THE UNIVERSITY OF MANITOBA

AN ANALYSIS OF SLAUGHTER HOG PRICING MECHANISMS IN THE PRAIRIE PROVINCES, 1951-1980

by

CHARLES L. PEARSON

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ABSTRACT

Major structural changes have occurred in the marketing mechanisms used to establish prices for Canadian slaughter hogs during the period 1951 through 1980. These changes were mainly the result of producer concerns about the ability of the market to establish slaughter hog prices which accurately reflect regional supply and demand conditions. The adoption of alternative marketing mechanisms such as the teletype Dutch auction, Dutch clock and formula pricing were due to swine producers attempts to improve the competitiveness of the slaughter hog market.

The overall objective of this thesis was to examine the influence of slaughter hog marketing mechanism changes in the provinces of Manitoba, Saskatchewan, Alberta and Ontario as to market performance. Univariate residual cross-correlation analysis was selected as the appropriate methodology. Average weekly slaughter hog prices established on the Winnipeg, Saskatoon, Edmonton and Toronto markets for the period 1951 through 1980 were used, as were average weekly slaughter hog prices for the seven central United States markets for the years 1973 through 1980. The analysis was conducted for two of the markets at a time with the data separated into appropriate time periods reflecting changes that had occurred in marketing mechanisms.

Results show changes have occurrred in the lead lag relationships between markets during the study period. The strongest relationship between Canadian market price changes occurred at zero lag (less than one week) during all periods, indicating an efficient transfer of

pricing information. Toronto price changes tended to occur instantaneously with or lead price changes on the three western markets. The analysis, however, did not hold true for the Edmonton-Toronto markets during the time prior to Alberta establishing a compulsory marketing mechanism. During these two periods, the Edmonton and Toronto markets exhibited a feedback relationship. For the years 1973 through 1980, results indicated slaughter hog prices on the seven central United States markets changed instantaneously with Toronto and Winnipeg, while price changes on the Saskatoon and Edmonton markets tended to lag the United States.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1

1. INTRODUCTION

Significant changes have occurred in the structure of the Canadian slaughter hog industry since the end of World War II.

Historically Western Canada has produced more hogs than it consumes and Eastern Canada has had to import pork to satisfy consumer demands. The trend in recent years has been a decrease in Western Canadian hog production relative to Eastern Canada[1] (see Table 1). These changes have altered the traditional patterns of pork movement in Canada. The province of Quebec has increased its share of total Canadian hog production in recent years due to the presence of provincial government subsidies and the vertical integration of swine producers with feed companies[2]. These shifts in production have meant that surplus pork produced in Western Canada has been exported on the international market.

The distribution of Canadian slaughter hog production has varied considerably over the study period of 1951-1980. These changes are illustrated by Table 1. Federally inspected hog slaughter in Canada ranged from a low of 4 488 007 head in 1951 to a high of 12 927 452

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[1] Western Canada refers to provinces west of the Manitoba-Ontario border, and Eastern Canada to provinces east of the Manitoba-Ontario border.

[2] W.H. Horner et al., Western Canadian Agriculture to 1990, (Calgary: Canada West Foundation, 1980), pp. 117-122.

Table 1. Federally Inspected Hog Slaughter in Western Canada in Relation to Total Canadian Federally Inspected Hog Slaughter

	Total Canadian Federally Inspected Hog Slaughter	Western Canadian Federally Inspected Hog Slaughter	Percentage Federally Inspected Hog Slaughter in Western Canada
	Head		Percent
1951	4 488 007	1 601 138	35.7
1952	6 234 145	2 384 900	38.3
1953	4 611 312	2 181 193	47.3
1954	4 679 214	2 219 604	47.4
1955	5 543 787	2 671 868	48.2
1956	5 548 289	2 545 402	45.9
1957	4 971 477	2 298 452	46.2
1958	5 963 928	2 949 310	49.6
1959	8 020 766	3 841 574	47.9
1960	6 182 315	2 855 590	46.2
1961	5 849 875	2 741 574	46.8
1962	6 031 933	2 647 521	43.9
1963	5 909 506	2 158 676	36.5
1964	6 627 600	2 650 522	39.4
1965	6 421 226	2 724 516	42.4
1966	6 129 632	2 418 601	39.4
1967	7 336 912	2 939 701	40.1
1968	7 423 754	3 066 780	41.3
1969	6 973 190	2 765 029	39.7
1970	8 280 481	3 582 977	43.2
1971	9 742 759	4 631 047	47.5
1972	9 357 143	4 215 064	45.0
1973	8 721 921	4 024 695	46.1
1974	8 939 335	3 839 852	43.0
1975	7 656 334	2 751 472	35.9
1976	7 493 245	2 457 524	32.8
1977	8 007 341	2 578 973	32.2
1978	8 934 470	2 656 480	29.7
1979	11 030 840	3 155 835	28.6
1980	12 927 452	3 666 585	28.4

Source: Agriculture Canada, Livestock and Meat Review, (Ottawa: Annual, Various Issues).

head in 1980. Federally inspected slaughter in Western Canada varied from a low of 1 601 138 in 1951 to a high of 4 631 047 in 1971. Column 3 expresses federally inspected hog slaughter in Western Canada as a percentage of total Canadian federally inspected hog slaughter. This percentage has varied from a low of 28.4 percent of total federally inspected slaughter in 1980 to a high of 49.6 percent in 1958.

Changes have occurred in the mechanisms by which slaughter hogs are marketed and prices established. These changes have occurred as a result of hog producers concerns about the competitiveness of the marketing systems and the ability of prices established by these markets to accurately reflect supply and demand conditions. Originally, hog prices were established at major livestock terminal markets. There was a gradual decline in the proportion of hogs that were marketed through these terminal markets although they continued to serve, for a time, as the basis for pricing on alternative market channels. Hog producers felt they were in a weak bargaining position relative to the large packing companies and therefore, adopted alternative marketing mechanisms to improve this situation. At present, the provinces (included in this study) of Manitoba, Saskatchewan, Alberta and Ontario have compulsory marketing systems where all slaughter hogs are used in determining prices. The objective of these marketing systems is to encourage competitive bidding among the buyers and to establish the highest prices possible for hog producers.

Changes in the slaughter hog marketing mechanisms that would theoretically result in more competitive prices still did not reduce the level of controversy in the industry. This was particularly true in

Western Canada during the 1970's. A prime concern of Western Canadian hog producers during this period was the allegedly wide price differential between the prairie markets and that of Toronto. Prairie producers felt that the price differentials were wider than could be justified on the basis of transfer costs between two competitive markets. Table 2 illustrates the annual price differential between the Toronto, Winnipeg and Edmonton markets.

1.1 Justification for Study

A historical analysis of the changes in pricing mechanisms is warranted to gather evidence on the ability of electronic marketing systems to improve market performance. This analysis should include both a description of the theoretical improvements in the market and an evaluation of the results on measurable aspects of pricing efficiency.

The pricing mechanisms now in use by the major slaughter hog markets provide a working example of electronic marketing systems as applied to an agricultural commodity. Several other livestock markets and agricultural products are under study for possible adoption of these alternative marketing mechanisms. Recent papers published for the North Central Project Number 117 express concern about the non-competitive nature of the red meat pricing mechanisms currently in use in the United States[3,4].

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[3] D.L. Hayenga, Formula Pricing and Price Reporting Problems in the Markets for Beef and Pork, Studies of the Organization and Control of the U.S. Food System, N.C. Project No. 117, Working Paper 32, May 1979.

[4] _____, Pork Pricing Systems: The Importance and Economic Impact of Formula Pricing, Studies of the Organization and Control of the U.S. Food System, N.C. Project No. 117, Working Paper 37, August 1979.

Table 2. Weighted Average Annual Prices for Slaughter Hogs on Toronto, Winnipeg and Edmonton Markets and Price Differentials

	Toronto[1]	Toronto-Winnipeg Price Differential	Winnipeg[1]	Winnipeg-Edmonton Price Differential	Edmonton[1]
			Dollars per CWT		
1951	32.85	2.00	30.85	(-1.85)	32.70
1952	25.70	1.25	24.45	(-0.15)	24.60
1953	30.40	3.00	27.40	(-1.38)	28.78
1954	30.90	3.05	27.85	(-0.20)	28.05
1955	25.05	3.00	22.05	(-0.15)	22.20
1956	26.50	3.10	23.40	0.00	23.40
1957	30.05	1.85	28.20	0.65	27.55
1958	28.13	2.93	25.20	0.61	24.59
1959	23.80	2.50	21.30	0.84	20.46
1960	23.75	2.10	21.65	1.02	20.63
1961	27.30	2.45	24.85	1.05	23.80
1962	28.60	2.95	25.65	0.25	25.40
1963	27.80	2.00	25.80	(-0.60)	26.40
1964	27.30	2.75	24.55	0.70	23.85
1965	33.40	1.75	31.65	3.30	28.35
1966	35.90	1.45	34.45	1.35	33.10
1967	30.70	2.15	28.55	1.85	26.70
1968	30.80	1.70	29.10	1.60	27.50
1969	35.70	0.25	35.45	2.15	33.30
1970	32.20	3.00	29.20	0.80	28.40
1971	25.80	2.95	22.85	1.60	21.25
1972	37.39	3.39	34.00	1.99	32.01
1973	54.66	3.35	51.31	1.39	49.92
1974	50.29	4.17	46.12	1.26	44.86
1975	67.22	4.67	62.55	(-2.41)	64.96
1976	64.10	5.07	59.03	(-0.84)	59.87
1977	60.97	4.19	56.78	(-0.67)	57.45
1978	69.80	1.97	67.83	0.32	67.51
1979	64.15	0.00	64.15	(-0.20)	64.35
1980	59.08	2.41	56.67	(-0.55)	57.22

[1]Weighted average annual prices for: Grade B hogs, warm dressed weight prior to 1963; Grade A hogs from 1963 through 1968; Index 100 slaughter hogs from 1969.

Source: Agriculture Canada, Livestock and Meat Review, (Ottawa: Annual, Various Issues).

Henderson examined the applicability of electronic pricing mechanisms for pricing red meat products in the United States[5]. Other studies have examined alternative selling methods for slaughter cattle[6,7].

Qualitative analyses have examined the effect of changes in marketing mechanisms on pricing efficiency. Quantitative measures of pricing efficiency need to be explored for evaluating marketing performance.

> Alternative pricing and trading systems are being viewed as variables rather than constants in the marketing system. Decisions regarding pricing systems require quantification of various pricing efficiency dimensions.[8]

A historical review is needed relating changes in price relationships among the four Canadian livestock markets as to the alternative marketing mechanisms employed during the study period. This analysis will provide insight into the ability of alternative marketing mechanisms (i.e. a change in market structure) to influence or establish competitive prices. The implications of adopting similar marketing techniques for other agricultural commodities will be of considerable interest to producer groups.

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[5] D.R. Henderson, Some Considerations in the Application of Electronic Marketing to Meat, Studies of the Organization and Control of the U.S. Food System, N.C. Project No. 117, Working Paper 35, July 1979.

[6] R.D. Johnson, "An Economic Evaluation of Alternative Marketing Methods for Fed Cattle," (Ph.D. Dissertation, University of Nebraska, 1971).

[7] L. Martin, R.R. Richards and W.R. Usborne, An Economic Comparison of Alternative Selling Methods for Slaughter Cattle in Ontario, (Guelph: School of Agricultural Economics and Extension Education, University of Guelph, Publication No. AEEE/79/1, January 1979).

[8] D.G. Frahm and L.F. Schrader, "An Experimental Comparison of Pricing in Two Auction Systems," American Journal of Agricultural Economics, Vol. 52, No. 4 (November 1970), p. 528.

1.2 Objectives

The overall objective of this thesis is to examine the influence of slaughter hog marketing mechanism changes in the provinces of Manitoba, Saskatchewan, Alberta and Ontario as to market performance.

The specific objectives are:

(1) review the historical changes which have occurred in the hog markets under study between 1951 and 1980;

(2) review the literature to develop a theoretical basis for evaluating market performance;

(3) descriptively evaluate the influence of slaughter hog marketing mechanism changes on market performance;

(4) apply statistical tests to determine if marketing mechanism changes have altered the relationship between slaughter hog prices established on the above markets.

1.3 Data

Weekly slaughter hog price data was used in this analysis. The data was obtained from the Livestock and Meat Trade Report[9]. Winnipeg, Saskatoon, Edmonton and Toronto were the markets selected for analysis. These markets represent the major provinces which have implemented alternate marketing mechanisms during the study period.

Canadian slaughter hog prices are reported on a warm dressed weight basis. Prices are reported for grade B slaughter hogs from 1951 to 1962, grade A slaughter hogs from 1963 to 1968 and Index 100 slaughter

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[9]Agriculture Canada, Livestock and Meat Trade Report (Ottawa: Weekly, Various Issues).

hogs from 1969 to 1980. De Graff describes the slaughter hog grading system which has existed in Canada since 1969 in the following manner:

> In 1969, the old grading system was replaced by the so called Index-100 system. The index reflects the predicted value from each carcass and is calculated by a complex formula. Basic to the formula are measurements of the maximum back fat thickness at the shoulder and the loin. These measurements are taken by federal graders at the packing plants. As the basis of each sale is the assumption that all hogs in a lot are Index 100, producers will receive more for grades indexed over 100 and less for those below. For instance, an animal which is graded at an index of 108 will receive an 8-percent premium over the Index-100 price.[10]

Average weekly slaughter hog price data for the seven central United States markets combined was obtained from the Livestock and Meat Trade Report for the period 1973-1980[11,12]. These prices are reported for barrows and gilts in the 200 and 220 pound weight range on a liveweight basis. For comparability the liveweight basis used in the United States was converted to the warm dressed weight basis used in Canada by dividing the average prices for the seven United States markets combined by the coefficient 0.77. As well, these slaughter hog prices were adjusted from United States dollars to Canadian dollars by using the prevailing exchange rates between the two countries.

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[10] J. de Graff, "Price Formation in Canadian Hog Marketing," Food Market Commentary, Vol. 3, No. 1 (March 1981), p. 21.

[11] Agriculture Canada, op. cit.

[12] The average price for the seven central United States markets combined includes the following markets; Sioux City, Iowa; St. Joseph, Missouri; St. Paul, Minnesota; Indianapolis, Indiana; Omaha, Nebraska; Kansas City, Kansas; and St. Louis, Illinois.

1.4 Organization of the Study

Chapter 2 outlines the changes which have occurred in the mechanisms for marketing slaughter hogs in Manitoba, Saskatchewan, Alberta and Ontario over the period 1951 to 1980. Particular attention is paid to the situation which existed prior to the establishment of marketing commissions/boards and producer's justifications for adopting alternative organizational structures and marketing mechanisms. The time periods for which alternative marketing mechanisms were in use provide the time frames for the empirical analysis.

Chapter 3 provides the theoretical basis for the study. The concept of market structure and its influence on market performance is discussed. The concept of perfect competition is introduced as a paragon and suggestions are made as to why this goal may not be obtainable. Workable competition is presented as an alternative criteria. The market structure of the major participants in the Canadian slaughter hog industry is discussed. Market performance criteria are presented in this chapter and an indication of how market performance might be analyzed is outlined.

Chapter 4 descriptively evaluates the marketing mechanisms existing in Canada over the period 1951 to 1980 with regards to market performance. The purpose of this chapter is to identify the marketing mechanism which should theoretically result in the greatest market performance. The specific performance criteria examined in this chapter include operating and pricing efficiency.

Chapter 5 applies empirical analyses to determine the influence of marketing mechanism changes on the price relationships between the four

Canadian markets under study. Specifically, tests are performed to determine if adoption of teletype Dutch auction and formula pricing for slaughter hogs has improved the transfer of pricing information between the markets under study.

Chapter 6 summarizes the results of the thesis and presents the implications of this study for the hog industry in Canada and for other livestock sectors evaluating alternative marketing mechanisms. In addition, suggestions are made for possible further research.

Chapter 2

2. HISTORICAL REVIEW

Significant changes have occurred in the marketing mechanisms used to establish prices on the major Canadian markets. These variations have influenced the market structure of the hog industry. The objective of this section is to review the marketing mechanism changes that have occurred over the study period. These changes provide the time periods for examining the price relationships between the four slaughter hog markets while the alternative marketing mechanisms were in use.

This chapter will be divided into two sections. The first section will examine the general conditions which existed in all markets prior to the establishment of a producer marketing board or commission. The justifications for introduction of a new marketing mechanism will be outlined. The next section will examine the marketing systems which have been implemented by the provincial marketing boards and commissions of Ontario, Manitoba, Saskatchewan and Alberta. Modifications to these marketing systems have occurred and will be reviewed.

2.1 Initial Marketing Mechanisms

By the end of World War II major changes were occurring in the way hogs were being marketed. The primary difference was the declining importance of the terminal markets as a means of marketing hogs. Manning made the following comment about the pricing role of the terminal exchanges in Alberta:

> The role of the terminal exchanges in establishing hog prices has declined substantially since the rail-grade-and-weight

> system of selling was introduced, but other changes in the industry also have influenced the method of marketing. The terminal stockyards were originally established at rail transportation junctions between the producing areas and the major consuming centers. The shifts toward truck transportation, decentralization of the packing industry, urbanization of western Canada, and increasing specialization of hog producers have reduced the need for the terminal stockyards as centers for assembly and concentration of hog shipments. Thus the physical functions of the stockyards declined at the same time as the pricing functions of exchange declined, and although the declines were from different causes, they reinforced one another.[1]

The major marketing system used at this time was direct delivery from the producer's farm to the packing plant. This technique reduced marketing costs by eliminating the commission charges levied at the terminal markets. It also reduced handling of slaughter hogs, thereby reducing shrinkage and bruising of hog carcasses. The increase in the number of direct deliveries created a situation where prices were still established on the terminal markets but the actual percentage of hogs sold using this mechanism was relatively small. Manning makes the following comment about prices received on the terminal market:

> Apparently the lowest prices were received by producers whose hogs were sold on the terminal exchanges. They received the base price less yardage and commission fees, while other producers received at least base price and often the higher of two or more alternative base prices and in some cases an incentive payment and/or absorption of some of the trucking costs. Thus, it would appear that producers who support the terminal market and help set the base prices pay a substantial penalty for the privilege. Such a situation cannot be defended on grounds of either efficiency or equity of treatment.[2]

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[1] T.W. Manning, Performance of the Hog Marketing System in Alberta, (Edmonton: Department of Extension, The University of Alberta, Agricultural Economics Research Bulletin 4, July 1967), p. 8.

[2] Ibid., p. 12.

Producers' major criticism of the marketing system at this time was their lack of bargaining power in the market place.

> Most of the producer groups felt that producers were at a disadvantage in the bargaining process by which prices for livestock are established. ... The loss in producer bargaining power was attributed to the decline in the proportion of the stock marketed through the Public Markets and the increase in the volume sold directly to packing plants. It was felt that in the direct method of marketing, prices are negotiated in a less competitive manner, since there is only one buyer present and the seller is usually less well informed than the buyer and less skilled in price negotiation.[3]

Producers felt that it was in the packing companies' best interest to maintain terminal prices at levels lower than would be obtained if the market was of a more competitive nature.

> In the case of hogs, the large processors buy few if any of their requirements at the public market. The result is that the major buyers secure their supplies without direct competitive bidding against other processors. It was argued that this system of marketing permits the processors to purchase livestock at a lower average price than would be obtained if all sales were made through a mechanism which would permit all buyers to bid on all lots sold. It was also felt by several producer groups that livestock producers would have a bargaining strength in price negotiation equal to that of processors and retailers only if all, or a large proportion of, livestock were sold by a single sales agency on behalf of the producers.[4]

These producer concerns about the competitiveness of the market resulted in the formation of provincial hog commissions or marketing boards and the development of alternative pricing mechanisms. The objective of the next section is to describe the evolution of hog marketing boards and pricing systems in the markets under study.

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[3]Select Committee of the Legislative Assembly of Manitoba, Livestock Marketing in Manitoba, (Winnipeg: Queen's Printer of Manitoba, February 1964), pp. 47-48.

[4]Ibid.

2.2 Development of Provincial Marketing Commissions and Boards

2.2.1 Ontario

The Ontario Hog Producers Marketing Board was established in 1947. The marketing functions were carried out by a negotiating committee.

> A Negotiating Committee, comprised of five representatives each from the Marketing Board and the packers, was empowered to negotiate agreement respecting minimum prices, forms of contract, conditions of sale, differentials, premiums and discounts for the grades and weights of the live and dressed hogs, and several other matters.[5]

The committee operated from 1947 to 1951 attempting to establish minimum prices for slaughter hogs. Lack of control over the supply or delivery of hogs reduced the committee's ability to improve producers bargaining position.

The next stage for the Hog Board involved the establishment of the United Livestock Sales Company in February 1953.

