffected. Consequently, prices, disappearance and net exports are almost unchanged.

By the middle of the simulation period the decreased feed prices increase supply in the West (an average of 3.96 percent) while Eastern production is hardly affected (with an average decrease of 0.09 percent). As with the beef market the increase in supply forces prices down both in the East and the West (price declines in the East, despite the minimal change in production, can be explained by the existence of the equation linking U.S. and Eastern Canadian hog prices). The decreased hog prices increase consumption but by less than the increase in production. Consequently, exports by Canada to the U.S. at first increase however over the last four years of the simulation net exports are below the base level as a result of U.S. production increases.

Table 5.13: Percentage Change in Pork Variables for a Ten Percent Decrease in the U.S. Price of Corn

Variable	Region	Impact	Average	Final
Disappearance	Can.	0.01	1.30	1.43
Net Exports[1/] (Canada/U.S.)		-0.06	0.06	-0.74
Price of Hogs	West	-0.46	-6.38	-5.25
	East	-0.40	-5.60	-4.85
	U.S.	-0.54	-6.26	-4.98
Production of Hogs	West	0.00	3.96	4.50
	East	0.00	-0.09	-0.14
	Can.	0.00	1.25	1.01
	U.S.	0.00	3.48	2.82
Value of Trade[2/]		-0.02	-0.21	-3.37

1/ Change in million pounds.
2/ Change in million dollars.

5.5.4 Gross Margins. Pork

Despite decreased feed prices hog prices also fall with the increase in supply in the U.S. such that operators in both the East and West are worse off, on average, following the decline in the price of corn (table 5.14). However, gross margins are above those in the base run for the first year of the simulation.

5.5.5 Experiment Three. Summary

The simulation in which the U.S. corn price is decreased by ten percent results in increased production and decreased livestock prices. The gross margins show that feed price decreases may make cow-calf producers better off while providing few long-run benefits for beef feedlot and farrow to finish operators.

Table 5.14: Impact of a Ten Percent Decrease in the U.S. Price of Corn on Pork Producer Gross Margins, ($/cwt.)

Enterprise	Region	Average G.M. Before	Average G.M. After	Change in G.M.	% Change in G.M.
Farrow to Finish	East	29.99	28.17	-1.81	-6.03
Farrow to Finish (after feed and livestock)	East	36.51	34.60	-1.91	-5.23
Farrow to Finish	West	26.40	23.96	-2.44	-9.2
Farrow to Finish (after feed and livestock)	West	33.01	30.48	-2.52	-7.6

5.6 Summary and Comparison of Experiments

Having conducted the three experiments it may be useful to summarize and compare the impacts of the changes on key variables in the Canadian red meat market.

Table 5.15 shows the effects on beef and pork production, using the average multipliers, as the basis for comparison. A ten percent devaluation of the Canadian dollar has a small positive influence on Canadian red meat production. Production of beef is up by 0.46 percent and pork by even less at 0.14 percent. This result follows from the fact that feed prices also rise with the devaluation, and generally by more and more rapidly, in percentage terms than livestock prices. The middle row of table 5.15 shows that a ten percent decline in Canada's feed grain prices relative to U.S. prices results in a substantial output response of 5.44 percent for beef and 3.57 percent for pork. Even a ten percent decline in feed prices across North America has a larger impact on meat production in Canada than a ten percent devaluation. This suggests that the devaluation of the dollar during the late 1970's and early 1980's was not as important a factor affecting the level of livestock production as many commentators have suggested.

The differential impacts of a devaluation and a decline in feed prices is obvious in the multipliers for beef and pork consumption (table 5.16). The devaluation results in reduced meat consumption, of 2.82 percent for beef and 0.43 percent for pork, because beef and pork prices rise more rapidly than the general price level following the devaluation. This occurs in spite of an increasing supply of beef and pork. The opposite situation occurs in the case of a feed price

Table 5.15: Summary of Average Changes in Canada's Production of Beef and Pork for Three Policy Experiments

Experiment	Beef Production Quantity Change	Beef Production Percent Change	Pork Production Quantity Change	Pork Production Percent Change
Ten Percent Devaluation	2.1	0.46	0.5	0.14
Ten Percent Decline in Canadian Feed Grain Prices	24.3	5.44	12.1	3.57
Ten Percent Decline in Canadian and U.S. Feed Grain Prices	13.7	3.07	4.2	1.25

Table 5.16: Summary of Average Changes in Canada's Disappearance of Beef and Pork for Three Policy Experiments

Experiment	Beef Disappearance Quantity Change	Beef Disappearance Percent Change	Pork Disappearance Quantity Change	Pork Disappearance Percent Change
Ten Percent Devaluation	-13.5	-2.82	-1.4	-0.43
Ten Percent Decline in Canadian Feed Grain Prices	4.1	0.86	0.5	0.15
Ten Percent Decline in Canadian and U.S.Feed Grain Prices	8.2	1.71	4.2	1.30

decline. Since lower feed prices increase supply and decrease prices, consumption also increases particularily in the case where feed prices decline in the United States since this results in much larger price impacts.

Table 5.17: Summary of Average Changes in Canada's Net Exports of Beef and Pork for Three Policy Experiments

Experiment	Beef Net Exports Quantity Change	Beef Net Exports Percent Change	Pork Net Exports Quantity Change	Pork Net Exports Percent Change
Ten Percent Devaluation	15.5	210.9	1.9	149.2
Ten Percent Decline in Canadian Feed Grain Prices	20.0	272.6	11.6	923.0
Ten Percent Decline in Canadian and U.S. Feed Grain Prices	5.5	74.4	0.1	4.7

The net effect of supply and consumption changes are reflected in variations in net trade (table 5.17). A ten percent devaluation has a much larger impact on beef trade than on pork trade. In the case of beef the devaluation increased exports, on average, by 15.48 million pounds per quarter. During the last quarter of the devaluation experiment net exports were up by 26.7 million pounds compared to an increase of 2.6 million pounds in net pork exports (slightly less than a five percent increase). As shown in table 5.17 a ten percent decline in Canadian feed grain prices resulted in an average net trade effect on beef about 30 percent greater than the devaluation, and for pork about six times greater. However, in the case of beef, by the last quarter of the simulation the change in net exports, caused by the devaluation, of 26.7 million pounds was larger than that caused by the feed price decline of 25.0 million pounds.

A general feed price decline in both the U.S. and Canada has almost no affect on the average level of pork trade, but increases beef exports by 5.48 million pounds per quarter. On average,and in the short-run, a general feed price decline results in increased Canadian exports, however, in the long-run (i.e., the end of the simulation period) Canada's net exports of both beef and pork have fallen below the base level.

To summarize, a ten percent devaluation results in a sizable increase in net exports for beef (of approximately the same size as would be caused by a ten percent decline in Canadian feed grain prices) particularly in the long-run. Most of this increased trade is the result of decreases in Canadian consumption of beef rather than increases in supply. On the other hand the devaluation of the Canadian dollar has not had a large impact on net exports of pork, with the average effect being less than two million pounds per quarter.

The price impacts of the three experiments are shown in table 5.18.

Table 5.18: Summary of Average Changes in Canadian Producer Prices for Beef, Pork and Grain for Three Policy Experiments

Experiment	Percentage Changes							
	Steer West	Price East	Calf West	Price East	Hog West	Price East	Grain West	Price East
Ten Percent Devaluation	7.70	9.03	7.08	7.56	9.92	8.61	9.82	9.98
Ten Percent Decline in Canadian Feed Grain Prices	-2.42	-0.64	0.89	5.10	-1.35	-1.84	-10.00	-10.00
Ten Percent In Canadian and U.S. Feed Grain Prices	-3.58	-3.07	-1.00	1.33	-6.38	-5.60	-9.99	-10.00

There are no real surprises here; with a devaluation all Canadian prices increase although there are some differences in the elasticity of price transmission across commodities and between Eastern and Western Canada.

Table 5.19 summarizes the impacts on average gross margins from the three experiments. The ten percent devaluation increases gross margins by the largest amount of the three experiments with the largest increases for cow-calf operators, averaging $4.00 to $5.00 per hundred weight. The second largest increase is for farrow-to-finish pork producers of 3-4 dollars per hundred weight, while the smallest increase is for the feed lot sector where margins are up by $0.65-$1.70/cwt. These changes are somewhat larger than the changes resulting from a ten percent decline in Canadian feed grain prices and considerably larger than those resulting from a general ten percent decline in feed prices.