> With a view to increasing its bargaining power, but also disturbing as little as possible the existing marketing system, the Hog Board was successful in bringing five commission firms in the Stockyards together with the United Cooperatives of Ontario to form a joint stock company called the United Livestock Sales Company. In February of 1953 this newly formed company was appointed agent of the Hog Board, with power to establish price, to sell and direct the movement of the hogs and to handle payments to producers.[6]

The company had control over all slaughter hogs being marketed through the stockyards; however, the large number of slaughter hogs sold direct to the packing plants reduced the influence of this system on producer bargaining power.

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[5] Ibid., p. 87.

[6] Ibid., pp. 87-88.

In 1955, the Ontario Hog Producers Marketing Board further modified its selling system.

> In 1955, the Ontario Hog Producers took over the marketing of their own hogs and set up the Ontario Hog Producers Co-Operative as their selling agency. By 1956, they had six marketing yards outside of Toronto and had control of an increased number of hogs and could influence the price to a greater extent. No processor had enough direct deliveries to satisfy his requirements and, now the number of open market hogs had increased, the small processor was becoming a larger factor in the establishment of price.[7]

In 1960, this system was made compulsory. This marketing mechanism resulted in controversy between the major participants in the market.

> During this period of time, the sales were handled almost entirely over the telephone. The packers claimed that even though they bid ten or fifteen cents a hundred weight more for any offering of hogs, they would not end up the day with extra hogs, but would have to pay the higher price for the balance of their buy that day. There were also accusations of allocation, favoritism, and lack of mechanical records to prove that hogs were sold to the highest bidder.[8]

The Ontario Hog Producers Marketing Board began selling slaughter hogs using the teletype Dutch auction on May 8, 1961. The following is a description of the teletype Dutch auction used in Ontario. The slaughter hogs are initially delivered to assembly yards. These slaughter hogs are divided into lots and the number of lots is communicated to the Board's central office in Toronto.

The actual bidding for these lots occurs over a teletype system. The major packing companies have teletypes located at their plants. These

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[7]M. Hawkins, "Hog Marketing in Ontario," Seventh Annual Agricultural Marketing Conference Proceedings, (Columbus: Department of Agricultural Economics, Ohio State University, March 1965), p. 80.

[8]Ibid.

teletypes are connected to a central teletype at the Board's main office. A lot is offered for sale to all buyers on the teletype system simultaneously. Prior to bidding, a message is sent out to all buyers on the teletype which communicates information about the lot to be sold such as the number of hogs, delivery point and delivery time.

The bidding procedure is based on the Dutch auction system; that is, slaughter hog lots are initially offered at prices slightly in excess of what the average sale price is expected to be. This initial price is based on prices established for previous sales on the current and prior days, prices established on other markets, number of hogs available to be sold and anticipated demand by the packing companies. The initial price is allowed to drop by five cents per hundredweight every two seconds. If a buyer observes the price he is willing to pay, he pushes the buy button on the teletype console. At this point, all other buyers are shut off the system. The successful bidder then confirms he has actually made the bid thus completing the sale. The price is then broadcast over the teletype to all other buyers without revealing the buyers identity.

If the price falls one dollar per hundredweight less than the original asking price, the auction is stopped and the lot is either offered again over the same price range or a lower price range or is withdrawn from the market and again offered for sale later in the day.

The period between the establishment of the teletype marketing system and the present has been one of apparent calm with both producers and packing companies being relatively satisfied with the system.

> During the sixties, the operating of the Board became more efficient, more acceptable to all parties concerned and

the directors were able to expand their efforts into the areas of promotion, research and communications.[9]

2.2.2 Manitoba

In 1962, the Manitoba government set up a committee to perform a comprehensive review of the livestock marketing system in Manitoba. One of the major recommendations to come out of this report was that a non-compulsory marketing commission be established in Manitoba to sell hogs. A further recommendation was that a pricing system be established using a teletype Dutch auction selling mechanism.[10]

The recommendations of this committee lead to the establishment of the Manitoba Hog Marketing Commission in February, 1965. The commission was non-compulsory so hog producers had the option of either delivering direct to the packing plants or selling through the Marketing Commission. However, the prices received for all hogs, including direct deliveries, were reported to the Commission to provide an accurate record of daily prices. This effectively eliminated the complaint that reported prices reflected only those prices paid for a relatively small portion of the hogs sold on the terminal market.

The next major change in the hog marketing system occurred in January, 1972, when the Commission was replaced by the Manitoba Hog

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[9] Ontario Pork Producers Marketing Board, Report to the Thirty-sixth Annual Meeting - 1977, (Toronto: Ontario Pork Producers Marketing Board, March 1977), p. A7.

[10] Select Committee of the Legislative Assembly of Manitoba, op. cit., pp. 210-211.

Producers' Marketing Board. The emphasis at this time shifted from the development of a more competitive market system to one in which there was greater emphasis on countervailing power in the market place[11]. The Marketing Board was given the right to market all slaughter hogs for Manitoba. The teletype Dutch auction system was maintained as the pricing mechanism for all slaughter hogs in Manitoba.

The next several years were a period of considerable controversy between the packing plants and the Manitoba Hog Producer's Marketing Board. Much of this controversy revolved around the purported widening price differential between the Winnipeg and Toronto hog markets. The Hog Producers' Marketing Board alleged that the price differential between the two markets was higher than could be justified on the basis of two competitive markets.

On September 7, 1977, the Hog Producers's Marketing Board discontinued the teletype Dutch auction mechanism of selling hogs and replaced it with a formula pricing system.[12] This formula price was the weighted average price determined as follows: eighty percent of the Toronto price and twenty percent of the Omaha price for the same period as purchases. Buyers bid on a differential price which was not allowed to be less than three dollars per hundredweight of the formula price. Estimated lots of hogs were allocated to buyers in order of lots bid. This system proved unsatisfactory and was discontinued on September 17, 1978.[13]

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[11] J.C. Gilson, The Pork Industry in Manitoba, (Winnipeg: Manitoba Department of Agriculture, 1979), p. 5.3.

[12] Manitoba Hog Producers' Marketing Board, "New Selling System for Manitoba Hogs," Hog Market News, Vol. 3, No. 4 (September 1977), p. 1.

[13] Manitoba Hog Producers' Marketing Board, "Dutch Clock Auction on 90-Day Trial," Hog Market News, Vol. 4, No. 4 (October 1978), p. 1.

The present system is a modified Dutch clock mechanism based on one day forward contracts. The sale occurs at the Manitoba Hog Producers' Marketing Board building. All the packer buyers are gathered in one room. Each buyer has his own desk, separated from the other buyers by partitions, so that no one buyer is able to observe the activities of others around him. At this desk is an electronic console which gives the buyer access to the Dutch clock selling mechanism. At the front of the room is the actual Dutch clock mechanism. The sale is coordinated by a Board staff member who operates the sale from an auction console connected to the clock and to each buyer's bid machine. Bidding starts at the predetermined price based on expected deliveries, the previous day's sale prices and prices of slaughter hogs on other major markets. The price is recorded on the clock at the front of the room and is then allowed to drop by five cents per hundredweight intervals every two seconds. When the buyer sees the price he is willing to pay, he pushes the buy button on his console stopping the sale. All other buyers are then shut off from the system and the purchasing buyer indicates that he actually made the bid thus confirming the sale. If the price has dropped by one dollar per hundredweight less than the starting price with no bid received, the sale is stopped and the lot is again offered over the same price range or a lower price level.

2.2.3 Saskatchewan

The first attempt at establishing a hog producers' marketing board in Saskatchewan occurred in 1964. A plebiscite was held to determine if hog producers favored a compulsory marketing plan. The results indicated producers were not in favour of such a plan at that time.

In 1966, a study by Brown, Heidt and Phillips examined the feasibility of implementing a teletype Dutch auction for marketing slaughter hogs in Saskatchewan. Based on their analysis, the authors made the following recommendations:

(1) Some form of hog marketing plan should be considered for Saskatchewan. The study committee feels that marketing plans such as in Manitoba and Ontario (teletype Dutch auctions) both offer advantages for the Saskatchewan hog production and marketing industries.

(2) In view of the close relationship of the Saskatchewan and Manitoba hog markets, initial action should centre on cooperation with the Manitoba plan.[14]

No action was taken on these recommendations until 1972 when the province of Saskatchewan established the Saskatchewan Hog Marketing Commission.

The Saskatchewan Hog Marketing Commission began operation on August 6, 1973. The commission implemented a slaughter hog pricing mechanism based on a negotiated formula rather than the teletype Dutch auction mechanism used by the other provincial Boards.

> A number of factors resulted in the rejection of the teletype auction system for Saskatchewan. Firstly, there are a limited number of buyers available to participate in a teletype system and therefore its adoption would not ensure competitive bidding. Secondly, it was felt that the adoption of formula pricing would facilitate better forward planning by the meat packing sector and hence, greater efficiency. Thirdly, the geographic distribution of Saskatchewan processing plants would not permit the concurrent operation of least cost transportation system under a teletype auction approach.[15]

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[14] J.A. Brown, A.A. Heidt and R.H.D. Phillips, Hog Marketing in Saskatchewan, (Saskatchewan: A Preliminary Report Prepared for the Saskatchewan Advisory Swine Council, June 1966), pp. 20-21.

[15] Saskatchewan Hog Marketing Commission, Annual Report 1973, (Saskatoon: December 1973), p. 8.

The 1973 Annual Report of the Saskatchewan Hog Marketing Commission describes the operation of this selling system:

> The negotiation-written offer selling system resulted in major conditions of sale being negotiated with buyers. This was followed by submission of written bids for purchase of specific lots of hogs ... over a contract period. The length of the contract period was specified, but could vary from one to three months. The selling system was later modified to a written tender system, where major purchasers submitted one tender for virtually all of the hogs required for a contract period, instead of bidding for individual lots.
>
> Packers compete for their hog requirements by basing their bids (or tenders) upon a Saskatchewan base market hog price which is determined each market day by the negotiated price formula. The base market hog price is related to the Toronto, Winnipeg, Edmonton and Omaha daily hog markets, and Toronto and Vancouver wholesale pork prices.[16]

2.2.4 Alberta

Producers and producer organizations began making representations to the Alberta Government in 1962 with the objective of establishing a Hog Marketing Board.[17] The legal framework for the Marketing Board was established under a revision to the Marketing of Agricultural Products Act in the 1965 session of the Alberta Legislature. During the period 1965-1967, several plans were developed for the organizational structure of the Marketing Board; however, the farm organizations representing producers were not able to agree on the appropriate alternative. The decision to establish a Marketing Board was based on a

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[16] Ibid.

[17] The historical review of hog marketing in Alberta as presented in this section draws on M. Hawkins, A. Warrack, J. Dawson and G. Geldart, Development and Operation of the Alberta Hog Producers Marketing Board, (Edmonton: Agricultural Economics and Rural Sociology, The University of Alberta, Bulletin 12, March 1977), pp. 1-6.

plebiscite held on February 20, 1968. The results favored compulsory marketing of slaughter hogs through a teletype Dutch auction.

The Alberta Hog Producers Marketing Board began operation on October 31, 1969. The functions of the Board were "to sell hogs, to conduct and encourage research and product promotion, and to provide market information."[18]

The period since the Board's inception has been characterized by controversy between the Board and the packing companies. In particular, Alberta hog producers have felt the prices they received for slaughter hogs were low relative to those established on other North American markets. These complaints were intensified by the changes occurring in the distribution of hog production in Canada and the resulting alterations in the traditional movement of pork products.

During the fall of 1977, disagreements between the Alberta Hog Producers Marketing Board and the packing companies resulted in the Alberta government commissioning Hu Harries and Associates to examine the hog industry in Alberta. The objective of this study was to: "review the price relationship which should exist between Alberta and other North American points regarding the price of Alberta hogs at both the producer and wholesale levels."[19]

The consultants indicated the following as being an important source of contention between hog producers and packing companies:

> Prior to 1974 Alberta produced more hogs than were needed to satisfy the local demand. (In referring to the local market

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[18] Ibid., p. 5.

[19] H. Harries, Price Relationships in the Alberta Hog Market, (Edmonton: Alberta Agriculture, October 1977), p. 2.

> it should be understood that Alberta and British Columbia can properly be viewed as one market and hence the term 'local' means both of these provinces.) The surplus hog production was 'exported' (mostly to central Canada) and as is the usual case in a competitive commodity market it was this surplus that established the trading price for the total production. The hog producer in Alberta therefore received the Toronto price less freight less processing costs less marketing costs for the hogs he put on the market.
>
> By 1974, the decline in hog production in Alberta had proceeded to the point where it was not able to supply consumer demand in Alberta. ... For a time the Toronto freight factor almost disappeared from Alberta prices but as imports of pork into Alberta began to occupy an even larger portion of the total market the freight factor or some similar discount on the producer price appeared to, at least partially, reassert itself.[20]

The Alberta Hog Producers Marketing Board attempted to improve the level of competition among the packing companies by altering the teletype marketing system. The Board modified the system to advance buyer bidding on March 17, 1978. Gilson describes the operation of this selling system:

> (i) A volume of hogs, based slightly in excess of anticipated producer offering volumes and current slaughter patterns, is broadcast over the teletype for buyer bids; (ii) various sized lots are used to accommodate individual buyer requirements and producer, trucker and assembler offering patterns; (iii) the highest bid price for a given lot is confirmed over the teletype to the successful bidder and then communicated to all buyers on the system; (iv) once the anticipated hog receipts have been offered for bids, the bids are ranked from highest to lowest bid price. This ranking is used to allocate the hogs which are delivered the following day; (v) following the bidding session for any given day, the producers are advised of the probable prices for their hogs. In other words, producers know the approximate price of their hogs before they decide to deliver. Producers must commit hogs for delivery before 10:00 a.m. the next marketing day; (vi) when the hogs are committed on a given day, they are allocated to buyers in accordance with the ranking system described in (iv); (vii) once the

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[20] Ibid., pp. 14-15.

> allocation of hogs committed for delivery is completed, all bidders receive information which includes number of hogs to be delivered, delivery time, identity of suppliers, with identifying lot number.[21]

In March 1980, the Alberta Hog Producers Marketing Board discontinued use of the teletype marketing system in favor of a bid-acceptance system. The Board felt that teletype marketing was not establishing competitive prices.

> The Board under the present system will accept tenders by telephone, telex, sealed bids or by the existing closed circuit teletype network.
>
> Tenders for purchasing hogs for the next day's delivery must be submitted by 9:00 a.m. of the morning of the preceding day. Once the tenders are in, the Board's staff reviews the tenders and matches them against what they estimate the volume of deliveries will be. When matching the tenders, the sales manager fills the highest bids first and then proceeds down the list until an estimated 'safe' delivery volume is committed. Packers with these tenders are then notified which tenders have been accepted. The remaining lower tenders may also be accepted but on the condition that a sufficient volume of hogs are delivered.[22]

Beginning in November 1979, the Alberta Hog Producers Marketing Board entered into domestic sales contracts with three packing companies. The Board describes these contracts in the following excerpt:

> Effective November [1979], the Alberta Pork Producers Marketing Board entered three new domestic contracts. ... The Board also entered a hog supply agreement with the Saskatchewan Hog Marketing Commission for the same number of hogs. This interprovincial agreement is designed to recognize the needs of packers and producers in both Saskatchewan and Alberta and commits the buyers involved to developing a market for prairie pork on a longer term basis.[23]

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[21]Gilson, op. cit., pp. 6.6-6.7.

[22]J.L. Foster et al., Hog Marketing Review Committee, (Edmonton: Alberta Agriculture, January 1981), p. 23.

[23]Alberta Pork Producers Marketing Board, "Alberta Report," Western Hog Journal, Vol. 1, No. 3 (Winter 1980), p. 42.

Chapter 3

3. THEORY RELATING TO THE PROBLEM

The previous chapter examined the changes in the mechanisms by which slaughter hogs are marketed and prices established on the major Canadian markets. This chapter's objective is to review the literature relevant to the concept of market performance. This description will provide the theoretical basis for examining the influence of selling mechanism changes on slaughter hog price relationships among the four major Canadian markets.

Industrial organization can be defined in the following manner:

> ... [the branch of economics] concerned with how productive activities are brought into harmony with society's demands for goods and services through some organizing mechanism such as a free market, and how variations and imperfections in the organizing mechanism affect the degree of success achieved by producers in satisfying society's wants.[1]

The tools of industrial organization are useful for analyzing the behavioral characteristics of an industry and in identifying potential policies to improve market performance.

> These conditions of market functioning are matters of positive knowledge ... postive analysis shows how the system functions. ... With this knowledge, one can think normatively, to diagnose market problems and to define the best policy treatments for them.[2]

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[1] F.M. Scherer, Industrial Market Structure and Economic Performance, (Chicago: Rand McNally Co., 1970), p. 1.

[2] W.G. Shepard, The Economics of Industrial Organization, (New Jersey: Prentice-Hall Inc., 1979), p. 4.

3.1 Market Structure

Market structure is a basic description of "the environmental characteristics of an industry which influence the behavior of firms in the marketplace"[3]. The environmental characteristics include:

> ... number and size distribution of sellers and buyers, the degree of physical or subjective differentiation prevailing among competing sellers' products, the presence or absence of barriers to the entry of new firms, the ratio of fixed to total costs in the short run for a typical firm, the degree to which firms are vertically integrated from raw material production to retail distribution, the amount of diversity or conglomerateness characterizing individual firms' product lines, and the geographic dispersion or concentration of buyers and sellers.[4]

Perfect competition is often presented as being the most desirable form of market structure. Bannock, Baxter and Rees[5] define perfect competition as being a market situation in which there are a large number of buyers and sellers. The market share of both the buyers and sellers is so small relative to the total quantity traded that individual marketing decisions do not affect market price. The product being traded is homogeneous. All market participants have perfect information regarding market prices. Finally, new firms are not impeded from entering the market by barriers to entry. The economic results of this particular market structure should be the most efficient allocation of resources.

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[3] R.S. Kohls and J.N. Uhl, Marketing of Agricultural Products, 5th Ed., (New York: MacMillan Publishing Co., 1980), p. 595.

[4] Scherer, op. cit., p. 5.

[5] G. Bannock, R.E. Baxter and R. Rees, A Dictionary of Economics, (Middlesex, England: Penguin Books, 1977), p. 314.

The consequences of these assumptions are:

> (i) The market adjusts rapidly to discrepancies between supply and demand, since such discrepancies will cause price changes which are transmitted throughout the market by the process of arbitrage, which relies on an unimpeded flow of information; (ii) When an equilibrium is achieved, it can only be at a single price; (iii) In the long run, there can be no profits, other than a normal competitive return to the entrepreneur, because if there are, entry takes place and they are competed away.[6]

In reality, most industries have some characteristics which violate the assumption of perfect competition.

> Competition is an enforcer. It imposes constraints on the options open to the individual firm ... Market power varies inversely to the degree of competition which prevails; market power makes possible the maintenance of wider price to cost margins. Less well understood is the notion that competition limits operational aspects of firm action within the market channel ... The larger the market, the more the specialization, the different the technology, the more important the cost economies of scale, and frequently, the less the market uncertainty. But competition enforces limits to the market demand accessible to the individual business firm.[7]

Perfect competition still provides a good benchmark for evaluating the effect of other structures. Koch describes the value of using the perfectly competitive market as a yardstick:

> ... the perfectly competitive model is frequently used as a parable and is not meant to describe or predict real world events when so utilized. Rather the model is employed as a representation of the optimum, a measuring stick against which all other circumstances and market structures may be compared and evaluated.[8]

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[6] Ibid.

[7] A. Warrack, "A Conceptual Framework for Analysis of Market Efficiency," Canadian Journal of Agricultural Economics, Vol. 20, No. 3 (November 1972), p. 10.

[8] J.V. Koch, Industrial Organization and Prices, (New Jersey: Prentice Hall Inc., 1974), p. 16.

Stigler suggests separating the concepts of the perfect market and perfect competition in analyzing market performance. The concept of the perfect market is described below:

> A market is an institution for the consummation of transactions. It performs this function efficiently when every buyer who will pay more than the minimum realized price for any class of commodities succeeds in buying the commodity, and every seller who will sell for less than the maximum realized price succeeds in selling the commodity. A market performs these tasks more efficiently if the commodities are well specified and if buyers and sellers are fully informed of their properties and prices. Possibly also a perfect market allows buyers and sellers to act on differing expectations of future prices. A market may be perfect and monopolistic or imperfect and competitive.[9]

The concept of workable competition was introduced to address some of the problems created by using perfect competition as a paragon.

> An industry may be judged to be workably competitive when, after the structural characteristics of its market and the dynamic forces that shaped them have been thoroughly examined, there is no clearly indicated change that can be effected through public policy measures that would result in greater social gains than social losses.[10]

Kohls and Uhl suggest judging the effectiveness of a marketing system on these criteria:

> (i) There must be an appreciable number of buyers and sellers. They do not need to be so numerous as to have no individual market influence, but the number must be great enough to provide alternative possibilities. (ii) No trader must be so powerful as to be able to coerce effectively his rivals. (iii) Traders must be responsive to incentives of profits and loss -- they must not be so huge that they can ignore commercial incentives over long periods of time. (iv) There must be no agreements on commercial policy among rivals. (v) Entry must be free from handicap, except that

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[9] G.J. Stigler, "Perfect Competition, Historically Contemplated," Essays in the History of Economics, (Chicago: The University of Chicago Press, 1965), p. 245.