Table 5.19: Summary of Average Changes in Canada's Beef and Pork Producers Gross Margins for Three Policy Experiments

Experiment	Beef Feedlot East	Beef Feedlot West	Cow-Calf East	Cow-Calf West	Farrow to Finish East	Farrow to Finish West
Nominal Dollars/CWT						
Ten Percent Devaluation	1.70	0.65	5.39	4.38	3.11	3.76
Ten Percent Decline in Canadian Feed Grain Prices	1.01	-0.02	3.34	0.97	0.74	0.90
Ten Percent Decline in Canadian and U.S. Feed Grain Prices	0.12	-0.09	0.51	-0.40	-1.81	-2.44
Real Dollars (1972 = 100) per CWT a/						
Ten Percent Devaluation	0.79	0.30	2.35	1.96	0.95	1.35
Ten Percent Decline in Canadian Feed Grain Prices	0.50	-0.01	1.75	0.57	0.41	0.48
Ten Percent Decline in Canadian and U.S. Feed Grain Prices	0.09	-0.05	0.35	-0.19	-0.86	-1.19

a/ Deflated by the Wholesale Price Index

The figures just reported ignore the fact, that the devaluation of the Canadian dollar results in a higher rate of general price inflation. In the bottom half of table 5.19 all of the gross margins have been deflated by the wholesale price index to remove any money illusion. After correcting for the varying inflation rate the conclusions stated in the previous paragraph are generally unchanged, but the difference in gross margins resulting from a devaluation and a decline in Canadian feed grain prices are even closer than previously.

It is a common misconception that a devaluation which raises output prices by ten percent implies a ten percent improvement in a producer's well being. This hypothesis is explored in table 5.20 where the average change in output prices from a ten percent devaluation are compared to the average change in gross margins. The table shows that feedlot owners have benefited only slightly from the steer price increases resulting from a devaluation with 15-30 percent of the output price increase showing up as an increased return to the owners' labor, management and equity. On the other hand, nearly the total output price impact has been passed on to cow-calf producers. This results from the fact that for the cow-calf producer most inputs are treated as non-tradable. In addition, cow-calf producers benefit substantially from lower interest rates and this accounts for the fact that in Eastern Canada the cow-calf margin is up by more than the output price increase.

The impact of the devaluation on farrow-to-finish pork producers shows that about 50-60 percent of the output price increase shows up as an increase in gross margins.

Table 5.20: A Comparison of Average Product Price Changes and Gross Margin Changes Following a Ten Percent Devaluation

	Change in Output Price	Change in Gross Margin	Δ Gross Margin / Δ Steer Price
	(Dollars/cwt)		(percent)
Beef Feedlot			
East	5.70	1.70	29.8
West	4.62	0.65	14.1
Cow-Calf			
East	5.31	5.39	101.5
West	5.16	4.38	84.9
Farrow-to-Finish			
East	5.66	3.11	54.9
West	6.34	3.76	59.3

CHAPTER SIX

SUMMARY AND CONCLUSIONS

6.1 SUMMARY

Since late 1976 the Canadian dollar has devalued significantly vis-a-vis the United States dollar. Many commentators have suggested that this has generated large benefits for Canadian producers of red meats. Their arguments follow from the fact that trade in beef and pork flows freely between Canada and the United States and that the U.S. market is almost ten times as large as Canada. This set of economic circumstances leads to prices in Canada which largely reflect prices in the United States adjusted for the exchange rate and transportation costs. Thus, a decline in the value of the dollar leads to increases in the prices of beef and pork and benefits to producers within the livestock sector. This argument, however, fails to account for the fact that this set of economic circumstances also exists within the markets for many inputs into livestock production (eg., feed grains, protein meal, purchased livestock) and a devaluation of the dollar also leads to increases in the costs of producing beef and pork. Consequently, the benefits (or costs) of a devaluation to Canadian producers will depend upon

1. the transmission elasticity of livestock prices with respect to the exchange rate;

2. the transmission elasticity of input prices with respect to the exchange rate; and,

3. the mix of traded and non-traded items used in producing beef and pork.

The major objective of this research was to quantify the influence of the Canadian/U.S. exchange rate on the Canadian red meat sector and more explicitly, to estimate the true benefits, if any, of the Canadian devaluation to producers of beef and pork. The second objective was to evaluate the relative importance of the exchange rate compared to other variables important in the production of livestock.

In order to satisfy these objectives, an econometric model of the North American red meat market was specified, estimated and validated which allowed the impact of exchange rate changes on Canadian producers to be assessed. These include the impact of the devaluation on trade, consumer and producer prices, quantities demanded and supplied, and gross margins. A model is an appropriate methodology because it provides a controlled experiment in which the effect of changes in exchange rates can be observed in isolation, with all other variables held constant.

Since the devaluation of the Canadian dollar involves changes in other macroeconomic variables, the general price level in Canada was linked to the price level in the United States using the purchasing power parity theorem as the theoretical basis for doing so. Interest rates in Canada were also endogenized using the interest rate parity theorem. In order to include the effect of exchange rates on income levels multipliers were obtained from the RDFX model and were incorporated directly into the model.

In order to measure the impact of a devaluation on the well-being of livestock producers, enterprise budgets were used. Gross margins were calculated for beef feedlot, cow-calf and farrow-to-finish operations in both Eastern and Western Canada. While the use of budget data suffers from a number of drawbacks their use does make explicit the distinction between traded and non-traded inputs and provides a rough indication of the influence of exchange rates on producer well-being.

Three experiments were run using the model. Impact, (1st quarter) average and (over 44 quarters) and long-run (44th quarter) elasticities and multipliers were obtained for all of the endogenous variables and these formed the basis for the comparisons among the different experiments. The first experiment was to devalue the Canadian dollar by ten percent. This provided information on how the beef and pork markets and producer gross margins were affected by a specific change in the exchange rate. The second experiment was to lower the Canadian prices for feed grains by ten percent while holding the United States price of corn at its original level. The third experiment was to decrease the U.S. price of corn by ten percent. The results of the second and third experiments were then compared with those for a ten percent devaluation of the dollar. This enabled an assessment of the relative importance of changes in the exchange rate compared to other variables important in the production of livestock.

6.2 CONCLUSIONS

The devaluation of the Canadian dollar was shown to have the expected impacts on Canadian red meat and grain prices. In general, feed grain prices increase by more, in percentage terms, and more rapidly than livestock prices. Canadian beef and pork production not increase substantially as a result of the devaluation of the Canadian dollar as feed price increases largely offset the impacts of output price increases. However, the demand for beef and pork is reduced as a result of the dollar devaluation driving up the price of meat. This is particularly true for beef and the decline in the amount of beef demanded has led to a substantial increase in beef exports. Net exports of pork were also up following the devaluation but by considerably smaller amounts than for beef. A ten percent decline in Canadian feed grain prices would have about the same impact on beef exports as a devaluation but a much larger impact on pork exports.

Measured either in real or nominal terms a ten percent devaluation

of the dollar is shown to have a more beneficial impact on producer gross margins than either a ten percent decline in Canadian feed grain prices or a combined ten percent decline in United States and Canadian feed grain prices. This conclusion may give the careful reader some cause for concern. If gross margins for beef are increased the most in the case of a ten percent devaluation, why is supply increased the least? In the context of the model this question is easily answered but from a "real world" point of view it is more troubling. The reason for the small simulated supply increase resulting from the devaluation is two-fold. First, following a devaluation the general level of prices (WPI) also increases and therefore the changes in nominal gross margins do not account for money illusion as is done in the supply equations. However, table 5.19 shows that even after deflating the gross margins the increase is the largest in the case of the devaluation. Consequently, this is not a complete answer to the question. Second, and of most importance, all of the supply functions in the model are functions of only <u>one</u> input, real feed grain prices. On the other hand the gross margins include a much more comprehensive assortment of production costs. Since feed grain costs are the item which increases in price by the most following a devaluation it is not surprising that supply changes and gross margin changes are seemingly in conflict. The authors in an attempt to resolve this dilemma attempted respecifying all of the supply functions using a variable including all of the costs included in the gross margin calculation. In general, the results of this attempt were very disappointing. The newly created cost variables often had the wrong sign, or if of the right sign low t-values. Further attempts to include only the assumed costs of feed grains, protein feeds and interest costs likewise led to results generally inferior to those obtained using just feed grain prices. The reasons for these results are not at all obvious. However, the values of some inputs such as silage and hay are imputed costs and therefore may not reflect the value placed on them by producers. In addition, the cost of capital is to some extent an opportunity cost but nonetheless it is difficult to reconcile producers' apparent lack of response to sizeable changes in the real rate of interest with economic theory. Consequently, this seeming contradiction between the supply responses in the model and the gross margin calculations is left as a problem to be explored in further research. In the authors' opinion it seems quite possible, however, that the gross margin calculations overstate the true benefits accruing to producers from a devaluation.

Ignoring the problem identified above, it seems clear that cow-calf producers would benefit the most from a devaluation of the Canadian dollar. In fact, these benefits may approach the full amount of the feeder calf price increase which was found to be 7-7.5 percent for a ten percent devaluation. This is the case because many of the inputs used in producing calves (eg. pasture) are nontraded. In addition, cow-calf producers benefit from the lower interest rates accompanying a devaluation. In contrast, benefits for feedlot operators from a devaluation are small. This is primarily because any changes in profitability in the feedlot sector is quickly bid into the price of feeder cattle.