[10] J. Markham, "An Alternative Approach to the Concept of Workable Competition," American Economic Review, (June 1950), pp. 349-361. Cited by F.M. Scherer, Industrial Market Structure and Economic Performance, (Chicago: Rand McNally Co., 1970), p. 38.

> which is automatically created by the existence of already established firms. (vi) There must be free access of buyers with sellers. There must be no substantial preferential treatment of any particular trader or group.[11]

One method suggested for improving market performance for agricultural products has been to increase producer bargaining power. Kohls and Uhl summarize the consequences of inadequate producer bargaining power and make suggestions for rectifying this situation.

> Because he [the producer] lacks a voice in pricing, yet holds a perishable, undifferentiated product, the farmer is sometimes said to be a weak seller when compared with the powerful farm product buyers. Furthermore, because price makers are likely to price in such a way as to cover costs -- passing whatever is left of the consumers' dollar back to farmers -- farmers are sometimes referred to as the residual income claimants in the food industry. There are two alternatives to correct this imbalance of market power between farmers and food marketing firms: (1) make farmers less perfectly competitive or (2) make food marketing firms more perfectly competitive.[12]

Canadian farmers have attempted to improve their bargaining position with respect to agricultural processors by the formation of marketing boards.

> A much noted feature of the output markets for Canadian agriculture is the increasing importance of marketing boards. This is a manifestation of producers' efforts to follow a countervailing power philosophy of increasing the extent of their control and market power in the marketing of farm products. The result has been many different types of Canadian marketing boards with very different activities and effects.[13]

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[11] Op. cit., pp. 195-198.

[12] Ibid., pp. 193-194.

[13] T.S. Veeman and M.M. Veeman, "The Changing Organization, Structure, and Control of Canadian Agriculture," American Journal of Agricultural Economics, Vol. 60, No. 4 (December 1978), p. 763.

The functions of these marketing boards vary from promotional activities and administration of a compulsory marketing system to control over the amount of commodity produced through production quotas. The provincial hog marketing boards and commissions have attempted to improve the competitiveness of the slaughter hog marketing mechanisms and the overall efficiency of the market.

3.2 Market Conduct

The structure of an industry influences the way participants behave in adapting or adjusting to the markets in which they sell or buy. Clodius and Mueller describe the following dimensions of market conduct:

> (1) Methods employed by the firm or group of firms in determining price and output; (2) product policy; (3) sales promotion policy; (4) means of coordination and cross adaption of price, product and sales-promotion policies among competing firms; and (5) presence or absence of, and extent of, predatory or exclusionary tactics directed against either established rivals or potential entrants.[14]

The market structure of the major participants in the slaughter hog industry influence their market conduct. The objective of the next section is to examine the market structure of the major participants and suggest what influence it may have on their respective conducts.

3.2.1 Market Structure and Conduct of the Buyers

The market structure of the packing companies could be characterized as an oligopsony. Kohls and Uhl define oligopsony as: "A com-

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[14] R.L. Clodius and W.F. Mueller, "Market Structure Analysis as an Orientation for Research in Agricultural Economics," American Journal of Agricultural Economics, Vol. 43, No. 3 (August 1961), p. 517.

petitive situation where there are a few large buyers of a product".[15] This market structure tends to give packing companies market power relative to swine producers. Brandow defines market power:

> A firm may be said to possess market power if a price, production, marketing or purchasing decision it might practically make can directly and materially affect the incomes of other firms or persons or can appreciably change the average price, total quantity, or purchasing practices in a market in which it participates.[16]

Economies of size in the packing industry make smaller, less efficient packing plants undesirable thus precluding an increase in the number of buyers. At present, there is underutilization of hog slaughter capacity.[17]

The small number and large size of the major packing companies results in their individual buying decisions potentially having a major influence on selling prices. The oligopsonists recognition of their interdependence tends to encourage buyers to present a unified position to the sellers. Bain makes the following observations concerning the effects of oligopsonies:

> ... with highly concentrated buying, patterns of tactic collusion implemented by buying price leadership by the largest buyer are frequently in evidence. If not, close inter-

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[15] Kohls and Uhl, op. cit., p. 597.

[16] G.E. Brandow, "Market Power and its Sources in the Food Industry," Journal of Farm Economics, Vol. 51, No. 1 (February 1969), p. 2.

[17] For estimates of the degree of underutilization of packing plants in Canada, see J.L. Morris and D.C. Iler, Processing Capacity in Canadian Meat Packing Plants, (Ottawa: Food Prices Review Board, 1975).

> dependence in the buying price policies of the principal buyers is found. Performance evidence concerning the height of price relative to suppliers' costs or to a hypothetical competitive level of price frequently suggests a lowering of price roughly consistent with the maximization of the joint profits of the buyers, and little independent or competitive action on the part of individual buyers.[18]

This mutual recognition of interdependence results in buyers acting in consort with one another:

> The oligopsonist doesn't know what effect a given independent price change will ultimately have on his share of the market. He can safely assume that any price changes he makes will cause his rivals to react with retaliatory price changes. The high degree of interdependence among a few buyers in any industry, associated with uncertainty of what happens when any given buyer acts independently with regard to price, causes most oligopsonies to emphasize non price rivalry. This may take the form of product variation, advertising, differentiation of services, etc., and seems less likely to degenerate into unbridled warfare than does open price competition.[19]

3.2.2. Market Structure and Conduct of Hog Producers

Changes in the pricing mechanisms and the development of marketing boards and commissions had a major influence on the structure of the slaughter hog market. Prior to the establishment of the hog marketing organizations, the sellers side of the market could be characterized as being close to perfectly competitive. There were a large number of hog producers who acted independently of each other. No individual producer raised enough hogs that his sales would influence

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[18] J.S. Bain, Industrial Organization, (New York: Wiley, 1968), p. 367.

[19] Select Committee of the Legislative Assembly of Manitoba, Livestock Marketing in Manitoba, (Winnipeg: Queen's Printer of Manitoba, February 1964), p. 101.

prices. There were low barriers to entry for new producers. Finally, the buyers were indifferent as to their source of hogs; that is, hogs are a homogenous commodity.

The advent of compulsory marketing mechanisms for slaughter hogs resulted in major market structure changes on the sellers side. Instead of producers negotiating individually with the packing companies, they now negotiated through a single bargaining agent in the form of a marketing board or commission. Although these organizations do not control the number of slaughter hogs produced, they are able to influence producers patterns of delivery and conditions of sale. The aspect of being sole bargaining agent for the hog producers gave the marketing boards and commissions all the market structure characteristics of a monopoly except that of supply control.

3.2.3 Effect of Changes in Market Structure of Producers on Price Stability

In recent years, the marketing boards in Manitoba and Alberta have attempted to use their position as exclusive selling agents to counteract the perceived strong bargaining position of the packing companies. The use of market power to influence prices under these circumstances could theoretically result in considerable market instability as the marketing boards compete with the packing companies to influence prices and conditions of sale in their favor. Gilson describes this situation in the Manitoba market after the establishment of a compulsory marketing system:

> When the Hog Producers' Marketing Board was established in 1971 with the provision that all hogs had to be sold through the Board, the sellers' side of the market could be

> described as potentially monopolistic in structure insofar as there was one effective seller of hogs in the market place. On the buyers' side of the market, the structure remained oligopsonistic in nature to the extent that the buyers acted individually but mixed with some elements of monopsonistic behaviour ("one large buyer") whenever the buyers acted in some collective form of behaviour on policy matters or general issues relating to marketing of hogs.[20]

A bilateral monopoly structure often leads to instability in the market and results in prices which are indeterminate within a wide range. Scherer describes this range of price indeterminacy in the following manner:

> ... the upper limit of this [price] range coincides with the price set by a monopolist facing a purely competitive buying industry; the lower limit is the price a monopsonistic buyer would impose upon purely competitive sellers. Pure conflict prevails within these extremes. The bargaining power wielded and the tactics employed by the trading partners determine the resolution of this conflict and on formal theoretical grounds it is possible to say almost anything can happen. The price may be either higher or lower than the equilibrium price resulting from bilateral competition under identical cost and demand conditions.[21]

The interaction of buyers and sellers in the changing market structures during the 1970's could have contributed to the destablizing of prices in Western Canada through this time period.

3.3 Market Performance

In the previous section, concepts were developed which related market structure, conduct and performance. Specifically, perfect competition was presented as being the market structure which would result

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[20] J.C. Gilson, The Pork Industry in Manitoba, (Winnipeg: Manitoba Department of Agriculture, 1979), p. 5.5.

[21] Scherer, op. cit., p. 242.

in the most socially desirable allocation of resources. Because markets violate some of the assumptions of perfect competition, it is normally only used as a benchmark for evaluating market performance. The concept of workable competition was introduced as an alternative to perfect competition.

The purpose of this section is to outline the alternative methods for evaluating market performance. Caves describes market performance as a normative appraisal of the social quality of resource allocation resulting from a market's conduct[22]. Clodius and Mueller define market performance as " ... the economic results that flow from the industry as an aggregate of firms."[23] These authors suggest that the market performance of an industry should be judged in terms of its efficiency, its progressiveness and its stability.

A necessary condition for evaluating changes in the slaughter hog marketing system is to develop criteria for assessing market performance.

> A marketing firm, function, or system cannot be judged as efficient or economical in any absolute sense, but only with respect to alternatives or to some standard. Studies may be designed to show how the existing marketing methods could be improved, that is, made more efficient and less costly. To be more useful, however, marketing research should be oriented with reference to a concept of an ideal or perfect market. Such a concept should make possible the most meaningful appraisal of the existing system both in

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[22]R. Caves, American Industry: Structure, Conduct and Performance, 4th ed., (New Jersey: Prentice Hall, 1977), p. 14.

[23]Loc. cit.

terms of the delineation of problem areas and of the indications of the magnitude and importance of the distortions.[24]

Kohls and Uhl suggest using efficiency as a measure of market performance. Efficiency can be defined as a "ratio of market output (satisfaction) to marketing input (cost of resources); an increase in this ratio represents improved performance, a decrease denotes reduced efficiency."[25]

Bressler and King identify two attributes of an efficient marketing system: "(1) to provide efficient and economical service and ownership transfers in the movement of commodities from seller to buyer, and (2) to provide an effective price-making mechanism."[26] Market efficiency is evaluated in a number of studies in terms of two factors: operational efficiency and pricing efficiency.[27,28,29,30] Operational efficiency is the cost of providing services required in the marketing process.[31]

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[24]R.G. Bressler and R.A. King, Markets, Prices and Interregional Trade, (New York: John Wiley and Sons, Inc., 1970), p. 414.

[25]Op. cit., p. 37.

[26]Op. cit., p. 410.

[27]M.H. Hawkins, "Alternative Methods of Marketing Livestock," Canadian Journal of Agricultural Economics, Vol. 17, No. 3 (November 1969), pp. 104-106.

[28]Warrack, op. cit., pp. 9-22.

[29]L. Martin, R. Richards and W.W. Usborne, An Economic Comparison of Alternative Methods for Slaughter Cattle in Ontario, (Guelph: School of Agricultural Economics and Extension, University of Guelph, 1979), pp. 1-2.

[30]R.D. Johnson, "An Economic Evaluation of Alternative Marketing Methods for Feeder Cattle," (Ph.D. Dissertation, University of Nebraska, 1971), p. 12.

[31]Martin, Richards and Usborne, op. cit., p. 1.

> Operational efficiency focuses on cost-reducing alternatives and technologies for physically providing marketing services. Here the focus is on the physical marketing functions of assembly, processing, storage and transportation; within the marketing channel these physical functions add form, place and time utility to the product in question. The operational problem is to create these utility increments with the least-cost level of inputs.[32]

The other component of marketing efficiency is pricing efficiency.

> Pricing efficiency ... is concerned with the ability of the market system to efficiently allocate resources and coordinate the entire food production and marketing process in accordance with consumer directives. Pricing efficiency is less than perfect when prices fail to (1) fully represent consumer preferences; (2) direct resources from lower to higher valued uses; (3) coordinate the buying and selling activities of farmers, marketing firms and consumers. The goal of pricing efficiency is efficient resource allocation and maximum economic output.[33]

Manning uses a similar concept to pricing efficiency which he calls "economic equity" in evaluating marketing performance:

> Economic equity, as it applies to the hog market, concerns 'fairness' in the distribution of the income generated by the market. The question of fairness involves values about which people may not agree, but most would agree that there should be no price discrimination which is not economically justified, no unethical practices, and no coercive use of market power to shift income from one individual or group to another.[34]

Pricing efficiency evaluates market performance on its ability to establish a price which accurately reflects supply and demand conditions.

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[32] Warrack, op. cit., p. 11.

[33] Kohls and Uhl, op. cit., p. 39.

[34] T.W. Manning, Performance of the Hog Marketing System in Alberta, (Edmonton: The University of Alberta, Department of Extension, Agricultural Economics Bulletin 4, July 1967), p. 13.

Martin, Richards and Usborne raise the following questions with regard to pricing efficiency:

> Do prices reflect current supply and demand conditions? In the long run, do prices at the various levels of the market reflect the costs of providing the eventual product to consumers? Do prices at various points reflect transfer costs between these points? Does the price for an individual unit of product reflect that unit's quality? Does the market system transmit price information accurately and rapidly to all buyers and sellers so that production and purchasing decisions can be made with reliability?[35]

The difficulty with using the above criteria for measuring pricing efficiency is that the information required for evaluation is not easily accessible.

Several studies have evaluated pricing efficiency on the basis of characteristics of the market in question, relative to the attributes of perfect competition.

> Since it is not possible to directly evaluate the pricing efficiency of the various selling methods by an objective comparison of prices, pricing efficiency can be best evaluated in terms of how closely each of the selling methods fulfills the conditions of perfect competition, which, of course, results in perfectly competitive prices, the ultimate in pricing efficiency.[36]

The characteristics of perfect competition are:

> (1) All buyers must have equal access to all sellers and vice versa. (2) All buyers and sellers have access to current market prices. (3) Buyers and sellers must have equal bargaining position. (4) No buyer or seller should be able to artificially influence price by restricting supply or demand.[37]

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[35] Martin, Richards and Usborne, op. cit., p. 2.

[36] Johnson, op. cit., p. 61.

[37] Martin, Richards and Usborne, op. cit., p. 51.

Kohls and Uhl suggest using the concept of the "law of one price"[38] in evaluating pricing efficiency.

> Pricing efficiency is maximized when there is a tendency for prices to maintain the relationship suggested by the law of one price. Under these conditions, resources will be allocated correctly between their alternative uses; prices will serve as accurate guides for food industry decisions; and total industry output will be maximized.[39]

This theory will be discussed more fully in the next section with regards to price differentials in space.

3.3.1 Price Differential Due to Differences in Space

According to the "law of one price", price differentials between different markets should not exceed transfer costs between the markets. Price differentials between any two markets in excess of transfer costs is an indication of pricing inefficiency. If the price differentials between the two markets did exceed transfer costs, product could be exported at a profit from the lower priced market to the higher priced market. This product movement would increase prices on the lower priced market as supply decreased and decrease prices on the higher priced market as the quantity increased. This process of arbitrage would continue until the price differential equaled the transfer costs between the two markets.

Sappington, Hill and Baldwin explain spatial price differentials for corn using the concept of the perfect market.

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[38] Kohls and Uhl, op. cit., p. 176, state this theory in the following manner: "Under certain conditions all prices within a market are uniform, after taking into account the costs of adding place, time and form utility to products within the market."

[39] Ibid., p. 178.

> Under the theoretical conditions of the perfect market, prices among geographic regions should differ by no more than the cost of transportation. ... To the extent that greater differences exist, they can be attributed to three categories of variables that explain price differentials within the economic model described above; (1) differences in the cost and availability of transportation among locations; (2) differences in operating costs of firms in different locations; (3) differences in supply and demand conditions in different locations.[40]

Transportation costs make up the major component of transfer costs; however, other expenses are important components of transfer costs. King outlines the other components of transfer costs involved with moving pork products.

> If the pork cuts are transported frozen, there is also the cost of freezing, the cost of cartons and the packaging, at least a one month storage charge, and the cost of carrying the product in transit (interest). The sum of these costs will cover some of the Edmonton-Toronto price differential remaining after the freight tariff has been deducted. There is a further expense associated with the time lag involved in transportation. The Edmonton-Toronto run takes some three or four days, during which time the local Toronto price is changing. There is thus a certain amount of speculation involved. A packer does not know what price he will be able to sell the shipment for when it arrives. This risk must be discounted in the return he receives from the market. One often finds that a packer is prepared to pay more than the local market price to obtain pork today, process it, and be sure he can meet the market at the right time and price, rather than take a gamble with a marginally cheaper load from the west.[41]

Theoretically, transfer costs determine the maximum price differentials between importing and exporting markets. Figure 1 illustrates the range of price differentials between two markets. Market Y prices greater than the price on market X plus transfer costs or

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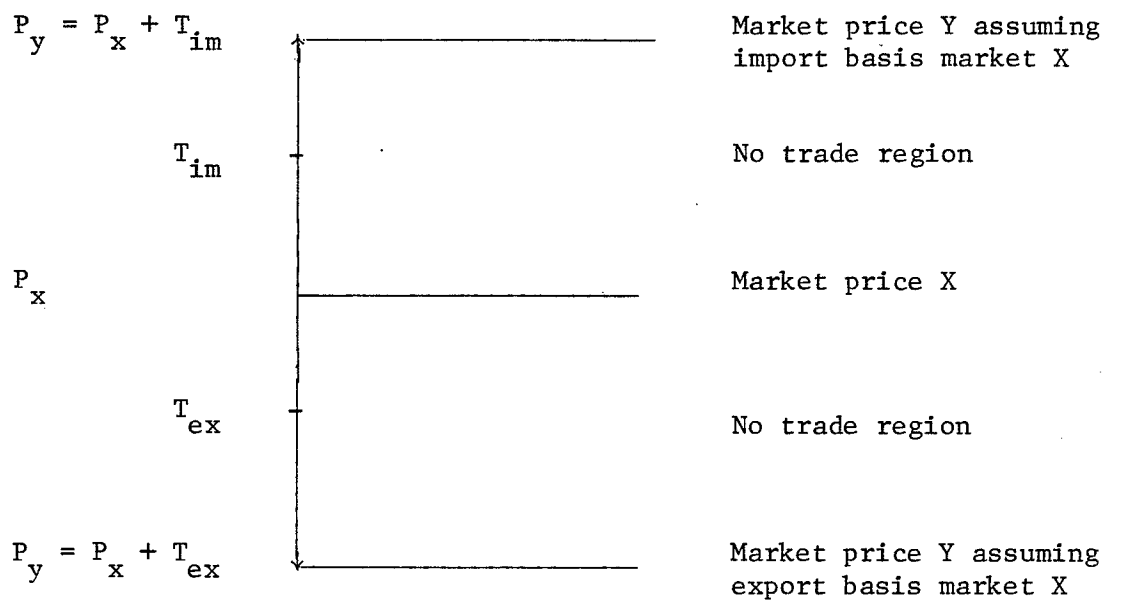
[40] C.B. Sappinton, L.D. Hill and E.D. Baldwin, Spatial Price Differentials for Corn, (Knoxville: University of Tennessee, Tennessee Agricultural Station, Southern Cooperatives Series Bulletin 196, January 1975), pp. 4-5.

[41] D. King, Spatial Price Differences for Hogs in Canada, (Ontario: Canadian Pork Council, March 1979), p. 5.6.

Figure 1. Price Differential Range



where: P_y = Price on market Y

P_x = Price on market X

T_{im} = Cost of moving product from market X to market Y

T_{ex} = Cost of moving product from market Y to market X

less than the market X price minus transfer costs is an indication of pricing inefficiency. Assuming that no trade occurs between the two markets, it is possible only to say that prices established on market Y will be somewhere between the price on market X plus transfer costs for moving the product to market Y or prices on market X less transfer costs. The actual prices established on market Y will depend on supply and demand conditions in that region. Assuming a no-trade position, this type of analysis provides no indication as to whether this market established prices efficiently. Davis and Hill describe the problem with using this criteria:

> Spatial prices in the perfect market would be assumed to differ by no more than the cost of transportation between any two points. This should not be accepted as evidence of adequate performance without a more detailed explanation, because price differentials well within the limits of transfer costs may still represent monopsony profits ... of a magnitude greater than the acceptable norms of workable competition.[42]

Differences in price differentials due to differences in operating costs are only possible if the buyers possess market power:

> Differences in operating costs can be reflected in price differences only if there is a degree of monopsony power present. Under perfect competition, the producer would presumably sell to the highest bidder with no knowledge of or interest in the costs of operation. Differences in costs would have to be absorbed in the returns to one of the fixed factors of production. ... To the extent that these [differences in operating costs] explain price differences, they are evidence of market power.[43]

Differences in supply and demand conditions influence price differentials. An example of this would be the affect of production

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[42] L. Davis and L. Hill, "Spatial Price Differentials for Corn Among Illinois Country Elevators," American Journal of Agricultural Economics, Vol. 56, No. 1 (February 1974), p. 136.

[43] Ibid.

practices on seasonal marketing patterns between Canada and the United States and the resulting influence this has on price differentials between the two countries. Petrie made the following comment regarding seasonal price differentials between Canada and the United States during the period 1948 to 1972:

> United States hog prices usually have been highest relative to Canadian prices between March and August in recent years. The differential generally narrows and often moves in favor of Canada over the remaining six months of the year.[44]

These differences in seasonal price differentials can be explained by differences in production patterns. In some parts of the United States, swine producers do not have heated farrowing barns. Because of this, sows are farrowed once a year in the spring to avoid colder winter temperatures. The slaughter hogs produced as a result of spring farrowing enter the market in the fall.

Because of the colder winter temperatures in Canada, most swine producers use heated farrowing barns. This enables Canadian swine producers to farrow their sows twice a year resulting in a more even flow of slaughter hogs to market.

During September to February, higher seasonal marketings of United States slaughter hogs would tend to depress prices relative to other times of the year. The increased deliveries of slaughter hogs in the United States and the decreased prices results in exports of pork into Canada. The result of this seasonal marketing pattern is that the United States slaughter hog prices are generally less than Canadian slaughter hog prices from September to February.

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[44] T.M. Petrie, Seasonal, Cyclical and Trend Variations in the Hog Industry, (Ottawa: Agriculture Canada, Economics Branch Publication No. 74/20, November 1974), p. 13.

The months from March to August are a period of lower hog marketings in the United States. This tends to result in the reverse situation where Canadian pork is exported more readily to the United States. United States slaughter hog prices are therefore greater than Canadian prices during this period.

3.4 Chapter Summary

The objective of this chapter was to review the theoretical basis for analyzing the influence of market structure changes in the Canadian slaughter hog industry on its market performance. The concept of perfect competition was presented as being an ideal market structure. However, reasons were given as to why this theoretical structure may not be achievable in the real world. The concept of workable competition was presented as a more viable alternative.

The market structure of the slaughter hog industry is described and suggestions are made as to how this might influence firms conduct. The market structure of the buyers is described as an oligopsony. The small number of packing companies in the industry results in a situation where major buyers are able to recognize their mutual interdependence in their buying practices and their potential influence on market prices. Prior to the existence of marketing boards and commissions, the market structure of hog producers approached that of perfect competition. With the advent of compulsory marketing, the structure of the slaughter hog market could be described as a monopoly with the boards and commissions acting as sole bargaining agent for producers. However, these boards and commissions were not given the power to restrict supply. The situation of strong sellers and strong buyers bargaining in the market place is indicated to have a destablizing effect on market prices.

Market performance is defined in terms of how well a market functions in efficiently allocating resources. Two components of market performance are identified; operational and pricing efficiency. Operational efficiency examines a market in terms of whether it functions at minimal costs. Pricing efficiency evaluates a market in terms of whether it is able to establish prices which accurately reflect supply and demand conditions. The law of one price is presented as a measure of pricing efficiency. The criteria used in this type of analysis suggest price differentials between regions should not exceed the cost of transferring product between regions; price differentials between time periods should not exceed storage costs; price differentials between different product forms should not exceed conversion costs; and price differentials between different grades should not exceed that justified by differences in demand.

Chapter 4

4. DESCRIPTIVE ANALYSIS

The previous chapter provided the theoretical framework for examining the influence of marketing mechanisms (MARKET STRUCTURE) on the prices received for slaughter hogs (MARKET PERFORMANCE). Two specific components of market performance were identified: operational efficiency and pricing efficiency.

The objective of this chapter is to descriptively evaluate the slaughter hog marketing mechanisms utilizing the two efficiency criteria. Hypotheses concerning the influence of marketing mechanism changes on the price relationships among the markets under study will be developed based on these criteria.

The four major categories of marketing mechanisms which will be analyzed include the following: (1) direct deliveries, (2) terminal markets, (3) electronic marketing mechanisms and (4) formula pricing. These are broad categories and will be divided further in the individual analyses. For example, the electronic marketing mechanisms could be further divided into compulsory or non-compulsory; teletype or clock; and advance buyer bidding or bidding on actual deliveries.

4.1 Operating Efficiency

Several studies have examined the operating costs of alternative marketing mechanisms.

Johnson analyzed the operational efficiency of eight alternative marketing mechanisms. These eight marketing mechanisms examined were:

(i) terminal or central markets, (ii) auction markets, (iii) direct selling, (iv) sales through a commission firm, (v) consignment, (vi) telephone auction, (vii) telephone direct and (viii) teletype auction[1].

Johnson ranked these alternative mechanisms with regard to operational efficiency:

> Consignment selling is the most efficient (least cost) selling method, teletype auction second, telephone auction third, direct and telephone direct are tied for fourth and fifth, country commission sixth, auction market seventh and the terminal market method of selling is eighth.[2]

Martin, Richards and Usborne examine the relative costs of five marketing alternatives for slaughter cattle in Ontario. The five alternative marketing systems examined in this study were: (i) country auctions, (ii) terminal markets, (iii) direct deliveries, (iv) listing services and (v) electronic auctions[3]. The conclusions of the study with regard to operating efficiency were as follows:

> For the base period (1977), the estimates showed that total marketing costs were highest for country auctions, followed in order by the terminal market, direct sales, listing service and electronic auction. Country auction and terminal method costs were estimated to be from $13 to $15 per head higher than the remaining three alternatives. The major reasons for these differences are: (1) higher total transportation costs, (2) higher intermediary costs and (3) higher costs of kill and yield efficiency for country auctions and the terminal method[4].

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[1] R.D. Johnson, "An Economic Evaluation of Alternative Marketing Methods for Feeder Cattle," (Ph.D. Dissertation, University of Nebraska, 1971), pp. 12-86.

[2] Ibid., p. 61.

[3] L. Martin, R. Richards and W.S. Usborne, An Economic Comparison of Alternative Selling Methods for Slaughter Cattle in Ontario, (Guelph: School of Agricultural Economics and Extension, AEEE/79/1, 1979), pp. 3-9.

[4] Ibid., p. 50.

> The study demonstrates that substantial economic savings are associated with the direct, listing service and electronic selling methods relative to the country auction or terminal methods. The study indicates that if a substantial number of cattle were sold in Ontario by these methods savings of several million dollars would result. Such savings would likely be reflected in higher prices paid to producers and/or lower prices paid by consumers.[5]

4.1.1 Direct Methods

Direct deliveries appeared to be operationally efficient. Producers who sold slaughter hogs directly to the packing companies avoided the marketing charges levied by country auctions and terminal markets. However, the packing companies incurred indirect expenses such as salary and travelling expenses for a buyer (in the case of on farm sales) or the costs of maintaining buying stations. Although these expenses were not paid directly by the producer, they reduced selling prices. This was especially true if the buyers were purchasing small lots, using on farm sales or buying stations which handled small volumes of livestock. The cost of sales direct to the plant appeared to be the least cost method since one buyer could purchase a large number of slaughter hogs.

4.1.2 Terminal and Country Auction Markets

Terminal markets and auction markets were thought to rate poorly with regard to operating efficiency. One of the major disadvantages of the terminal market was its high costs.

> The physical facilities, the staff to operate them, the costs of feed, bedding and water, insurance against fire,

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[5] Ibid., p. 51.

> and selling commissions are covered by deductions from the livestock receipts. Even if the services are supplied with the utmost efficiency, it still costs a great deal to provide them, and most of these services are necessary for the effective operation of a public market.[6]

Local auction markets suffered the problem of poor operating efficiency even more than terminal markets because of the lower sales volumes involved.

Another disadvantage of these markets was thought to be the increased handling and slow speed of delivery.

> It [the public market] is a roundabout method of marketing which involves extra handling and moving, delays prior to and after sale plus additional moving to the final destination. Greater shrinkage and more bruising are therefore involved and producer returns are reduced as a consequence.[7]

4.1.3 Teletype Selling Mechanism

Although the expense of operating a teletype probably exceeds that of direct deliveries to the packing plant, this selling mechanism rates high with regard to operating efficiency.

> The total cost of selling by teletype would depend on the number of services provided. The selling function could be performed at considerably less cost than at the central market since fewer physical facilities and much less labor would be required to negotiate sales and to distribute payments to producers. The costs might be higher than for direct deliveries, though savings in transportation costs might result in lower over-all costs.[8]

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[6] Select Committee of the Legislative Assembly of Manitoba, Livestock Marketing in Manitoba, (Winnipeg: Queen's Printer of Manitoba, February 1964), p. 167.

[7] Ibid., p. 167.

[8] Ibid., p. 169.

4.1.4 Formula Pricing

Speed of delivery would be similar to that of the teletype system depending on whether the marketing agencies use assembly yards to concentrate hog shipments or allow deliveries direct to the packing plants. Cost of operation would be similar to those of comparable electronic marketing mechanisms.

4.2 Pricing Efficiency

This section will evaluate the influence of the various marketing mechanisms on the pricing efficiency of the slaughter hog market in Canada. A methodology suggested for accomplishing this objective is to descriptively compare the structure of the marketing mechanisms in question with the theoretical attributes of perfect competition. The marketing system which has the most attributes of perfect competition is hypothesized to result in the greatest pricing efficiency. Several studies have used this technique in evaluating marketing mechanisms. These studies indicated that the teletype Dutch auction pricing mechanism has more attributes of perfect competition than other marketing systems. The following subsections will descriptively compare the attributes of various marketing mechanisms with those of perfect competition.

4.2.1 Direct Deliveries

As described earlier, direct deliveries involved the negotiation of prices between one seller and one buyer directly. Direct deliveries can take the following forms:

(i) packer buyers visit actual farms to solicit deliveries of hogs,

(ii) hired truckers to whom the farmer may or may not have given instructions concerning deliveries to a particular packing company,

(iii) deliveries to packer owned buying stations and,

(iv) the farmer delivering directly to the packing plant.

The major criticism of this selling system is its lack of competitiveness.

> It is seriously lacking in competition if the producer is not fairly well informed about current market prices, if he is not a good judge of quality and the settlement is not based on rail grade, if he is not a good judge of dressing percentage and the settlement is not based on rail weight, if he is not a good judge of liveweight and the offer is on a per head basis, and if he is not a good bargainer even if he is well informed and a skillful judge of animals.[9]

The farmer's ability to obtain on farm bids for his livestock is an advantage of on farm sales (assuming the producer's bargaining ability was equal to the buyer's). Once the producer had delivered his hogs either directly to the packing plant or to the terminal market, he is compelled to sell through this system unless he incurs the expense of returning the slaughter hogs to his farm.

4.2.2 Terminal Markets and Country Auctions

Terminal markets served as the main price establishing role prior to the development of electronic marketing mechanisms and provincial marketing boards and commissions. These markets are located in major cities and close to packing plants.

Assuming a large number of buyers and sellers present at each sale on the terminal market, the level of competition on these markets should

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[9] Ibid., p. 161.

be relatively high. That is, no one buyer or seller should be able to influence price levels. However, producers were concerned that the terminal markets were so thin (i.e. the number of hogs marketed through the terminal market was small relative to total number of hogs marketed) that prices established by this marketing mechanism were not competitively established. Tomek makes the following comment with regard to the influence of thin markets on pricing efficiency.

> Thin markets may create problems in pricing farm products. One concern is that a small volume of trading at a central market place can result in price behaviour not warranted by economic conditions. Moreover, deliberate manipulation of prices is more feasible with a small volume. If the central market quotations are used as base prices in other transactions, the problems of unwarranted or manipulated prices acquire increased economic importance.[10]

> The warranted price is usually defined in terms of the perfect competition norm. Prices may deviate from the norm because of deliberate manipulation or poor information. The issue of manipulation, however, is difficult to analyze with the data typically available. Observations on the actions and motives of individual traders are probably needed.[11]

However, the degree of equity may be fairly high in the terminal markets:

> Prices established in the central market are probably more uniform for different sellers, since all sales are negotiated by agents whose skill and knowledge are on par with that of the buyers or a mechanism is used in which buyers compete against others with similar skills.[12]

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[10] W.G. Tomek, "Price Behaviour on a Declining Terminal Market," American Journal of Agricultural Economics, Vol. 62, No. 3 (August 1980), p. 434.

[11] Ibid.

[12] Select Committee of the Legislative Assembly of Manitoba, op. cit., p. 167.

4.2.3 Electronic Marketing Mechanisms

Electronic marketing mechanisms have the greater potential to be competitive in pricing than either producer sales directly to the packing plant or sales through auction mechanisms.

> Its advantage over auction selling in the sales ring is that the identity of the buyer of each lot is not revealed. In an auction ring buyers are influenced by the bidding of the larger firms. The major buyers tend to set the pace and the smaller buyers can be discouraged from bidding aggressively in order to increase the volume of their purchases beyond their customary shares.
>
> In a teletype auction this kind of intimidation is impossible since the major buyers do not know whether an advance in the bidding is initiated by one of their major rivals or by a small buyer seeking to expand. Even if they did know who bought each lot after the sale, they would still not be able to squeeze out such a smaller buyer except by buying all lots offered at a higher price to keep the smaller buyer from increasing his purchases by aggressive bidding.[13]

Prices established by the electronic marketing mechanisms should theoretically be more equitable than those established by other selling systems.

> Pricing should be more equitable in teletype selling than in all other methods except the public market auction. Discrimination among sellers would be impossible. Pricing between areas would be kept in line if lots were offered for sale in various locations since all buyers would have a chance to bid on every lot.[14]

Henderson describes the advantage of a teletype Dutch auction:

> ... because price negotiations occur in a highly competitive centralized arena, the ability of a dominant trader to unduely influence price and other terms of exchange is sharply reduced compared to the typical one-on-one nature of direct, private negotiation. As a result, prices tend to be much more accurate representations of market-wide supply and demand conditions. That is, prices and other terms are determined prim-

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[13] Ibid., pp. 168-169.

[14] Ibid., pp. 169-170.

> arily by the impersonal forces of the marketplace, as reflected by numerous potential buyers and sellers, each striving to make the best deal possible given their individual assessment of market conditions, rather than unduely reflecting the individual assessments of only the two or three traders who typically participate in any one direct, privately negotiated sale.[15]

Henderson indicates that all the electronic marketing systems have their own individual characteristics specific to the particular product involved and the locational and structural characteristics of buyers and sellers involved. He does, however, identify the following necessary features for an electronic auction to work: "(1) simultaneous negotiations among numerous traders, (2) remote trading, (3) description selling, (4) performance guarantees and (5) sufficient trading volume".[16]

The study identifies flexibility as being the major advantage of electronic marketing mechanisms.

> Because of the large capacity and high speed with which modern electronic communication and computing systems can communicate and process data, an electronic system could be designed to meet almost any set of trading rules or industry conditions. For the most part, existing trading procedures can be incorporated in the rules and design of an electronic marketing system. An electronic market does, of course, require uniformity in trading rules and procedure across the market. This means that, in actual application, some traders must modify their practices to conform with industry norms in order to participate.[17]

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[15] D.R. Henderson, Some Considerations in the Application of Electronic Marketing to Meat. Studies of the Organization and Control of the U.S. Food System, N.C. Project No. 117, Working Paper 35, July 1979, pp. 3-4.

[16] Ibid., p. 4.

[17] Ibid., p. 11.

As indicated previously, several variations of electronic marketing mechanisms have been used in Canada. The first variation in electronic marketing concerns whether or not it should be compulsory for all hog producers to market through the teletype Dutch auction. Manitoba is the only province which has used a non-compulsory teletype to market slaughter hogs. The non-compulsory type Dutch auction allowed producers to choose between the teletype or direct delivery to the packing plants. All sales were reported to the Manitoba Hog Marketing Commission. Chen found that the percentage of hogs sold through the teletype was mainly affected by the day of the week and lot size of slaughter hogs.[18] More hogs were sold through the teletype Monday to Thursday whereas on Friday, the majority of hogs were direct delivered. Similarly, small producers were more likely to patronize the teletype system whereas larger producers were more apt to deliver their hogs directly to the packing plants. Approximately two-thirds of the hogs were sold through the teletype Dutch auction during the period 1965-1971. In later years, this proportion declined such that producers again expressed concerns about the slaughter hog processors' market power and their ability to influence prices established by the teletype Dutch auction. The teletype Dutch auction was made compulsory in Manitoba commencing January 1972 to improve buyer competition.

Another aspect of the electronic marketing mechanism is the actual type used: teletype versus Dutch clock auctions. With the teletype

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[18] L. Chen, "Effect of the Proportion of Hogs Sold Through Teletype on Realized Hog Prices," (M.Sc. Thesis, University of Manitoba, 1970), pp. 88-94.

Dutch auction, buyers are able to bid at their packing plants via teletype. With the clock mechanism, all buyers are required to be in one location. The argument against the former system is that because the packer buyers are more remotely located, there is opportunity for collusion. Having all buyers in one location provides an opportunity to observe the bidding of the buyers. At present, Manitoba is the only province which employs a Dutch clock pricing mechanism.

Another aspect of the electronic marketing mechanism which influences its ability to establish competitive prices is whether the system uses advance buyer bidding or whether the slaughter hogs are committed for sale prior to the price actually being established. Two of the provincial marketing boards (Alberta and Manitoba) presently use the advance buyer bidding to establish prices for slaughter hogs. Under this system packer buyers bid on anticipated deliveries of slaughter hogs to the market on the day prior to delivery and producers react to these bids by deciding the number of slaughter hog deliveries. Under the latter system producers commit themselves to a certain number of slaughter hog deliveries by shipping them to an assembly point or informing the Hog Board about the number of hogs being delivered en route to the marketing center. With this knowledge, packer buyers bid on the actual number of hogs delivered. The former system has an advantage similar to on farm sales in that the producer knows the approximate slaughter hog price before he ships them off his farm. This is an effective way of reducing the risk of short term price changes but in terms of effects exceeding one week, its effect is marginal because of the index system of grading hogs which severely penalizes producers for marketing non-optimal weight slaughter hogs.

One of the major benefits of the electronic Dutch auction pricing mechanism is the large number of buyers and sellers which can participate in this system. This factor tends to equalize the bargaining position of buyers and sellers and thus reduce the ability of market participants to artificially influence prices in their favor.[19,20] Similarly, the teletype Dutch auction provides all market participants equal opportunity to bid on all lots sold. Finally, only one price is established under the electronic Dutch auction mechanisms and this price is equally and easily available to both buyers and sellers.

4.2.4 Formula Pricing

Saskatchewan uses a formula pricing system to establish prices for slaughter hogs. Manitoba utilized this pricing mechanism from September 1977 to September 1978. Formula pricing is defined as: "A pricing technique whereby an individual transaction is priced according to an agreed upon basis".[21]

> Formula pricing contracts involve prices on individual shipments or transactions which are tied directly, by formula, to a specific market price quotation. After buyers and sellers agree on the formula, subsequent transactions are routine and low in cost.[22]

In the formula pricing system for slaughter hogs, prices are established on the basis of prices established on other markets. The

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[19] Johnson, op. cit., pp. 63-67.

[20] Martin, Richards and Usborne, op. cit., p. 54.

[21] R.S. Kohls and J.N. Uhl, Marketing of Agricultural Products, 5th Ed., (New York: MacMillan Publishing Co., 1980), p. 591.

[22] M.L. Hayenga and L.F. Schrader, "Formula Pricing in Five Commodity Marketing Systems," American Journal of Agricultural Economics, Vol. 62, No. 4 (November 1980), p. 753.

actual price differential between the markets is agreed on by negotiation between the buyers and sellers.

In assessing the competitiveness of this marketing mechanism several factors must be kept in mind; first, since it is a negotiated price the assumption must be made that neither the buyer or seller possess enough market power to influence market prices; second, the pricing formula must be negotiated frequently to ensure prices reflect changing supply and demand conditions; and finally, it must be assumed prices on other markets are competitively established and reflect national supply and demand conditions.

One of the major advantages of formula pricing is that forward pricing allows the buyers and sellers to more accurately plan their future operations by reducing the uncertainty regarding price.

The major problem with formula pricing is that it requires another competitively established market price as a base. Other studies have noted increases in the proportion of product priced using a formula relative to product priced competitively can lead to a situation of poor pricing efficiency.

> A market in which formula pricing is present presents a setting where a continued increase in the use of quite efficient formula pricing arrangements could gradually erode the volume involved in the price determination process. In the logical (or illogical) extreme, formula pricing would expand to the point where the negotiated market would become extinct, and in so doing, make extinct the base market price necessary for the formula.[23]

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[23] _____, Pork Pricing Systems: The Importance and Economic Impact of Formula Pricing. Studies of the Organization and Control of the U.S. Food System, N.C. Project No. 117, Working Paper 37, August 1979, p. 7.