Farrow-to-finish pork producers would benefit from a devaluation of the dollar but these benefits are perhaps only 50-60 percent of the associated output price increase (see table 5.19).

6.3 LIMITATIONS OF THE STUDY

Although this research provides valuable information in an area that has been largely ignored, it is subject to a number of limitations that should be mentioned among the concluding remarks.

One limitation of the model is that it solves only at the final product level (i.e. beef and pork meat). The model does not include a structural representation of the feeder calf and cattle market and ignores trade in live animals. Previous research has shown that this market is particularly difficult to model. However, a more complete analysis of the effects of exchange rates on the agricultural industry would benefit from the inclusion of both intermediate and final product markets.

A further limitation is the method used to link macroeconomic variables. Although the method used is adequate, a more sophisticated treatment of these variables would improve the reliability of the results.

Weaknesses in the model also lie in the specification of costs of production within the livestock supply equations. Typically, only feed grain costs are included thus excluding the costs of other inputs such as protein supplements, purchased livestock and interest rates. This results in contradictions between simulated supply responses and calculated gross margins.

The changes in gross margins following a shock to the model are quite sensitive to the technical coefficients employed in the budgets. Small changes in these coefficients can change simulated benefits to losses. Unfortunately, there is little uniformity within the farm management literature and it was impossible to find an unambigous measure of these coefficients.

A final limitation is that the two stage least squares (2SLS) estimates failed to produce satisfactory results and the use of ordinary least squares (OLS) implies that the estimated coefficients are influenced by simultaneous equation bias.

APPENDIX I

DATA DEFINITIONS AND SOURCES

ENDOGENOUS VARIABLE DESCRIPTIONS

AVFOER34 Forward exchange rate, Canadian dollars per U.S. dollar. (Bank of Canada).

BF1SLGE Western Canada value of silage, $/ton. (Agriculture Alberta).

BF2SLGE Eastern Canada value of silage, $/ton. (Ontario Cattlemen's Association).

CPI3 Canada Consumer Price Index for all items, 1971=100. (Statistics Canada: The Consumer Price Index Cat. 62-001).

CWBF3 Canada average cattle carcass weight, lb./head. (Agriculture Canada: Canadian Livestock and Meat Trade Report, Livestock Market Review).

CWBF4 U.S. average cattle carcass weight, lb./head. (U.S. Dept. of Agriculture: Livestock and Meat Statistics).

DBF3 Canada disappearance of beef, mil.lb. From the identity: Disappearance = supply + beginning stocks - ending stocks - net trade.

DBF4 U.S. disappearance of beef, mil.lb. From the identity: Disappearance = supply + beginning stocks - ending stocks - net trade.

DBW1 Western Canada federally inspected slaughter of cows and bulls, '000 head. (Agriculture Canada: Canadian Livestock and Meat Trade Report).

DBW2 Eastern Canada federally inspected slaughter of cows and bulls, '000 head. (Agriculture Canada: Canadian Livestock and Meat Trade Report).

DBW4 U.S. federally inspected slaughter of cows and bulls, '000 head. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).

DHFS3 Canada federally inspected slaughter of heifers and steers, '000 head. (Agriculture Canada: Canadian Livestock and Meat Trade Report, Livestock Market Review).

DHFS4 U.S. federally inspected slaughter of heifers and steers, '000 head. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).

DPK3 Canada disappearance of pork, mil.lb. From the identity: Disappearance = supply + beginning stocks - ending stocks - net trade.

DPK4 U.S. disappearance of pork, mil.lb. From the identity: Disappearance = supply + beginning stocks - ending stocks - net trade.

DRPBF3 Canada deflated retail price of beef. From the identity: Canada CPI for beef/Canada CPI for all items.

DRPBF4 U.S. retail price of beef, cents/lb. From the identity: U.S. retail price of beef/U.S. CPI for all items.

DRPPK3 Canada deflated retail price of pork. From the identity: Canada CPI for pork/Canada CPI for all items.

DRPPK4 U.S. deflated retail price of pork, cents/lb. From the identity: U.S. retail price of pork/U.S. CPI for all items.

FORPREM Forward premium on foreign exchange. From the identity: (AVFOER34-ER34) * 4/ER34.

FPCO2 Price of No.2 yellow corn on track, Chatham, $/tonne. (Statistics Canada: Grains and Oilseeds Review Cat. 32-012).