> Formula-pricing arrangements reduce the fraction of total supply entering into market price determination, and the resulting, more thinly traded markets may be more sensitive to erratic or manipulative influences on market prices or market price reports.[24]

In a 1978 consultative study of the slaughter hog marketing mechanisms in Manitoba, it was concluded that prices established under a competitive system such as the electronic Dutch auction should be the preferred system to a formula pricing system where Manitoba hog prices are based on prices established on other North American markets.

> ... We have also concluded that a price in Manitoba which is competitively established, and which is, and is seen to be fair and equitable to buyers and sellers, is preferable to some form of formula pricing. Formula neglects or complicates the particular demand and supply conditions which may exist in Manitoba at any particular time.[25]

4.3 Chapter Summary

Recent studies of alternative marketing mechanisms for livestock in the United States and Canada have found the electronic marketing mechanisms desirable systems in terms of market efficiency.[26,27] That is, the electronic Dutch auctions were found to have more of the attributes of perfect competition than alternate marketing mechanisms. Similarly, the costs associated with these mechanisms are lower than other alternatives. Martin made the following comment about the teletype Dutch auction and the competitiveness of the market:

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[24] _____ and Schrader, loc. cit.

[25] Manitoba Department of Agriculture, Report of the Hog Marketing Co-ordinating Committee, (Winnipeg: December 1978), pp. 13-14.

[26] Johnson, op. cit., pp. 88-94.

[27] Martin, Richard and Usborne, op. cit., pp. 48-54.

> Under this system each potential buyer has equal and simultaneous access to information on the availability of hogs at geographically separated marketing yards. Each has instantaneous knowledge of prices and sales. Each buyer has equal access to a given lot of hogs. Each seller, through the board, has equal access to each buyer. Finally, because both selling and grading systems allow purchases without visual inspection and because access to the buying facility is inexpensive, transaction costs are very low. Hence there are virtually no barriers to entry.[28]

In a study examining marketing mechanism alternatives for meat in the United States, Henderson noted that adoption of the teletype would improve market performance from the aspects of both operational efficiency and pricing efficiency.

> ... the greatest impact of electronic marketing stems from its ability to put the price discovery function into an arena characterized by competitive, impersonal and visible interaction among numerous buyers and sellers. At the same time, electronic marketing offers the capability of maintaining the benefits of efficiency in physical transfer of products from sellers to buyers and improved seller-buyer communications and coordination that are associated with privately negotiated direct sales. Thus, the electronic market can be characterized as a method for maintaining physical transfer and coordination efficiencies while enhancing the process of competitive pricing vis-a-vis private, direct sales.[29]

As indicated by this discussion, the implementation of the teletype Dutch auction should theoretically have improved the efficiency of the hog marketing system in Canada. Prior to the establishment of marketing boards, producers expressed concern about the efficiency of the marketing mechanisms for slaughter hogs. These concerns were based on producer opinion that although the terminal market had the potential to be price efficient (if all hogs were marketed in this manner), they noted the

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[28] L. Martin, "Effectiveness of Canada's Hog Marketing Boards," Proceedings of National Pork Seminar, (Montreal, Quebec: October 24-26, 1977), pp. 161-162.

[29] Henderson, op. cit., p. 11.

thinness of the market resulted in a non-competitive situation. In addition, producers expressed concerns over the costs involved in operating this system and the excessive handling of slaughter hogs required. Direct deliveries to the packing plants was the method most producers used to market slaughter hogs. This mechanism was operationally efficient in that it minimized the costs associated with marketing and the handling of slaughter hogs. It was considered to result in poor pricing efficiency since the packing companies were alleged to have excessive market power.

The articles reviewed here tend to indicate that electronic marketing mechanisms such as the teletype Dutch auction should theoretically result in better market efficiency than alternative methods for marketing hogs. The costs involved and the amount of handling of slaughter hogs required should compare favorable with that of direct deliveries. Similarly, the ability to have participation in the market by a large number of buyers and sellers and the establishment of one market price would tend to indicate pricing efficiency.

Based on the conclusions presented in the papers reviewed for this section, the hypothesis is advanced that the teletype Dutch auction and its variations should theoretically result in prices which more accurately reflect supply and demand conditions. The objective of the next section is to determine if in fact changes in marketing mechanisms have influenced the price relationships between the various markets under study. Specifically, the objective is to determine if the establishment of the teletype Dutch auction has improved the transfer of pricing information among markets. Specific tests of these

hypotheses will be used to determine if price changes on the Toronto market have been fully reflected on the three prairie markets under study and to determine how quickly price information is being communicated among the different markets.

Chapter 5

5. EMPIRICAL ANALYSIS

5.1 Introduction

Previous chapters have identified changes in the marketing mechanisms for Canadian slaughter hogs and have examined the theoretical effects of changes in market structure on performance. Related studies were reviewed which rated theoretically the various marketing alternatives using operating and pricing efficiency as the criteria for evaluating market performance. The teletype and Dutch clock auctions were found to have more of the characteristics of perfect competition than pricing mechanisms existing before the establishment of hog marketing boards and commissions and, thus, were concluded to theoretically establish more efficient prices.

This section examines the influence of marketing mechanism changes on the price relationship among the various markets. The examination of price relationships should indicate that improvements in marketing mechanisms have improved the transfer of information among the markets. Price changes among markets should be reflected quickly such that relationships of time, form and place utility are maintained. Slow or only partial transfer of information could be interpreted as an indication of pricing inefficiency. This type of evidence would indicate market prices are not being communicated efficiently to all market participants. This condition may result from poor market information or misuse of market power by one of the participants.[1]

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[1] W.G. Tomek, "Price Behavior on a Declining Terminal Market," American Journal of Agricultural Economics, Vol. 62, No. 3 (August 1980), pp. 434-435.

5.2 Preliminary Analysis

Initially, the data was plotted and evaluated visually to provide an overview of price relationships. Figure 2 illustrates the price differentials between Winnipeg and the other three markets using weighted average annual data for the period 1951 to 1980. Except for 1978, Toronto slaughter hog prices exceeded Winnipeg prices in all years. Winnipeg slaughter hog prices exceeded Saskatoon during the study period except for the years 1976 through 1979. Edmonton slaughter hog prices exceeded Winnipeg prices during the years 1951 to 1955 and during the years 1975 to 1980 except for 1978. During 1956, weighted average prices in the two markets were equal. During all other years, Winnipeg prices exceeded Edmonton prices.

For each pair of markets, simple correlations were calculated using weekly slaughter hog prices separated on an annual basis (Table 3). These simple correlations were close to one in value indicating a strong relationship among slaughter hog prices on the selected markets.

5.3 Univariate Residual Cross-Correlation Analysis

Simple yearly correlation between weekly price data for the four major Canadian markets indicated a close price relationship. This would imply that price information is communicated relatively quickly among the study markets. However, the results of this type of analysis can be misleading due to the time series properties of the data.

> It has long been recognized that the finding of high correlation among variates does not in any necessary sense establish that they are causally related. Variables may be functionally related, yet be uncorrelated; and, perhaps more often, they may be correlated yet not causally related. The

Figure 2. Price Differentials on Major Canadian Slaughter Hog Markets Using Winnipeg as a Base, 1951-1980.

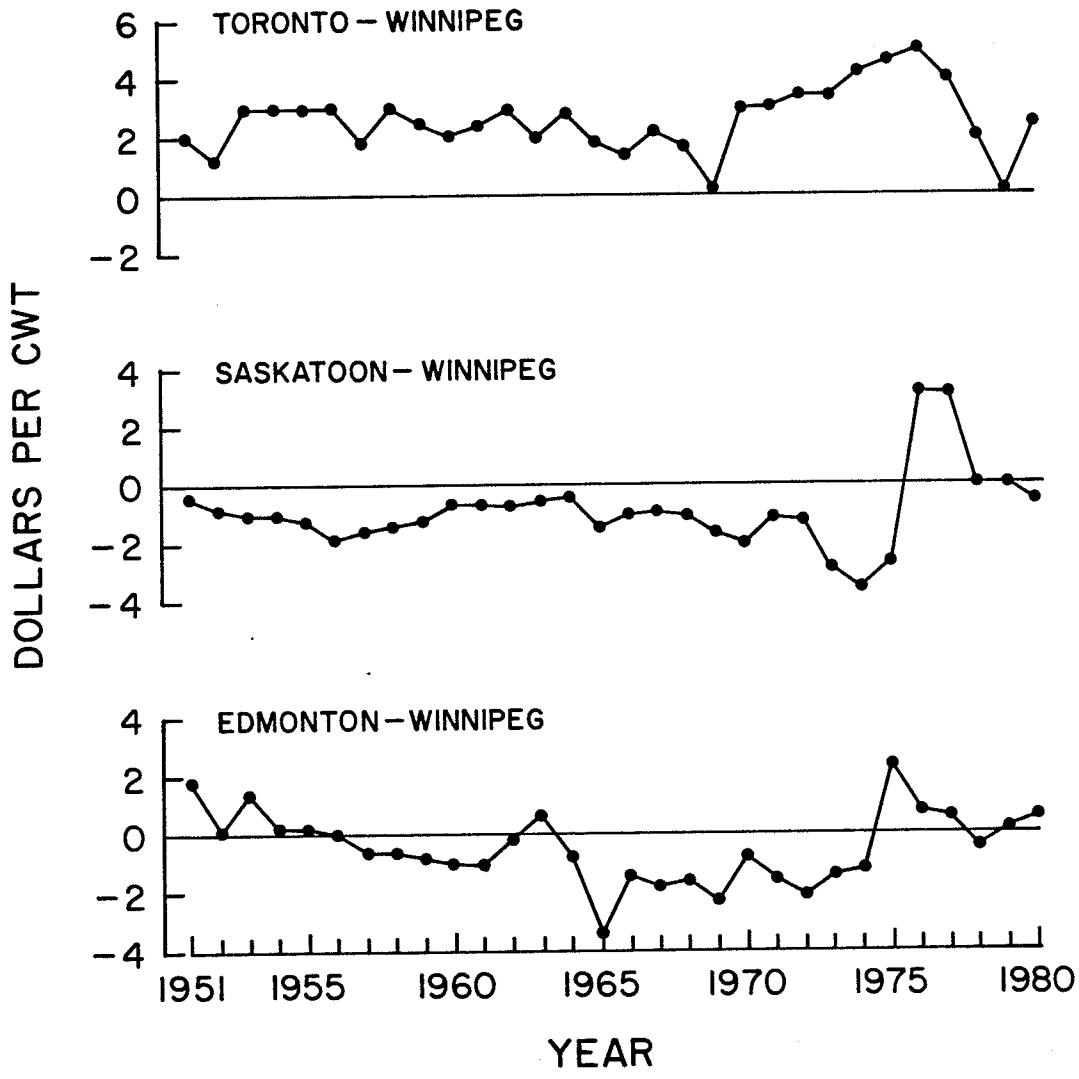

Table 3. Simple Correlation Coefficients for Slaughter Hog Prices on Major Canadian Markets, 1951-1980

	Wpg-Sas	Wpg-Edm	Wpg-Tor	Sas-Edm	Sas-Tor	Edm-Tor
1951	0.99	.96	.94	.96	.95	0.93
1952	0.94	.83	.91	.84	.98	0.84
1953	0.99	.97	.97	.97	.96	0.94
1954	0.99	.97	.99	.97	.99	0.96
1955	0.98	.96	.98	.97	.99	0.96
1956	0.99	.97	.99	.97	.99	0.96
1957	0.99	.97	.95	.97	.95	0.95
1958	0.99	.98	.99	.97	.98	0.97
1959	0.94	.96	.94	.98	.94	0.97
1960	0.99	.98	.98	.98	.96	0.96
1961	0.97	.92	.88	.95	.87	0.82
1962	0.99	.96	.98	.96	.98	0.93
1963	0.99	.93	.97	.93	.96	0.88
1964	0.99	.88	.97	.90	.94	0.81
1965	0.99	.98	.99	.98	.99	0.98
1966	0.99	.98	.94	.99	.94	0.94
1967	0.99	.93	.91	.93	.91	0.94
1968	0.99	.98	.97	.98	.97	0.98
1969	0.99	.98	.94	.97	.93	0.94
1970	0.99	.99	.99	.99	.99	0.99
1971	0.99	.92	.89	.92	.89	0.92
1972	0.99	.99	.97	.98	.96	0.94
1973	0.99	.99	.98	.98	.98	0.98
1974	0.99	.98	.97	.98	.96	0.95
1975	0.99	.97	.99	.97	.99	0.96
1976	0.99	.97	.98	.99	.97	0.96
1977	0.99	.93	.98	.96	.98	0.92
1978	0.99	.93	.90	.96	.88	0.82
1979	0.99	.98	.88	.99	.88	0.87
1980	0.99	.99	.98	.99	.98	0.97

> former effect arises because correlation is a measure of linear association only; the latter because of common association of each with additional factors.[2]

A method for examining pricing efficiency is to determine the time period for pricing information to be communicated among markets. The actual lead-lag relationship is compared to a time period that is deemed to be socially acceptable.

Univariate residual cross-correlation analysis has been used in recent studies to examine lead-lag relationships between two data series. Miller has applied this procedure in examining lead-lag relationships at the retail, wholesale and farm levels for beef and pork in the United States.[3,4] Miller indicates this technique is useful for evaluating pricing efficiency.

> Since a possible criterion for evaluating alternative price discovery mechanisms might be the speed with which price changes are reflected through the marketing system, analysis of the lead-lag relationships ... would provide useful benchmark information for evaluation of alternative price discovery mechanisms.[5]

Bessler and Schrader use this procedure in two studies. In the first study, the authors apply this technique in examining lead-lag re-

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[2]D.A. Pierce and L.D. Haugh, "Causality in Temporal Systems," Journal of Econometrics, Vol. 5 (1977), p. 265.

[3]S.E. Miller, "Univariate Residual Cross-Correlation Analysis: An Application to Beef Prices," North Central Journal of Agricultural Economics, Vol. 1, No. 2 (July 1979), pp. 141-146.

[4]S.E. Miller, "Lead-lag Relationships Between Pork at the Retail, Wholesale and Farm Levels," Southern Journal of Agricultural Economics, Vol. 12, No. 1 (July 1980), pp. 73-76.

[5]Op. cit., p. 141.

lationships between turkey product prices in the United States.[6] In a second article, the authors apply this procedure in examining the lead-lag relationships between two price reporting services for egg shells.[7] Faminow applied this procedure for testing the lead-lag relationships between two daily beef carcass price quotes from two privately owned wholesale meat price reporting services.[8]

The univariate residual cross-correlation analysis is applied to determine the lead-lag relationship between prices of the different markets. It is hypothesized that price changes on individual markets should be reflected quickly on other markets. The objective is to investigate the lead-lag relationships between markets during the periods of alternative marketing mechanisms. Time periods which reflect price changes between markets quickly are hypothesized to be indicative of good pricing efficiency.

Bishop describes an interesting aspect of using causality tests to examine lead-lag relationships. These tests can be applied in determining how prices are transmitted between countries (or in this case markets).

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[6] D.A. Bessler and L.F. Schrader, "Measuring Leads and Lags Among Prices: Turkey Products," Agricultural Economics Research, Vol. 32, No. 3 (July 1980), pp. 1-7.

[7] _____, "Relationship Between Two Price Quotes for Eggs." American Journal of Agricultural Economics, Vol. 62, No. 4 (November 1980), pp. 766-771.

[8] M.D. Faminow, "Analysis of the Lead-Lag Structure of Two Wholesale Beef Price Quotes Using Residual Cross-Correlation," North Central Journal of Agricultural Economics, Vol. 3, No. 2 (July 1981), pp. 89-94.

> If one defines a world price as one that 'drives' other prices, one could determine which price, if any, is the world price, as well as discern whether a causal structure exists (whether prices are transmitted among regions).[9]

A similar test could be performed on North American hog prices to determine which markets generally establish price trends, how closely the other markets follow these price changes and whether this price relationship has changed over the time period under study.

These tests are not meant to indicate conclusively that changes in marketing mechanisms have improved pricing efficiency but rather only that prices established by the newer marketing mechanisms fall within a more acceptable range. Griffith describes this justification:

> ... rigorous analysis would involve a micro-economic appraisal of least-cost equillibrium transfers from each level of the system to the next. But even if this were done, the basic assumption of perfect, costless information about the past, present and future in general still does not hold. ... under conditions which are imperfect, efficiency may be acceptable if the pricing system provides values within some reasonable range.[10]

5.4 Analytic Procedure

The following is a description of univariate residual cross correlation analysis. This technique is used as a measure of the price relationships among the various markets. Haugh describes this procedure as being useful for examining the relationship between time series data.

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[9] R.V. Bishop, "The Construction and Use of Causality Tests," Agricultural Economics Research, Vol. 31, No. 4 (October 1979), p. 1.

[10] G.R. Griffith, "A Cross-Spectral Approach to Measuring Pricing Efficiency in the New South Wales Pigmeat Market," Review of Marketing and Agricultural Economics, Vol. 43, No. 4 (December 1975), p. 164.

> Particularly in the early stages of system identification, one is first concerned with checking the independence of the two series, and then, in addition, with discovering whether one of the series may act as a leading indicator of the other.[11]

The cross-correlation analysis can be used to measure lead-lag relationships. However, autocorrelation in time series data can make interpretations of cross-correlations difficult.

> ... attempting to detect causality by analyzing cross-correlations or regressions of levels of Y on past levels of X and Y can be a difficult problem. ... the significance tests (t- and F-statistics) obtained from relating levels of highly autocorrelated series can be grossly overestimated, thus leading us to assert a causal relationship when none may exist.[12]

Haugh and Box describe the difficulties encountered in interpreting estimates of cross-correlation functions:

> ... when each of the series X and Y are themselves autocorrelated, then lagged cross-correlation estimates can have high variance and the estimates at different lags can be highly correlated with one another. One may be misled in such situations by attributing some significance to apparent patterns in the cross-correlation function which in fact are a result of the sampling properties of the estimates used. This can happen even if two series are independent.[13]

Application of univariate residual cross-correlation analysis involves two stages. Schrader and Lang discuss these two stages:

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[11] L.D. Haugh, "Checking the Independence of Two Covariance Stationary Time Series: A Univariate-Residual Cross Correlation Approach," Journal of the American Statistical Association, Vol. 71, No. 354 (June 1976), p. 378.

[12] D.A. Bessler and L.F. Schrader, "Relationships Between Two Price Quotes for Eggs," American Journal of Agricultural Economics, Vol. 62, No. 4 (November 1980), p. 767.

[13] L.D. Haugh and G.E.P. Box, "Identification of Dynamic Regression (Distributed Lag) Models Connecting Two Time Series," Journal of the American Statistical Association, Vol. 72, No. 357 (March 1977), p. 122.

> First, each series is processed to remove all time series properties ... That is, the regular features of trend, seasonal, and cyclical patterns as well as systematic correlation with past values of the same series are removed. The deviations of this series from this analysis are cross-correlated to test for causal relationships.[14]

The statistical significance of estimated cross-correlations can be evaluated using Haugh's U statistic. Bessler and Schrader use the following formula for calculating Haugh's U statistic.

$$U_m = n \sum_{k=1}^{m} r_k^2$$

> where n refers to the number of observations on innovations of X and Y, r_k^2 the squared cross-correlation at lag k, and m is an integer, greater than or equal to one, chosen large enough to include expected nonzero coefficients. Under the null hypothesis of series independence, the U-statistic is distributed chi-square with m degrees of freedom.[15]

The following methodology is used in calculating univariate residual cross-correlations. Initially, autocorrelation functions are calculated for each of the time series data to determine if they are stationary. First differencing, seasonal differencing and logarithmic transformations are performed to determine if these transformations would make the data stationary. If the autocorrelation function obtained from the transformed data contain autocorrelations which are significantly different from zero, Box-Jenkins time series

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[14] L.F. Schrader and M.G. Lang, Turkey Pricing in the United States, (West Lafayette, Indiana: Station Bulletin No. 275, Dept. of Agr. Econ., Purdue University, April 1980), p. 26.

[15] Bessler and Schrader, "Relationships Between Two Quotes for Eggs," loc. cit.

analysis is applied to the data. The residuals obtained from this procedure are cross-correlated. The following formula is used in calculating cross-correlations.

$$r_k = r_{uv}(k) = \frac{\Sigma \hat{u}_{t-k}\ \hat{v}_t}{[\Sigma \hat{u}_t^2\ \Sigma \hat{v}_t^2]^{\frac{1}{2}}}$$

where u_t and v_t are white noise residuals obtained from applying Box Jenkins procedures.[16]

These cross-correlations are judged as to their significance by comparing them to their standard error. Their standard error is calculated in the following manner.

$$\text{s.e.} = \frac{1}{\sqrt{n}}$$

where n equals the sample size. Statistical tests can be applied to determine the significance level of these cross-correlations. Pierce describes some of the conclusions which can be reached as a result of applying Haughs' U statistic.

> ... "X causes Y" may be asserted at significance level α ... if
>
> $$n \sum_{k=1}^{m} \hat{r}_k^2 > \chi_\alpha^2 (m)$$
>
> where the right member ... is the upper α percentage point of $\chi^2(m)$ distribution. Similarly the hypothesis that X and Y are unrelated would not be rejected at level α if and only if
>
> $$n \sum_{k=-m}^{k=m} \hat{r}_k^2 < \chi_\alpha^2 (2m+1)$$

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[16] D.A. Pierce, "Relationships - and the Lack Thereof - Between Economic Time Series, With Special Reference to Money and Interest Rates," Journal of the American Statistical Association, Vol. 72, No. 357 (March 1977), pp. 11-22.

where m is chosen large enough to include expected nonnegligibly nonzero coefficients.[17]

Pierce and Haugh identify three potential classifications of these relationships: "(a) whether (or not) X causes Y, (b) whether Y causes X, and (c) whether instantaneous causality exists.[18] Table 4 outlines some of the potential conclusions which can be reached as a result of applying this statistical technique.

5.5 Results Obtained from Univariate Residual Cross-Correlation Analysis

The objective of this section is to assess the lead-lag relationships for slaughter hog prices established on the four Canadian markets under study. The freedom of hog and pork movement among the regions under study and the availability of market information to all buyers and sellers should result in the efficient transfer of price information.

The methodology used to accomplish these objectives is to separate the data into different time periods based on the marketing mechanisms in use on each market. Lu used a similar procedure to analyze the influence of the implementation of the teletype Dutch auction on price relationships between Manitoba and Ontario slaughter hog prices.[19] The slaughter hog price data for each set of markets could conceivably be divided into three time periods: Period 1 when neither market had a compulsory marketing mechanism; Period 2 when one market had adopted a compulsory marketing mechanism but the other had not; and Period 3

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[17] Ibid.

[18] Op. cit., p. 276.

[19] W.F. Lu, "Effect on Regional Price Levels of Selling Hogs by Teletype," (M.Sc. Thesis, University of Manitoba, 1968), pp. 56-74.

Table 4. Potential Causal Relationships Identified from Application of Univariate Residual Cross-Correlation Analysis

Relationship	Restrictions
(1) X causes Y	$P_{uv}(k) \neq 0$ for some $k>0$
(2) Y causes X	$P_{uv}(k) \neq 0$ for some $k<0$
(3) Instantaneous feedback	$P_{uv}(k) \neq 0$
(4) Feedback	$P_{uv}(k) \neq 0$ for some $k>0$ and for some $k<0$
(5) X causes Y but not instantaneously	$P_{uv}(k) \neq 0$ for some $k>0$ and $P_{uv}(0) = 0$
(6) Y does not cause X	$P_{uv}(k) = 0$ for all $k<0$
(7) Y does not cause X at all	$P_{uv}(k) = 0$ for all $k\leq 0$
(8) Unidirectional causality from X to Y	$P_{uv}(k) \neq 0$ for some $k>0$ and $P_{uv}(k) = 0$ for either (a) all $k<0$ or (b) all $k\leq 0$
(9) X and Y are related only instantaneously (if at all)	$P_{uv}(k) = 0$ for all $k\neq 0$
(10) X and Y are related instantaneously and in no other way	$P_{uv}(k) = 0$ for all $k\neq 0$ and $P_{uv}(0) \neq 0$
(11) X and Y are independent	$P_{uv}(k) = 0$ for all k

Source: D.A. Pierce and L.D. Haugh, "Causality in Temporal Systems," Journal of Econometrics, Vol. 5, (1977) p. 276.

when both markets had adopted a compulsory marketing mechanism. Additional time periods are identified for Manitoba, Saskatchewan and Alberta based on the modifications to marketing mechanisms in these provinces. The influence which Ontario's adoption of a compulsory teletype had on the price relationship between the three prairie markets is examined. Additional time periods are identified which reflect modifications which have occurred in Manitoba. These modifications include; a non-compulsory teletype Dutch auction (February 25, 1965 to December 31, 1971); a compulsory teletype Dutch auction (January 1, 1972 to September 5, 1977); a compulsory formula pricing system (September 6, 1977 to September 16, 1978) and a Dutch clock pricing mechanism with advance buyer bidding (September 17, 1978 to present). Alberta also modified their slaughter hog marketing mechanisms over the study period. These modifications include; a compulsory teletype Dutch auction (October 31, 1969 to March 16, 1978); a compulsory teletype Dutch auction with advance buyer bidding (March 17, 1978 to February 27, 1980); and a bid/acceptance system (February 28, 1980 to December 31, 1980). The latter two periods are not separated in the analysis because of the short period the bid/acceptance system has been in operation in Alberta. Table 5 indicates the dates of modifications to slaughter hog marketing mechanisms.

For the reasons cited previously, cross-correlation analysis was not applied directly to actual or first differenced data. The autocorrelation present in the data invalidates the normal statistical tests of significance. Because of the sampling properties of the data, Box-Jenkins procedures were applied to transform the data. A discussion of the Box-Jenkins procedure is contained in the Appendix. The

Table 5. Dates of Hog Marketing Mechanism Changes Within Manitoba, Saskatchewan, Alberta and Ontario

May 8, 1961	Ontario commences sale of hogs through compulsory teletype Dutch auction
February 25, 1965	Manitoba commences sale of hogs through non-compulsory teletype Dutch auction
October 31, 1969	Alberta commences sale of slaughter hogs through compulsory teletype Dutch auction
January 1, 1972	Sale of slaughter hogs made compulsory in Manitoba through teletype Dutch auction
August 6, 1973	Saskatchewan commences sale of hogs through formula pricing system
September 6, 1977	Manitoba adopts formula pricing
March 17, 1978	Alberta adopts advance buyer bidding through teletype Dutch auction
September 17, 1978	Manitoba adopts Dutch clock mechanism and advance buyer bidding
February 28, 1980	Alberta drops compulsory teletype Dutch and adopts a system under which the packing companies submit bids and the Board allocates slaughter hogs to the highest bidders

autocorrelation and partial autocorrelation functions of first differenced data, coefficients obtained for the selected equations using Box-Jenkins procedure and the autocorrelations of the residuals are also presented in the Appendix (Tables 21-38).

The cross-correlations and Haugh's U statistics are presented in Tables 7 to 17. Cross-correlations which are at least three times their standard error are judged to be statistically different from zero.[20] Haugh's U statistic is used to test for the various hypotheses outlined in Table 4. These tests were conducted at the one percent confidence level.

The number of leads and lags used in this analysis was limited to two based on a priori expectations that market information should be transferred between markets within two weeks.

In all cases, the results indicate the strongest relationship between markets occurred at the zero lag period. This would indicate an efficient flow of information between the markets for the study period. However, the conclusions concerning the lead-lag relationships and feedback of price information varied among the different time periods under study. The following sections will attempt to identify the categories of information transfer: (1) instantaneous, (2) one market leading the other and (3) feedback of price information between the two markets.

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[20] Other studies have used two times the standard error in evaluating whether cross-correlations are significantly different from zero. Three times the standard error is used in this analysis as the criteria since the study is only interested in identifying the strongest lead-lag relationships.

5.5.1 Toronto-Winnipeg

Tables 6 and 7 present the results of applying univariate residual cross-correlation analysis to Toronto and Winnipeg slaughter hog prices. The data was divided into six time periods; Period 1 (January 1, 1951 to May 7, 1961) when neither Ontario or Manitoba had adopted a teletype Dutch auction; Period 2 (May 8, 1961 to February 24, 1965) when Ontario had implemented a compulsory teletype Dutch auction; Period 3 (February 25, 1965 to December 31, 1971) when Manitoba had adopted a non-compulsory teletype Dutch auction; Period 4 (January 1, 1972 to September 5, 1977) when both markets used a compulsory teletype Dutch auction; Period 5 (September 6, 1977 to September 16, 1978) when Manitoba adopted a formula pricing system; and Period 6 (September 17, 1978 to December 31, 1980) when Manitoba replaced the formula pricing system with the Dutch clock selling mechanism and advance buyer bidding.

The estimated cross-correlations between white noise residuals of weekly Toronto and Winnipeg slaughter hog price changes are presented in Table 6. The results indicate that Toronto and Winnipeg prices have their strongest association at zero lag for all six time periods. The zero lag cross-correlations were smallest during the time periods when Manitoba had adopted a non-compulsory teletype Dutch auction (Period 3) and a compulsory teletype Dutch auction (Period 4). Ontario used a compulsory teletype Dutch auction during both these periods. The zero lag relationships were greatest during the time period when Ontario had a compulsory teletype Dutch auction and Manitoba used traditional pricing mechanisms (Period 2) and during the time period Manitoba used a compulsory formula pricing system (Period 5). The

Table 6. Estimated Cross-Correlations Between White Noise Residuals of Weekly Toronto and Winnipeg Slaughter Hog Price Changes

	Lags					
k	-2[a]	-1[a]	0[b]	1[c]	2[c]	s.e.[d]
Period 1	0.030	0.041	0.698[e]	0.232[e]	-0.029	0.043
Period 2	0.033	-0.005	0.775[e]	0.153	-0.039	0.071
Period 3	0.038	0.101	0.505[e]	0.186[e]	0.132	0.053
Period 4	-0.024	0.168	0.602[e]	0.125	0.072	0.058
Period 5	-0.079	0.119	0.875[e]	0.019	-0.069	0.137
Period 6	0.000	0.138	0.693[e]	0.251	-0.068	0.091

Period 1 (January 1, 1951 to May 7, 1961) neither market used a teletype Dutch auction; Period 2 (May 8, 1961 to February 24, 1965) Ontario adopted a compulsory teletype Dutch auction; Period 3 (February 25, 1965 to December 31, 1971) Manitoba adopted a non-compulsory teletype Dutch auction; Period 4 (January 1, 1972 to September 5, 1977) Manitoba made teletype Dutch auction compulsory; Period 5 (September 6, 1977 to September 16, 1978) Manitoba adopted compulsory formula pricing system; Period 6 (September 17, 1978 to December 31, 1980) Manitoba adopted a compulsory Dutch clock auction using advance buyer bidding.

[a] Winnipeg slaughter hog prices lead Toronto slaughter hog prices.

[b] Lag zero cross-correlations.

[c] Winnipeg slaughter hog prices lag Toronto slaughter hog prices.

[d] Estimated standard error.

[e] At least three times standard error.

Table 7. Calculated U Statistics for Alternative Causal Orderings Between Toronto and Winnipeg Price Series

	Winnipeg Leads Toronto[a]	Instantaneous Relationship[b]	Winnipeg Lags Toronto[c]
Period 1	1.40	342.75*	29.57*
Period 2	0.22	124.08*	4.94
Period 3	4.16	113.77*	18.57*
Period 4	8.47	121.13*	6.12
Period 5	1.08	41.93*	0.27
Period 6	2.27	67.46*	8.05

Period 1 (January 1, 1951 to May 7, 1961) neither market used a teletype Dutch auction; Period 2 (May 8, 1961 to February 24, 1965) Ontario adopted a compulsory teletype Dutch auction; Period 3 (February 25, 1965 to December 31, 1971) Manitoba adopted a non-compulsory teletype Dutch auction; Period 4 (January 1, 1972 to September 5, 1977) teletype Dutch auction made compulsory in Manitoba; Period 5 (September 6, 1977 to September 16, 1978) Manitoba adopted formula pricing system; Period 6 (Setpember 17, 1978 to December 31, 1980) Manitoba adopted a compulsory Dutch clock auction and advance buyer bidding.

[a]Calculated from first two negative cross-correlations and distributed χ^2 with two degrees of freedom. The critcal value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

[b]Calculated from first two negative, zero and first two positive cross-correlations and distributed χ^2 with five degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 15.09 at the one percent level.

[c]Calculated from first two positive cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

*Significant at the one percent level.

latter period reflects the fact that Toronto slaughter hog prices were a major component used in the formula calculating Winnipeg slaughter hog prices. The one week cross-correlations are significantly different from zero for Toronto slaughter hog price changes leading Winnipeg price changes in Periods 1 and 3.

Tests for lead-lag relationships (Table 7) indicated that price changes on the Toronto market lead price changes on the Winnipeg market during Period 1 (neither market had adopted a compulsory teletype Dutch auction) and Period 3 (Ontario retained compulsory teletype Dutch auction while Manitoba adopted a non-compulsory Dutch auction). During all other periods, price changes occurred instantaneously and in no other way.

5.5.2 Toronto-Saskatoon

Results for this section are presented in Tables 8 and 9. The univariate residual cross-correlation analysis is divided into three periods for Toronto and Saskatoon; Period 1 (January 1, 1951 to May 7, 1961) when Ontario had not yet adopted a compulsory teletype and Saskatchewan used traditional marketing methods; Period 2 (May 8, 1961 to August 5, 1973) when Ontario had adopted a teletype Dutch auction and Saskatchewan retained traditional marketing mechanisms; and Period 3 (August 6, 1973 to December 31, 1980) when Saskatchewan had adopted a compulsory formula pricing system.

In all three time periods, cross-correlations for a zero lag period are larger than other lead-lag periods (Table 8). The zero lag cross-correlations were highest in Period 1 when neither market had a

Table 8. Estimated Cross-Correlations Between White Noise Residuals of Weekly Toronto and Saskatoon Slaughter Hog Price Changes

	Lags					
k	-2[a]	-1[a]	0[b]	1[c]	2[c]	s.e.[d]
Period 1	0.060	0.092	0.697[e]	0.134[e]	-0.036	0.043
Period 2	0.020	0.084	0.560[e]	0.257[e]	0.084	0.040
Period 3	0.067	0.063	0.648[e]	0.171[e]	0.035	0.051

Period 1 (January 1, 1951 to May 7, 1961) neither Ontario or Saskatchewan had adopted current marketing system; Period 2 (May 8, 1961 to August 5, 1973) Ontario adopted compulsory teletype Dutch auction; Period 3 (August 6, 1973 to December 31, 1980) Saskatchewan adopted formula pricing system.

[a]Saskatoon slaughter hog prices lead Toronto slaughter hog prices.

[b]Lag zero cross-correlations.

[c]Saskatoon slaughter hog prices lag Toronto slaughter hog prices.

[d]Estimated standard error.

[e]At least three times standard error.

Table 9. Calculated U Statistics for Alternative Causal Orderings Between Toronto and Saskatoon Price Series

	Saskatoon Leads Toronto[a]	Instantaneous Relationship[b]	Saskatoon Lags Toronto[c]
Period 1	6.53	279.76*	10.42*
Period 2	4.76	251.47*	46.64*
Period 3	3.26	177.11*	11.76*

Period 1 (January 1, 1951 to May 7, 1961) neither market had adopted an alternative marketing mechanism; Period 2 (May 8, 1961 to August 5, 1973) Ontario adopted compulsory teletype Dutch auction; Period 3 (August 6, 1973 to December 31, 1980) Saskatchewan adopted compulsory formula pricing system.

[a]Calculated from first two negative cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

[b]Calculated from first two negative, zero and first two positive cross-correlations and distributed χ^2 with five degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 15.09 at the one percent level.

[c]Calculated from first two positive cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

*Significant at the one percent level.

compulsory marketing mechanism and lowest in Period 2 when Toronto used a compulsory teletype Dutch auction and Saskatoon used traditional pricing mechanisms. In all three periods, the cross-correlations for Toronto leading Saskatoon slaughter hog price changes by one week are significantly different from zero. This evidence would seem to indicate that Toronto price changes have historically lead Saskatoon price changes by one week.

Tests were conducted using Haugh's U statistic to determine the significance of these lead-lag relationships (Table 9). Tests for Periods 1, 2 and 3 indicate that as well as price changes occurring instantaneously between Toronto and Saskatoon, the Toronto slaughter hog price changes lead Saskatoon price changes to some extent.

5.5.3 Toronto-Edmonton

Results for this section are presented in Tables 10 and 11. The data is separated into four time periods for this analysis; Period 1 (January 1, 1951 to May 7, 1961) when neither Ontario nor Alberta had adopted a compulsory teletype Dutch auction; Period 2 (May 8, 1961 to October 30, 1969) when Ontario had adopted a teletype Dutch auction but Alberta still relied on traditional methods; Period 3 (October 31, 1969 to March 16, 1978) when both markets had adopted a teletype Dutch auction; and Period 4 (March 17, 1978 to December 31, 1980) when Alberta adopted advance buyer bidding. During Period 4, two alternative marketing mechanisms were used in Alberta. From March 17, 1978 to February 27, 1980, the board used a teletype Dutch auction while from February 28, 1980 to the present they have used a bid/allocation system.

During all periods, the Toronto and Edmonton markets were most highly related at zero lag. As depicted in Table 10, Toronto and

Table 10. Estimated Cross-Correlations Between White Noise Residuals of Weekly Toronto and Edmonton Slaughter Hog Price Changes

	Lags					
k	-2[a]	-1[a]	0[b]	1[c]	2[c]	s.e.[d]
Period 1	0.006	0.150[e]	0.478[e]	0.271[e]	0.008	0.043
Period 2	-0.023	0.168[e]	0.519[e]	0.213[e]	0.017	0.048
Period 3	0.000	0.108	0.456[e]	0.289[e]	0.087	0.048
Period 4	0.036	-0.087	0.523[e]	0.294[e]	0.082	0.083

Period 1 (January 1, 1951 to May 7, 1961) neither market had adopted compulsory teletype Dutch auction; Period 2 (May 8, 1961 to October 30, 1969) Ontario adopted a compulsory teletype auction; Period 3 (October 31, 1969 to March 16, 1978) Alberta adopted a compulsory teletype Dutch auction; Period 4 (March 17, 1978 to December 31, 1980) Alberta adopts advance buyer bidding.

[a]Edmonton slaughter hog prices lead Toronto slaughter hog prices.

[b]Lag zero cross-correlations.

[c]Edmonton slaughter hog prices lag Toronto slaughter hog prices.

[d]Estimated standard error.

[e]At least three times standard error.

Table 11. Calculated U Statistics for Alternative Causal Orderings Between Toronto and Edmonton Slaughter Hog Price Series

	Edmonton Leads Toronto[a]	Instantaneous Relationship[b]	Edmonton Lags Toronto[c]
Period 1	12.19*	175.57*	39.77*
Period 2	12.71*	151.95*	20.18*
Period 3	5.07	135.15*	39.62*
Period 4	1.29	54.83*	13.60*

Period 1 (January 1, 1951 to May 7, 1961) neither market had adopted compulsory teletype Dutch auction; Period 2 (May 8, 1961 to October 30, 1969) Ontario adopted a compulsory teletype Dutch auction; Period 3 (October 31, 1969 to March 16, 1978) Alberta adopted a compulsory teletype Dutch auction; Period 4 (March 17, 1978 to December 31, 1980) Alberta adopts advance buyer bidding.

[a]Calculated from first two negative cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

[b]Calculated from first two negative, zero and first two positive cross-correlations and distributed χ^2 with five degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 15.09 at the one percent level.

[c]Calculated from first two positive cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

*Significant at the one percent level.

Edmonton prices are most highly related at zero lag in Periods 2 and 4 and least related in Period 3. That is, the cross-correlations for a zero lag are largest during the time when Ontario used a compulsory teletype Dutch auction and Alberta used traditional selling mechanisms (Period 2) and when Alberta used teletype Dutch auction with advance buyer bidding (Period 4). The prices on these two markets were least related at zero lag when both markets priced slaughter hogs on the basis of teletype Dutch auction.

One week cross-correlations for Toronto leading Edmonton are significantly different from zero during all four time periods. In Period 1 and 2, one week cross-correlations for Edmonton leading Toronto are significantly different from zero. This would seem to indicate feedback of pricing information between the two markets during Periods 1 and 2.

The implication from using Haugh's U statistic (Table 11) indicate feedback of price information between the Toronto and Edmonton markets during Periods 1 (neither market had adopted a compulsory teletype Dutch auction) and Period 2 (Ontario had adopted a compulsory teletype Dutch auction while Alberta maintained traditional techiques). During Periods 3 and 4 (both markets had some form of compulsory marketing mechanism), tests using Haugh's U statistic indicate that Toronto price changes tended to lead Edmonton price changes.

5.5.4 Winnipeg-Saskatoon

The price data for Winnipeg and Saskatoon can be divided into seven periods. During Periods 1 and 2 (January 1, 1951 to May 7, 1961

and May 8, 1961 to February 24, 1965), both Manitoba and Saskatchewan used traditional pricing mechanisms. The second time period is identified to determine the influence of the adoption of teletype Dutch auction in Ontario on the price relationship between these two markets. During Period 3 (February 25, 1965 to December 31, 1971) Manitoba adopted a non-compulsory teletype Dutch auction while Saskatchewan still used traditional pricing mechanisms. Marketing slaughter hogs through the teletype Dutch auction was made compulsory in Manitoba in Period 4 (January 1, 1972 to August 5, 1973) and Saskatchewan commenced marketing slaughter hogs using a formula pricing system in Period 5 (August 6, 1973 to September 5, 1977). During Period 6 (September 6, 1977 to September 16, 1978), Manitoba adopted a formula pricing system while in Period 7 (September 17, 1978 to December 31, 1980), Manitoba switched to Dutch clock auction and advance buyer bidding.