IBF3 Canada closing stocks of beef, mil.lb. (Statistics Canada: Canadian Livestock and Meat Report, Livestock Market Review).

IBF4 U.S. closing stocks of beef, mil.lb. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).

IBWD1DEC Western Canada closing inventory of cows and bulls from both beef and dairy sectors, '000 head. (Statistics Canada: Livestock and Animal Product Statistics, Cat. 23-203). Note: Inventory taken December 1st prior to 1973 and on January 1st since.

IBWD2DEC Eastern Canada closing inventory of cows and bulls from beef and dairy sectors, '000 head. (Statistics Canada: Livestock and Animal Products Statistics, Cat. 23-203). Note: Inventory taken Dacember 1st prior to 1973 and on January 1st since.

IBWD4DEC U.S. closing inventory of cows and bulls from both beef and dairy sectors, '000 head. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics). Note: Inventory taken on December 1st prior to 1973 and on January 1st since.

IBW1DEC Western Canada closing inventory of cows and bulls from the beef sector, '000 head. (Statistics Canada: Livestock and Animal Products Statistics, Cat. 23-203). Note: Inventory taken on December 1st prior to 1973 and on January 1st since.

IBW2DEC Eastern Canada closing inventory of cows and bulls from the beef sector, '000 head. (Statistics Canada: Livestock and Animal Products Statistics, Cat. 23-203). Note: Inventory taken on December 1st prior to 1973 and on January 1st since.

IBW4DEC U.S. closing inventory of cows and bulls from the beef sector, '000 head. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics). Note: Inventory taken on December 1st prior to 1973 and on January 1st since.

IPK3 Canada closing stocks of pork, mil.lb. (Statistics Canada: Stocks of Frozen Meat Products, Cat. 32-012).

IPK4 U.S. closing stocks of pork, mil.lbs. (U.S. Department of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).

NT3BF4 Canada to U.S. net trade in beef, mil.lb., exports - imports. (Statistics Canada: Exports by Commodity, Cat. 65-004, Imports by Commodity, Cat. 65-007).

NT3PK4 Canada to U.S. net trade in pork, mil.lbs., exports - imports. (Statistics Canada: Exports by Commodity, Cat. 65-004, Imports, by Commodity, Cat. 65-007).

OPBA3 Prairie Provinces off board price of barley, $/tonne. (Canadian Grain Commission: Statistics Weekly).

PBW1 Western Canada (Calgary) Price of cows and bulls, $/cwt. (Agriculture Canada: Livestock Market Review).

PBW2 Eastern Canada (Toronto) price of cows and bulls, $/cwt. (Agriculture Canada: Livestock Market Review).

PCDY3 Canada per capita disposible income, $/capita/quarter. From the identity: Canada disposible income/Canada population.

PCO3 Canada price of feed, $/tonne. From the identity: 0.582 * OPBA3 + 0.418 * FPCO2. Note: The weightings are those used in PSS3.

PFC1 Western Canada (Calgary) price of feeder calves (400 - 600 lbs.), $/cwt. (Agriculture Canada: Canadian Livestock and Meat Trade Report, Livestock Market Review).

PFC1A Western Canada (Calgary) annual average deflated price of feeder calves (400 - 600 lbs.), $/cwt. From the identity: PFC1A = PFC1/WPI3 + PFC(-1)/WPI(-1) + PFC1(-2)/WPI3(-2) + PFC1(-3)/WPI3(-3)) * 0.25.

PFC2 Eastern Canada (Toronto) price of feeder calves (400 - 600 lbs.), $/cwt. (Agriculture Canada: Canadian Livestock and Meat Trade Report, Livestock Market Review).

PFC2A Eastern Canada (Toronto) annual average deflated price of feeder calves (400 - 600 lbs.), $/cwt. From the identity: PFC2A = (PFC2/WPI3 + PFC2(-1)/WPI3(-1) + PFC2(-2)/WPI3(-2) + PFC2(-3)/WPI3(-3)) * 0.25.

PFC4 U.S. (Kansas City) price of choice feeder calves (400 - 600 lbs.), $/cwt. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).

PFC4A U.S. (Kansas City) annual average deflated price of feeder calves (400 - 600 lbs.), $/cwt. From the identity: PFC4A = (PFC4/WPI4 + PFC4(-1)/WPI(-1) + PFC4(-2)/WPI(-2) + PFC4(-3)/WPI(-3)) * 0.25.

PFSALB Western Canada (Calgary) price of feeder steers (600-700 lbs.), $cwt. (Agriculture Canada: Canadian Livestock and Meat Trade Report, Livestock and Meat Review).

PFSSASK Western Canada (Saskatoon) price of feeder steers (600-700 lbs.), $/cwt. (Agriculture Canad: Canadian Livestock and Meat Trade Report, Livestock Market Review).

PHAY2 Eastern Canada value of hay, $/ton. (Ontario Ministry of Agriculture and Food).

PHG1 Western Canada (Edmonton) price of index 100 hogs, $/cwt. (Agriculture Canada: Canadian Livestock and Meat Trade Report, Livestock Market Review).

PHG2 Eastern Canada (Toronto) price of index 100 hogs, $/cwt. (Agriculture Canada: Canadian Livestock and Meat Trade Report, Livestock Market Review).

PHG3 All Canada price of index 100 hogs, $/cwt. From the identity: 0.379 * PHG1 + 0.621 PHG2. Note: Weights given based on an average 37.9 percent of marketings occurring in West and 62.1 percent in East.

PHG4 U.S. price of barrows and gilts at seven markets, $/cwt. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).

PRM1 Western Canada (Kamloops) price of rapeseed meal, $/ton. (Livestock Feed Board of Canada: Grain Facts).

PSM1 Western Canada (Kamloops) price of soybean meal (49% protein), $/tonne. (Livestock Feed Board of Canada: Grain Facts).

PSM2 Eastern Canada (Toronto) price of soybean meal (49% protein), $/tonne. (Livestock Feed Board of Canada: Grain Facts).

PSS1 Western Canada (Edmonton) price of slaughter steers (A1,2), $/cwt. (Agriculture Canada: Canadian Livestock and Meat Trade Report, Livestock Market Review).

PSS2 Eastern Canada (Toronto) price of slaughter steers (A1,2), $/cwt. (Agricultural Canada: Canadian Livestock and Meat Trade Report, Livestock Market Review).

PSS3 All Canada price of steers, $/cwt. From the identity: 0.582 * PSS1 + 0.418 * PSS2.

PSS4 U.S. (Omaha) price of slaughter steers (900 - 1100 lbs.), $/cwt. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).

QBF3 Canada federally inspected slaughter of beef, mil.lbs. From the identity: QBF3 = CWBF3 * (DHFS3 + DBW1 + DBW2)/1000.

QBF4 U.S. federally inspected slaughter of beef, mil.lbs. From the identity: QBF4 = CWBF4 * (DHSF4 + DWB4)/1000.

QPK1 Western Canada production (slaughter) of pork, mil.lbs. (Agriculture Canada: Canadian Livestock and Meat Trade Report, Livestock Market Review).

QPK2 Eastern Canada production (slaughter) of pork, mil.lbs. (Agriculture Canada: Canadian Livestock and Meat Trade Report, Livestock Market Review).

QPK3 All Canada production of pork, mil.lbs. From the identity: QPK1 + QPK2.

QPK4 U.S. production of pork, mil.lbs. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).

RPBF3 Canada CPI for beef, 1971=100. (Statistics Canada: Consumer Prices and Price Indexes, Cat. 62-010).

RPBF4 U.S. production of pork, mil.lbs. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).

RPPK3 Canada CPI for pork, 1971=100. (Statistics Canada: Consumer Prices and Price Indexes, Cat. 62-010).

RPPK4 U.S. retail price of pork, cents/lb. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).

RTB3 Interest rate on treasury bills, percent. (Bank of Canada: Bank of Canada Review).

VOTBF3 Value of Canada's net exports of beef to the U.S. From the identity: PSS3 * NT3BF4.

VOTPK3 Value of Canada's net exports of pork to the United States. From the identity: PHG3 * NT3PK4.

WAPK3 Canada average weekly earnings in the slaughtering and meat processing industry, $/employee/week. (Statistics Canada: Emoloyment, Earnings and Hours, Cat. 72-002).

WP13 Wholesale price index, 1935-39=100. (Statistics Canada: Prices and Price Indexes, Cat. 62-002).

EXOGENOUS VARIABLE DESCRIPTIONS

CPI4 U.S. CPI for all items, seasonally adjusted, 1967=100. (U.S. Dept. of Commerce: Statistical Abstract of the U.S.).

DY3 Canada disposible income, $mil. (Statistics Canada: National Income and Expenditure Accounts, Cat. 13-201).

D19712 Equals one for 1971 2nd calendar quarter, zero otherwise.