In all periods, prices established on the Winnipeg and Saskatoon markets were most highly related at zero lag. Cross-correlations (Table 12) at zero lag indicate Winnipeg slaughter hog prices were most highly cross-correlated with Saskatoon in Periods 3 and 4 (Manitoba priced hogs using a non-compulsory and compulsory teletype Dutch auction respectively while Saskatchewan used traditional methods) and least cross-correlated in Period 5 (when Saskatchewan began pricing slaughter hogs using a formula pricing system).

Cross-correlations at one week were significantly different from zero for Winnipeg lagging Saskatoon in Period 1. During Period 5, the cross-correlations for Winnipeg leading Saskatoon by one week are significantly different from zero. This may reflect a change in the

Table 12. Estimated Cross-Correlations Between White Noise Residuals of Weekly Winnipeg and Saskatoon Slaughter Hog Price Changes

	Lags					
k	-2^a	-1^a	0^b	1^c	2^c	s.e.[d]
Period 1	0.025	0.170[e]	0.818[e]	0.061	-0.021	0.043
Period 2	-0.036	-0.015	0.804[e]	0.164	-0.142	0.071
Period 3	0.034	0.006	0.937[e]	0.067	0.057	0.053
Period 4	0.033	-0.093	0.948[e]	0.049	0.009	0.110
Period 5	0.090	0.061	0.722[e]	0.365[e]	-0.051	0.069
Period 6	0.023	0.008	0.839[e]	-0.009	0.070	0.137
Period 7	-0.003	0.215	0.792[e]	0.171	0.056	0.091

Period 1 (January 1, 1951 to May 7, 1961) both markets and traditional pricing mechanisms; Period 2 (May 8, 1961 to February 24, 1965) both markets used traditional pricing mechanisms and Toronto, Ontario adopted compulsory teletype Dutch auction; Period 3 (February 25, 1965 to December 31, 1971) Manitoba adopted a non-compulsory teletype Dutch auction; Period 4 (January 1, 1972 to August 5, 1971) teletype Dutch auction made compulsory in Manitoba; Period 5 (August 6, 1973 to September 5, 1977) Saskatchewan adopted compulsory formula pricing system; Period 6 (September 6, 1977 to September 16, 1978) Manitoba adopted compulsory formula pricing system; Period 7 (September 17, 1978 to December 31, 1980) Manitoba adopts Dutch clock pricing mechanism and advance buyer bidding.

[a]Saskatoon slaughter hog prices lead Winnipeg slaughter hog prices.

[b]Lag zero cross-correlations.

[c]Saskatoon slaughter hog prices lag Winnipeg slaughter hog prices.

[d]Estimated standard error.

[e]At least three times standard error.

price relationship between Winnipeg and Saskatoon resulting from Saskatchewan's adoption of a formula pricing system.

Haugh's U statistic (Table 13) is used to test the significance of the above relationships. During Periods 3 and 4 (Manitoba used a non-compulsory and compulsory teletype Dutch auction respectively while Saskatchewan used traditional methods) and Period 6 and 7 (Manitoba used a formula pricing system and Dutch clock pricing mechanism respectively while Saskatchewan used a formula pricing system), the U statistic supports the hypothesis of instantaneous transfer of price information between the two markets. Evidence provided by these tests indicate that Winnipeg slaughter hog price changes lag Saskatoon price changes by one week in Period 1 (both markets used traditional pricing mechanisms). Haugh's U statistic indicates Winnipeg slaughter hog price changes lead Saskatoon price changes in Period 2 (Both markets used traditional marketing methods while Toronto had adopted a compulsory teletype Dutch auction) and Period 5 (Manitoba used a compulsory teletype Dutch auction while Saskatchewan used formula pricing system).

5.5.5 Winnipeg-Edmonton

The price series for Winnipeg and Edmonton can be divided into seven time periods based on the alternative marketing mechanisms used. During Periods 1 and 2, neither Manitoba nor Alberta used a teletype Dutch auction (January 1, 1951 to May 7, 1961 and May 8, 1961 to February 24, 1965 respectively). Period 2 is included to examine the influence of the teletype Dutch auction in Ontario on the price relationship between these two markets. During Period 3 (February

Table 13. Calculated U Statistics for Alternative Causal Orderings Between Winnipeg and Saskatoon Slaughter Hog Price Series

	Saskatoon Leads Winnipeg[a]	Instantaneous Relationship[b]	Saskatoon Lags Winnipeg[c]
Period 1	15.97*	380.22*	2.25
Period 2	0.30	137.61*	9.32*
Period 3	0.43	316.62*	2.76
Period 4	0.79	73.78*	0.20
Period 5	2.51	141.81*	28.80*
Period 6	0.03	37.60*	0.26
Period 7	5.50	84.00*	3.85

Period 1 (January 1, 1951 to May 7, 1961) both markets used traditional pricing mechanisms; Period 2 (May 8, 1961 to February 24, 1965) both markets used traditional pricing mechanisms and Toronto adopted compulsory teletype Dutch auction; Period 3 (February 25, 1965 to December 31, 1971) Manitoba adopted a non-compulsory teletype Dutch auction; Period 4 (January 1, 1972 to August 5, 1973) teletype Dutch auction made compulsory in Manitoba; Period 5 (August 6, 1973 to September 5, 1977) Saskatchewan adopted compulsory formula pricing system; Period 6 (September 6, 1977 to September 16, 1978) Manitoba adopted compulsory formula pricing system; Period 7 (September 17, 1978 to December 31, 1980) Manitoba adopted Dutch clock pricing mechanism and advance buyer bidding.

[a]Calculated from first two negative cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

[b]Calculated from first two negative, zero and first two positive cross-correlations and distributed χ^2 with five degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 15.09 at the one percent level.

[c]Calculated from first two positive cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

[d]Significant at the one percent level.

25, 1965 to October 30, 1969) Manitoba commenced using a non-compulsory teletype Dutch auction while Alberta retained traditional mechanisms. During Period 4 (October 31, 1969 to December 31, 1971) Alberta commenced using a compulsory teletype Dutch auction. In Period 5 (January 1, 1972 to September 5, 1977) Manitoba commenced compulsory marketing of slaughter hogs through teletype Dutch auction. During Period 6 (September 6, 1977 to September 16, 1978) changes occurred on both markets in the way slaughter hogs were marketed. During the entire period, slaughter hogs were sold using formula pricing in Manitoba. Also, commencing March 17, 1978, Alberta began using advance buyer bidding with the teletype Dutch pricing mechanism. During Period 7, Manitoba commenced selling through a Dutch clock pricing mechanism. Alberta used two marketing mechanisms during this time period; teletype Dutch auction and a bid/acceptance system. Both systems were based on advance buyer bidding.

During all periods, the markets were most highly related at zero lag (Table 14). The largest zero lag cross-correlation between the two markets occurred in Period 3 when Manitoba had a non-compulsory teletype Dutch auction and Alberta used traditional marketing mechanisms. The smallest zero lag cross-correlation occurred in Period 5 when both Manitoba and Alberta marketed slaughter hogs using a compulsory teletype Dutch auction.

Cross-correlations for a one week lead-lag are significant for Winnipeg lagging Edmonton and Winnipeg leading Edmonton in Period 1. The cross-correlation for Winnipeg lagging Edmonton by one week is significant in Period 2. In periods 5 and 7, one week cross-correlations for Winnipeg leading Edmonton were significantly different from zero.

Table 14. Estimated Cross-Correlations Between White Noise Residuals of Weekly Winnipeg and Edmonton Slaughter Hog Price Changes

	Lags					
k	-2[a]	-1[a]	0[b]	1[c]	2[c]	s.e.
Period 1	0.028	0.212[e]	0.566[e]	0.193[e]	-0.014	0.043
Period 2	-0.114	0.278[e]	0.594[e]	0.043	-0.018	0.071
Period 3	0.043	0.078	0.671[e]	0.161	0.045	0.064
Period 4	-0.009	0.080	0.575[e]	0.199	0.143	0.094
Period 5	-0.007	0.143	0.498[e]	0.214[e]	0.108	0.058
Period 6	-0.119	0.015	0.533[e]	0.154	0.101	0.137
Period 7	0.079	0.074	0.570[e]	0.472[e]	-0.072	0.091

Period 1 (January 1, 1951 to May 7, 1961) Manitoba and Alberta used traditional marketing mechanisms; Period 2 (May 8, 1961 to February 24, 1965) Manitoba and Alberta used traditional marketing mechanisms and Ontario adopted a compulsory teletype Dutch auction; Period 3 (February 25, 1965 to October 30, 1969) Manitoba adopted a non-compulsory teletype Dutch auction; Period 4 (October 31, 1969 to December 31, 1971) Alberta adopted a compulsory teletype Dutch auction; Period 5 (January 1, 1972 to September 5, 1977) Manitoba adopted compulsory teletype Dutch auction; Period 6 (September 6, 1977 to September 16, 1978) Manitoba adopted compulsory formula pricing system; Period 7 (September 17, 1978 to December 31, 1980) Manitoba adopted Dutch clock pricing mechanism.

[a]Edmonton slaughter hog prices lead Winnipeg slaughter hog prices.

[b]Lag zero cross-correlations.

[c]Edmonton slaughter hog prices lag Winnipeg slaughter hog prices.

[d]Estimated standard error.

[e]At least three times standard error.

Haugh's U statistic indicates the following relationships (Table 15). During Period 1 (neither market had yet adopted a compulsory marketing system), it would appear there was a feedback of price information between the two markets. During Period 2 (neither market had yet adopted an alternative marketing system but Ontario had adopted a compulsory teletype Dutch auction), it appears Winnipeg slaughter hog price changes lagged Edmonton price changes by one week. During Period 5 (Manitoba and Alberta used compulsory teletype Dutch auction) and Period 7 (Manitoba used a compulsory Dutch clock pricing mechanism with advance bidding while Alberta used compulsory teletype Dutch auction with advance buyer bidding), it appears Winnipeg price changes lead Edmonton price changes. In all other time periods, tests indicate an instantaneous transfer of price information between the two markets.

5.5.6 Saskatoon-Edmonton

The examination of price relationships between Saskatoon and Edmonton slaughter hog prices can be broken down into 5 periods. During Periods 1 and 2 (January 1, 1951 to May 7, 1961 and May 8, 1961 to October 30, 1969), both Saskatchewan and Alberta used traditional marketing mechanisms. Period 2 reflects Ontario's use of a compulsory teletype Dutch auction. During Period 3 (October 31, 1969 to August 5, 1973) Saskatchewan used traditional pricing mechanisms while Alberta adopted a compulsory teletype Dutch auction. Saskatchewan adopted a compulsory formula pricing system in Period 4 (August 6, 1973 to March 16, 1978) while in Period 5 (March 17, 1978 to December 31, 1980), Alberta adopted advance buyer bidding. During Period 5, Alberta used

Table 15. Calculated U Statistics for Alternative Causal Orderings Between Winnipeg and Edmonton Price Series

	Edmonton Leads Winnipeg[a]	Instantaneous Relationship[b]	Edmonton Lags Winnipeg[c]
Period 1	24.74*	218.31*	20.26*
Period 2	17.88*	88.18*	0.43
Period 3	1.93	118.13*	6.79
Period 4	0.73	44.88*	6.79
Period 5	6.03	95.83*	16.89*
Period 6	0.76	17.82*	1.80
Period 7	1.39	67.19*	27.13*

Period 1 (January 1, 1951 to May 7, 1961) Manitoba and Alberta used traditional marketing mechanisms; Period 2 (May 8, 1961 to February 24, 1965) Manitoba and Alberta used traditional marketing mechansisms - Ontario adopted a compulsory teletype Dutch auction; Period 3 (February 25, 1965 to October 30, 1969) Manitoba adopted a non-compulsory teletype Dutch auction; Period 4 (October 31, 1969 to December 31, 1971) Alberta adopted a compulsory teletype Dutch auction; Period 5 (January 1, 1972 to September 5, 1977) Manitoba adopted compulsory teletype Dutch auction; Period 6 (September 6, 1977 to September 16, 1978) Manitoba adopted compulsory formula pricing system; Period 7 (September 17, 1978 to December 31, 1980) Manitoba adopted Dutch clock pricing mechanism.

[a]Calculated from first two negative cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

[b]Calculated from first two negative, zero and first two positive cross-correlations and distributed χ^2 with five degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 15.09 at the one percent level.

[c]Calculated from first two positive cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

*Significant at the one percent level.

two marketing mechanisms; a teletype Dutch auction (March 17, 1978 to February 27, 1980) and a bid/allocation system (February 28, 1980 to December 31, 1980).

During all periods, price changes on the Saskatoon and Edmonton markets were most highly related at zero lag (Table 16). Cross-correlations for zero lag are smallest during Period 4 when Saskatchewan used a formula pricing system and Alberta used a teletype Dutch auction and largest during Period 5 when Saskatchewan used a formula pricing and Alberta used advance buyer bidding. The latter may reflect the existence of sales contracts between the two provinces.

Cross-correlations for a one week lead and lag were both significantly different from zero in Period 1. In Period 2, cross-correlations for Saskatoon lagging Edmonton by one week are significantly different from zero. In Periods 4 and 5, one week cross-correlations for slaughter hog price changes on Saskatoon leading price changes on the Edmonton market were significantly different from zero.

Haugh's U statistic tests (Table 17) would indicate a feedback relationship between slaughter hog prices on the Saskatoon and Edmonton markets during Period 1 (both Saskatchewan and Alberta used traitional marketing mechanisms). During Period 2 (same as Period 1 except Ontario had adopted a teletype Dutch auction), Edmonton slaughter hog price changes lead Saskatoon price changes. In Period 3 (Alberta adopted a compulsory teletype Dutch auction), prices on the two markets were established on the two markets instantaneously. In Periods 4 and 5 (Saskatchewan had adopted a formula pricing system), Saskatoon slaughter hog price changes appear to lead Edmonton price changes.

Table 16. Estimated Cross-Correlations Between White Noise Residuals of Weekly Saskatoon and Edmonton Slaughter Hog Price Changes

	Lags					
k	-2[a]	-1[a]	0[b]	1[c]	2[c]	s.e.[d]
Period 1	0.009	0.174[e]	0.563[e]	0.194[e]	0.047	0.043
Period 2	0.021	0.156[e]	0.654[e]	0.101	0.045	0.048
Period 3	0.056	0.166	0.596[e]	0.158	0.082	0.072
Period 4	-0.046	0.176	0.510[e]	0.240[e]	0.066	0.065
Period 5	0.059	0.097	0.692[e]	0.349[e]	0.058	0.083

Period 1 (January 1, 1951 to May 7, 1961) both Alberta and Saskatchewan used traditional pricing mechanisms; Period 2 (May 8, 1961 to October 30, 1969) same as period 1 except Ontario adopted compulsory teletype Dutch auction; Period 3 (October 31, 1969 to August 5, 1973) Alberta adopted a compulsory teletype Dutch auction; Period 4 (August 6, 1973 to March 16, 1978) Saskatchewan adopts a compulsory formula pricing system; Period 5 (March 17, 1978 to December 31, 1980) Alberta adopted advance buyer bidding.

[a]Edmonton slaughter hog prices lead Saskatoon slaughter hog prices.

[b]Lag zero cross-correlations.

[c]Edmonton slaughter hog prices lag Saskatoon slaughter hog prices.

[d]Estimated standard error.

[e]At least three times standard error.

Table 17. Calculated U Statistics for Alternative Causal Orderings Between Saskatoon and Edmonton Slaughter Hog Price Series

	Edmonton Leads Saskatoon[a]	Instantaneous Relationship[b]	Edmonton Lags Saskatoon[c]
Period 1	16.42*	209.46*	21.56*
Period 2	10.95*	205.41*	5.40
Period 3	5.98	81.43*	6.18
Period 4	7.91	84.88*	14.81*
Period 5	1.88	90.07*	18.27*

Period 1 (January 1, 1951 to May 7, 1961) both Alberta and Saskatchewan used traditional pricing mechanisms; Period 2 (May 8, 1961 to October 30, 1969) same as period 1 except Ontario adopted compulsory teletype Dutch auction; Period 3 (October 31, 1969 to August 5, 1973) Alberta adopted a compulsory teletype Dutch auction; Period 4 (August 6, 1973 to March 16, 1978) Saskatchewan adopted compulsory formula pricing system; Period 5 (March 17, 1978 to December 31, 1980) Alberta adopted advance buyer bidding.

[a]Calculated from first two negative cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

[b]Calculated from first two negative, zero and first two positive cross-correlations and distributed χ^2 with five degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 15.09 at the one percent level.

[c]Calculated from first two positive cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

*Significant at the one percent level.

5.6 Lead-Lag Relationships Between Slaughter Hog Prices Established in the United States and Canada

The objective of this section is to examine the lead-lag relationships between slaughter hog prices established on the four major Canadian markets and a weighted average price of the seven major Midwest United States markets. The data used in this analysis are weekly average prices for Toronto, Winnipeg, Saskatoon and Edmonton and a weekly average price for the following seven United States markets: Sioux City, Iowa; St. Joseph, Missouri; St. Paul, Minnesota; Indianapolis, Indiana; Omaha, Nebraska; Kansas City, Kansas; and St. Louis, Illinois. The time period January 1, 1973 to December 31, 1980 was selected because of (1) the availability of the data from published Canadian sources, (2) most Canadian markets had some form of compulsory hog marketing system during this period (Saskatchewan used traditional marketing methods from January 1, 1973 to August 5, 1973) and (3) the time period represents the beginning of open conflict between the Western Canadian hog boards and commissions and the packing companies concerning the allegedly widening price differentials among the markets in Canada. This period reflects declining hog production in Western Canada relative to total production in Canada. During this time period, Canada switched from being a surplus pork producing region to a deficit one. This was the situation from 1974 to 1978.

Results indicate that in all markets under study, slaughter hog prices are most highly related at zero lag indicating that market information is communicated rapidly between markets (Table 18). Cross-correlations indicate Canadian markets are more highly cross-correlated

Table 18. Estimated Cross-Correlations Between White Noise Residuals of Weekly Slaughter Hog Price Changes; January 1, 1973 to December 31, 1980

	Lags				
k	-2^a	-1^a	0^b	1^c	2^c
Toronto lags 7 U.S. markets	-0.011	0.105	0.262*	0.125	0.003
Winnipeg lags 7 U.S. markets	0.077	0.084	0.262*	0.127	0.031
Saskatoon lags 7 U.S. markets	0.053	0.144	0.240*	0.151*	0.031
Edmonton lags 7 U.S. markets	-0.084	0.080	0.188*	0.183*	0.144
Winnipeg lags Toronto	-0.026	0.124	0.682*	0.105	-0.011
Saskatoon lags Toronto	0.063	0.052	0.636*	0.192*	0.026
Edmonton lags Toronto	0.041	0.073	0.429*	0.310*	0.055
Saskatoon lags Winnipeg	0.052	0.019	0.788*	0.188*	-0.036
Edmonton lags Winnipeg	-0.012	0.097	0.523*	0.246*	0.096
Edmonton lags Saskatoon	-0.022	0.141	0.519*	0.255*	0.031

Note: Estimated standard error is 0.05.

[a]Negative lags (that is, leads)

[b]Lag zero cross-correlations.

[c]Positive lags.

*At least three times standard error.

with each other than they are with the seven major United States markets. Cross-correlations at zero lag ranged from 0.262 for the seven United States markets with both Toronto and Winnipeg to 0.188 for seven United States markets combined and Edmonton. Toronto slaughter hog prices are most highly cross-correlated with Winnipeg prices (0.682) and least cross-correlated with Edmonton prices (0.429) at zero lag. With regards to the three western markets, Winnipeg slaughter hog prices are most highly cross-correlated with Saskatoon slaughter prices at zero lag (0.788). Cross-correlations of these markets with Edmonton are less cross-correlated at zero lag with these two markets (0.523 and 0.519 respectively for Winnipeg and Saskatoon).

In examining the cross-correlations (Table 18) it is apparent a relationship exists between slaughter hog price changes on all of the markets. In the cases of the seven United States markets and Canadian markets, the one week cross-correlations for United States slaughter hog prices leading Saskatoon and Edmonton are both significantly different from zero. One week cross-correlations for Toronto price changes leading Saskatoon and Edmonton are significantly different from zero. One week cross-correlations for Winnipeg leading Saskatoon and Edmonton are significantly different from zero. One week cross-correlations for Saskatoon leading Edmonton are significantly different from zero.