D19732 Equals one for 1973 2nd calendar quarter, zero otherwise.

D19733 Equals one for 1973 3rd calendar quarter, zero otherwise.

D19734 Equals one for 1973 4th calendar quarter, zero otherwise.

D19744 Equals one in 1974 4th calendar quarter, zero otherwise.

D7423 Equals one in 1974 2nd and 3rd calendar quarters, zero otherwise.

D7823 Equals one in 1978 2nd and 3rd calendar quarters, zero otherwise.

D19803 Equals one in 1980 3rd quarter, zero otherwise.

DQUEX Equal to a linear time trend between 1977(3) and 1980(1), zero before 1977(3) and eleven after 1980(1).

ER34 Canada - U.S.A. exchange rate, $Can./$U.S.A. (Bank of Canada: Bank of Canada Review).

IBA3 Barley total stocks at end of crop year, '000 tonnes. (Statistics Canada: Supply and Disposition of Major Grains in Canada, Crop Year Aug.1 - July 31).

IDC1DEC Western Canada closing inventory of dairy cows, '000 head. (Statistics Canada: Livestock and Animal Product Statistics, Cat. 23-203).

IDC2DEC Eastern Canada closing inventory of dairy cows, '000 head. (Statistics Canada: Livestock and Animal Product Statistics, Cat. 23-203).

IDC4DEC U.S. closing inventory of dairy cows, '000 head (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).

IM1BF9 Western Canada imports of beef from all countries excluding U.S.A., mil.lbs. (Statistics Canada: Trade of Canada: Exports by Commodity, Cat. 65-004).

IM2BF9 Eastern Canada imports of beef from all countries excluding U.S.A., mil.lbs. (Statistics Canada: Trade of Canada: Exports by Commodity, Cat. 65-004).

IM4BF9 Imports of beef to U.S.A. from all countries excluding Canada, mil.lbs. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).

IM4PK9 Imports of pork to U.S.A. from all countries exluding Canada, mil. lbs. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistivs).

JS1 Equals one in 1st calendar quarter, zero otherwise.

JS2 Equals one in 2nd calendar quarter, zero otherwise.

JS3 Equals one in 3rd calendar quarter, zero otherwise.

JS4 Equals one in 4th calendar quarter, zero otherwise.

NT3BF9 Canada net trade in beef to countries excluding U.S., mil.lbs., exports - imports. (Statistics Canada: Trade of Canada: Exports by Commodity, Cat. 65-004, Trade of Canada: Imports by Commodity, Cat. 65-007).

NT3PK9	Canada net trade in pork to countries excluding U.S., mil.lbs., exports - imports. (Statistics Canada: Trade of Canada: Exports by Commodity, Cat. 65-004, Trade of Canada: Imports by Commodity, Cat. 65-007).
NT4PK9	U.S. net trade in pork to countries excluding Canada, mil. lbs., exports - imports. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).
PCDY4	U.S. per capita disposible income, $/capita/quarter, (U.S. Dept. of Commerce: Statistical Abstract of the U.S.).
PCO4	United States price of No.2, yellow corn, Chicago, $/ton (U.S.D.A., Feed Outlook and Situation).
POPN3	Canada population, mil. (Statistics Canada: Canadian Statistical Review, Cat. 11-003).
POPN4	U.S. population, mil. (U.S. Dept. of Commerce: Statistical Abstract of the U.S.).
PSM4	U.S. (Decatur) price of soybean meal (44% protein), $/tonne (U.S. Dept. of Agriculture: Feed Outlook and Situation Report).
RPCK4	U.S. retail price of chicken, cents/lb. (U.S. Dept. of Agriculture: Livestock and Meat Situation, Livestock and Meat Statistics).
RWAPK3	Canada real average weekly earnings in the slaughtering and meat processing industry. From the identity: WAPK3/CPI3.
TIME	Time trend variable, equal to 1 in 1961(1), 1.25 in 1961(2), 1.50 in 1961(3), 1.75 in 1961(4), 2 in 1962(1), etc.
UNEMPLT	Unemployment rate, percent. (Statistics Canada: The Labour Force, Cat. 71-001).
WAPK4	U.S. average weekly earnings in packing plants, $/week. (U.S. Dept. of Labor Statistics: Employment and Earnings).
WPI4	U.S. wholesale price index, 1967=100. (U.S. Dept. of Commerce: Statistical Abstract of the U.S.).
RTB4	Interest rate on U.S. treasury bills, percent. (U.S. Dept. of Commerce: Statistical Abstract of the U.S.).

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