Calculated Haugh's U statistics are presented in Table 19. Results of these tests indicate price changes on the seven United States

Table 19. Calculated U Statistics for Alternative Causal Orderings Between Seven United States Markets Combined and Canadian Markets Slaughter Hog Price Series

	Negative Lags[a]	Instantaneous Relationship[b]	Positive Lags[c]
Toronto lags 7 U.S. markets	4.64	39.70*	6.50
Winnipeg Lags 7 U.S. markets	5.40	41.06*	7.11
Saskatoon Lags 7 U.S. markets	9.79*	43.64*	9.88*
Edmonton Lags 7 U.S. markets	5.60	42.86*	22.56*
Winnipeg Lags Toronto	6.68	204.81*	4.64
Saskatoon Lags Toronto	2.78	186.66*	15.62*
Edmonton Lags Toronto	2.92	120.71*	41.24*
Saskatoon Lags Winnipeg	1.28	274.83*	15.24*
Edmonton Lags Winnipeg	3.97	146.77*	29.01*
Edmonton Lags Saskatoon	8,47	147.98*	27.45*

[a]Calculated from first two negative cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

[b]Calculated from first two negative, zero and first two positive cross-correlations and distributed χ^2 with five degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 15.09 at the one percent level.

[c]Calculated from first two positive cross-correlations and distributed χ^2 with two degrees of freedom. The critical value for rejecting the hypothesis that the cross-correlations come from a random series is 9.20 at the one percent level.

*Significant at the one percent level.

markets and on Toronto and Winnipeg are established instantaneously and in no other way. Results indicate a feedback of price information between Saskatoon and the seven United States markets combined. (This does not make sense considering Saskatchewan has the smallest sales volumes of all the markets. It may be that Saskatoon relies more heavily in its pricing formula on one of the individual markets which tend to lead the seven United States markets, e.g. Omaha). Haugh's U statistic would seem to indicate that price changes on the seven United States markets combined lead Edmonton price changes.

Toronto and Winnipeg slaughter hog prices change instantaneously and in no other way. Toronto slaughter hog price changes lead price changes on both the Saskatoon and Edmonton markets. Winnipeg slaughter hog price changes lead price changes on the Saskatoon and Edmonton markets. Saskatoon slaughter hog price changes lead Edmonton price changes.

5.7 Chapter Summary

The objective of this chapter was to empirically examine the influence of marketing mechanism changes on the price relationships among the four Canadian markets under study as well as some cursory comparison with the seven midwest United States hog markets. The technique selected to accomplish this objective was univariate residual cross-correlation analysis.

Univariate residual cross-correlation analysis was examined as a technique for evaluating lead-lag relationships. This technique was applied to examine lead-lag relationships among the four Canadian markets under study. The data was separated into different time periods based on the alternative marketing mechanisms in use on each market.

The strongest relationships occurred at zero lag regardless of the marketing mechanisms in use indicating an efficient transfer of price information. Results indicated the strongest zero lag relationships occurred during the time periods when one of the markets used a teletype Dutch auction and the other market used traditional pricing mechanims. The weakest zero lag relationships were noted when both markets used some form of alternative pricing mechanism such as the teletype Dutch auction or formula pricing.

Toronto slaughter hog price changes lead Winnipeg price changes during the time period neither market had established a teletype Dutch auction and during the period Manitoba had established a non-compulsory teletype Dutch auction. During all other time periods, prices on the two markets change instantaneously and in no other way.

Price changes on the Toronto slaughter hog market lead Saskatoon price changes in all time periods.

Haugh's U statistic indicates a feedback relationship existed between the Toronto and Edmonton slaughter hog price changes prior to the existence of a teletype Dutch auction in Alberta. Toronto slaughter hog price changes have lead Edmonton price changes since Alberta adopted compulsory marketing mechanisms.

Saskatoon slaughter hog price changes lead Winnipeg price changes prior to 1961. Winnipeg slaughter hog price changes tended to lead Saskatoon price changes during two periods - during the period Manitoba and Saskatchewan used traditional marketing mechanisms and Ontario adopted a teletype Dutch auction; and during the period Manitoba marketed slaughter hogs using a compulsory teletype Dutch auction and Saskatchewan

used a formula pricing system. During all other time periods price changes between the two markets occurred instantaneously.

Feedback occurred between price changes on the Winnipeg and Edmonton markets prior to 1961. Edmonton slaughter hog price changes tended to lead Winnipeg price changes during the period both markets used traditional pricing and Ontario had adopted a compulsory teletype Dutch auction. Winnipeg slaughter hog price changes tended to lead Edmonton price changes during the time periods both markets used some form of compulsory teletype or Dutch clock auction.

A feedback relationship existed between price changes on the Saskatoon and Edmonton markets prior to 1961. Edmonton slaughter hog price changes lead Saskatoon price changes during the period both markets used traditional pricing mechanisms and Ontario used a compulsory teletype Dutch auction. Saskatoon slaughter hog price changes lead Edmonton price changes during the periods Saskatchewan used a compulsory formula system and Alberta used a compulsory teletype Dutch auction.

Univariate residual cross-correlation analysis over the period January 1, 1973 to December 31, 1980 indicated that Canadian slaughter hog price changes are more related with each other at zero lag than they are with weighted average prices of the seven central United States markets. Haugh's U test indicate the slaughter hog price changes for the seven United States markets lead price changes on the Edmonton and Saskatoon markets while they are related instantaneously with the Toronto and Winnipeg markets. Winnipeg and Toronto slaughter hog price changes are related instantaneously and in no other way. Slaughter hog price

changes on both these markets lead price changes on the Saskatoon and Edmonton markets. Saskatoon slaughter hog price changes lead price changes on the Edmonton market during this period.

Chapter 6

6. SUMMARY AND IMPLICATIONS

During the period 1951-1980, significant changes have occurred in the marketing systems for slaughter hogs in Canada. These changes were mainly a result of producers' concerns about the competitiveness of traditional marketing mechanisms. Prior to the adoption of teletype, Dutch clock and formula pricing systems, terminal markets established slaughter hog prices; even when the vast majority of slaughter hogs were sold direct to packing plants. Prices established on the terminal market were considered to be non-representative because of the small sales volume handled by these markets. Terminal markets were less operationally efficient than direct deliveries because of the commission charges levied and the extra handling of slaughter hogs involved. Producers expressed concerns about the competitiveness of direct selling since this mechanism involved one on-one negotiation between buyer and seller with the packing companies holding most of the bargaining power.

As a result of these concerns about the competitiveness of the existing marketing systems, alternative methods of pricing slaughter hogs were developed. Ontario was the first province to adopt a compulsory teletype Dutch auction (May 8, 1961). Manitoba adopted a non-compulsory teletype Dutch auction on February 25, 1965. This system was made compulsory on January 1, 1972. On September 6, 1977, the compulsory teletype Dutch auction in Manitoba was replaced with a formula pricing system. Since September 17, 1978, Manitoba has employed a compulsory Dutch clock pricing mechanism with advance buyer bidding. Saskatchewan has used a compulsory formula pricing mechanism since August 6,

1973. Alberta adopted a compulsory teletype Dutch auction on October 31, 1969, and on March 17, 1978, this was modified to include advance buyer bidding. On February 28, 1980, Alberta discontinued the teletype Dutch auction in favor of a system in which the Board collects bids by telephone, telex, sealed bids or by the existing closed circuit teletype network.

The overall objective of this thesis was to examine the influence of slaughter hog marketing mechanism changes in the provinces of Manitoba, Saskatchewan, Alberta and Ontario as to market performance. The specific objectives were; (1) to review the historical changes which have occurred in the hog markets under study between 1951-1980, (2) to review the literature to develop a theoretical basis for evaluating market performance, (3) to descriptively evaluate the influence of slaughter hog marketing mechanism changes on market performance and (4) to apply statistical tests to determine if marketing mechanism changes have altered the relationship among slaughter hog prices established on the above markets.

Market performance can be evaluated descriptively in terms of two criteria; operational efficiency and pricing efficiency. Operational efficiency involves minimizing the costs associated with the marketing process. Pricing efficiency examines the ability of a marketing mechanism to establish prices which accurately reflect supply and demand conditions. The structural characteristics of perfect competition are normally used as criteria in evaluating pricing efficiency.

A theoretical analysis of alternative marketing mechanisms indicated that the teletype and Dutch clock auctions should result in better market performance than any of the other alternatives. The teletype and Dutch clock auctions were suggested to be operationally efficient used

in conjunction with direct deliveries. In terms of pricing efficiency, the teletype and Dutch clock auctions should result in a situation where no buyer or seller is able to influence prices by restricting demand or supply. The price established using this mechanism is known to all market participants. Prices are established on the value determining characteristics of slaughtered hogs. As a result of this analysis, it is hypothesized that the teletype and Dutch clock auctions should establish more efficient prices relative to the other slaughter hog marketing mechanisms as described in this thesis.

The analysis also has implications for other agricultural commodities examining alternative marketing mechanisms. The ability of electronic pricing mechanisms such as the teletype and Dutch clock auctions to handle a large sales volume, the low costs of operation and the theoretical improvements in pricing efficiency are desirable market characteristics for any agricultural commodity. Other characteristics which are necessary for operation of an electronic marketing mechanism, make it less applicable to some agricultural commodities. These characteristics include the following; (i) electronic auctions are based on descriptive selling, and (ii) the adoption of compulsory electronic auctions results in the producers loss of freedom to select an alternative marketing mechanism.

The objective to the empirical analysis was to determine whether or not price changes on the markets under study were communicated more efficiently after the establishment of alternative marketing systems. The procedure used was univariate residual cross-correlation analysis. Cross-correlation analysis can not be applied

directly to the actual or first differenced data because of the influence of autocorrelation on statistical tests. The time series properties of the data may result in the acceptance of the hypothesis that a significant relationship exists between markets when this is not the case. To eliminate autocorrelation from the data, Box-Jenkins time series analysis procedures were applied and the white noise residuals obtained were used in calculating cross-correlations. Cross-correlations obtained in this manner are judged to be significantly different from zero if they are at least three times their standard error. Haugh's U statistic is used to test the significance of the cross-correlations for the following three relationships; (i) instantaneous, (ii) one market leading the other market, and (iii) feedback of pricing information between the two markets. The one percent confidence level was used with this statistical test.

Cross-correlations are calculated for first two negative, zero and first two positive lags based on a priori expectations that price information should be communicated between markets within two weeks.

The analysis is conducted on two markets at a time. The data is subsequently divided into different time periods based on the marketing mechanisms that were in effect on each market. These divisions involve at least three time periods; (i) a period when both markets used traditional pricing mechanisms (terminal market and direct deliveries), (ii) a period when one of the markets had adopted an alternative pricing mechanism (teletype Dutch auction) and the other still used a traditional pric-

ing system and (iii) a period when both markets used some form of alternative marketing mechanisms.[1]

The initial hypothesis advanced for the empirical analysis was that the implementation of teletype and Dutch clock auctions should improve the transfer of pricing information among the markets under study. It was further thought that Toronto slaughter hog prices should theoretically lead price changes on the other markets. Eastern Canada has historically been a pork deficit region and it takes three to four days to transport pork and pork products from Western Canada to Eastern Canada. Finally, the adoption of electronic marketing mechanisms should have improved the transfer of pricing information among the markets under study. Therefore, it was hypothesized to be less likely for the markets to exhibit lead-lag relationships during the time both of the markets used some form of alternative marketing mechanism.

Results of univariate residual cross-correlation analysis indicate that during all time periods, slaughter hog prices are most highly related at zero lag. Haugh's U statistic confirms the hypothesis of instantaneous transfer of pricing information among the markets in all periods. Results obtained from univariate residual cross-correlation analysis at zero lag indicate price changes on the Winnipeg and Saskatoon markets were most highly related. This reflects the historical movement of slaughter hogs from Saskatchewan into Manitoba. The weakest

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[1]Traditional pricing mechanisms refer to the use of direct deliveries and terminal markets for pricing slaughter hogs. Alternative methods refer to the use of teletype Dutch auction, Dutch clock auction and formula pricing systems for pricing slaughter hogs.

relationships were indicated between Edmonton and Toronto. This reflects the long distance separating these two markets. In most cases, cross-correlations at zero lag are largest during time periods when one of the markets had adopted an alternative marketing mechanism and the other maintained a traditional one. This may indicate the market which used traditional marketing systems relied on the market which used the alternative marketing mechanism as an important source of market information. Cross-correlations at zero lag were smallest during time periods when both markets used some form of alternative pricing system. During these periods, both markets relied more heavily on regional supply and demand conditions in determining market prices. Cross-correlations at zero lag for time periods when both markets used traditional pricing mechanisms were between these two extremes.

The empirical analysis indicates marketing mechanism changes have influenced the lead-lag relationships between slaughter hog prices established on the markets under study. The existence of one period lead-lag relationships provides an indication of pricing inefficiencies. Bessler and Schrader observe the following relationship between results obtained from univariate residual cross-correlation analysis and pricing efficiency.

> We suggest that if one series can be shown to lead the other, the leading series is the more accurate or senstitive indicator of equilibrium value. We assume that, in time, both quotes will change in the same direction as a change in the unobserved equilibrium values at all levels in the market. ... If both quotes are equally accurate indicators of value change, one would not expect any lead or lag. If one is more sensitive, it would be expected to lead.[2]

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[2] D.A. Bessler and L.F. Schrader, "Relationship Between Two Price Quotes for Eggs," American Journal of Agricultural Economics, Vol. 62, No. 4 (November 1980), pp. 766-767.

Slaughter hog price changes in the Toronto market led price changes on the Winnipeg market by one week during the period both markets used traditional marketing mechanisms (terminal markets and direct deliveries). The same results were noted during the period Ontario used a compulsory teletype Dutch auction and Manitoba employed a non-compulsory teletype Dutch auction. This evidence indicates pricing inefficiency on the Winnipeg market during these two time periods. The instantaneous transfer of pricing information during the other periods of alternative pricing mechanisms is an indication of pricing efficiency on both markets.

The results obtained from univariate residual cross-correlation analysis indicates Toronto slaughter hog price changes led Saskatoon price changes by one week during all time periods identified for this study. This would seem to imply pricing inefficiencies on the Saskatchewan market during the three time periods identified in the analysis.

The results obtained from univariate residual cross-correlation analysis indicate that Toronto slaughter hog price changes have led Edmonton price changes by one week during the four time periods under study. This analysis also indicated Edmonton slaughter hog price changes led Toronto price changes by one week prior to Alberta establishing a compulsory marketing system; that is, a feedback relationship is indicated during the first two time periods. The existence of this feedback relationship prior to Alberta establishing a compulsory marketing mechanism indicates previous weeks price changes on the Toronto market influenced price changes on the Edmonton market. In addition previous weeks price changes in the Edmonton market influenced price changes on the Toronto market. The indication that Toronto slaughter hog price changes led Edmonton price

changes since the adoption of compulsory marketing mechanisms in Alberta provides evidence of pricing inefficiency on the Alberta market.

The Manitoba market showed signs of pricing inefficiency when Saskatoon slaughter hog price changes led Winnipeg price changes during the period none of the markets had yet adopted a compulsory marketing mechanism. The indication that Winnipeg slaughter hog price changes led Saskatoon price changes during the period Manitoba used a compulsory teletype Dutch auction and Saskatchewan adopted a compulsory formula pricing system would seem to provide evidence of pricing inefficiency in the Saskchewan market during this time period. The evidence supporting the instantaneous transfer of price changes between these two markets indicates the efficient transfer of pricing information between these two markets during other periods.

The results of univariate residual cross-corrleation analysis indicate a feedback relationship between the Winnipeg and Edmonton markets in the period prior to any of the markets establishing alternative marketing mechanisms. Edmonton slaughter hog price changes led Winnipeg price changes during the period both markets used traditional marketing mechanisms and Ontario had adopted a compulsory teletype Dutch auction indicating pricing inefficiency on the Manitoba market. Except for the period Manitoba adopted a compulsory formula pricing, Winnipeg slaughter hog price changes have led Edmonton price changes during the periods both markets used compulsory marketing mechanisms. This would seem to indicate pricing inefficiency on the Alberta market during these two time periods because Edmonton and Winnipeg are not separated by a large distance, a priori expectations were that price changes on these two markets would occur instantaneously if both markets were performing efficiently.

The results of univariate residual cross-correlation analysis indicate a feedback relationship between slaughter hog price changes on the Saskatoon and Edmonton markets prior to any of the markets establishing a compulsory teletype Dutch auction. Edmonton slaughter hog price changes led Saskatoon price changes during the period both markets used traditional marketing mechanisms and Ontario adopted a compulsory teletype Dutch auction. This would seem to indicate pricing inefficiency on the Saskatoon market during this time period. The indication that Saskatoon slaughter price changes led Edmonton prices during the periods both markets had adopted compulsory marketing mechanisms provides evidence of pricing inefficiency on the Alberta market.

Univariate residual cross-correlation analysis was used in examing the lead-lag relationship between prices established on the four Canadian markets under study and an average price of seven central United States markets combined for the period 1973 to 1980. The results of this analysis indicated that Canadian markets were more highly related with each other at zero lag than they were with the slaughter hog prices established on the seven central United States markets combined. Tests for lead-lag relationships indicated that slaughter hog price changes on the Toronto, Winnipeg and on the seven United States markets occurred instantaneously and in no other way. Slaughter hog price changes on the Toronto, Winnipeg and for the seven Midwest United States markets combined lead price changes on the Saskatoon and Edmonton markets. The analysis also indicates Saskatoon price changes lead price changes on the seven United States markets combined indicating a feedback relationship between these two price series. The results indicating slaughter hog price changes on the Edmonton market

lag behind price changes on the other markets are an indication of pricing inefficiency on the Alberta market.

Results obtained from univariate residual cross-correlation analysis indicates the adoption of alternative marketing mechanisms in Western Canada has altered the lead-lag relationships between the markets under study. Edmonton slaughter hog price changes lagged price changes on other Canadian markets during the time periods all the provinces under study had adopted compulsory pricing mechanisms. In previous periods, Edmonton slaughter hog price changes had either led, exhibited a feedback relationship or occurred instantaneously with other markets. This relationship between Edmonton and the other markets since adoption of compulsory marketing mechanisms would seem to indicate pricing inefficiency on the Alberta market. This evidence implies that either the teletype Dutch auction has not proven to be an effective way of improving pricing efficiency on the Edmonton market or other structural changes have decreased the effectiveness of this alternative marketing mechanism in improving pricing efficiency.

6.1 Limitations

The influence of marketing mechanism changes on the pricing relationships between markets is the main objective examined in this thesis. Other structural changes such as shifts in production levels, influence of federal and provincial government stabilization policies, changes in Canadian export and import trading agreements have also influenced price relationships over the study period. These changes have influenced the regional import/export relationships with outside markets and therefore the price relationships among these markets. However, these factors were not examined in the empirical analysis.

Another limitation is measuring pricing efficiency by analyzing changes in price relationships rather than comparing price differentials in time, form and space. Griffith makes a similar comment in an examination of the pigmeat market in Australia using spectral analysis:

> The point has been emphasized in this study, that we are measuring pricing efficiency not by comparing price differentials and transport, storage or processing costs, but by examining the relationships between certain pig price series.[3]

There are several problems associated with examining the supply and demand relationships in each region and developing a trade model which minimizes price differentials such that they equal transfer costs. The first is the lack of data necessary for this type of analysis. No information is available on provincial consumption patterns of pork products. Although data is available for interprovincial movement of live hogs, data on interprovincial movement of pork and pork products is not. Transportation costs for moving pork products is not easily obtainable. In recent years, a major portion of pork products have been moved using the trucking industry. Rates for this mode have not been regulated and are negotiated on an individual load basis with no published rates available. Finally, even if data for this type of analysis were available and a model was estimated one would have to question whether the conclusions based on an analysis of this type would be accurate. That is, if aberrations from the predicted ideal model and real world situation occur, can these results be inter-

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[3]G.R. Griffith, "A Cross-Spectral Approach to Measuring Pricing Efficiency in the New South Wales Pigmeat Market," Review of Marketing and Agricultural Economics, Vol. 43, No. 4 (December 1975), p. 178.

preted as an indication of pricing inefficiency or do they reflect the inability of the model to predict real world events?[4]

6.2 Suggestions for Further Research

A suggestion for further research would be to examine the lead-lag relationship between slaughter hog prices at the farm level and pork prices at the retail level. This lead-lag relationship could be compared with the time period which elapses between the day a producer sells a slaughter hog and the day the corresponding pork reaches the retail store. Lead-lag relationships of longer than this period would be indicative of poor market performance.

An analysis identifying the influence of falling or rising price patterns on the lead-lag relationships between prices established on the markets under study would provide an interesting method for examining pricing efficiency. The following question could be examined using this technique: Do slaughter hog price changes on a specific market respond more to price changes on other markets during periods of rising or falling prices?

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[4]For further discussion of applying this procedure for measuring pricing efficiency, see W.G. Tomek and K.L. Robinson, "Agricultural Price Analysis and Outlook," A Survey of Agricultural Economics Literature, Vol. 1, ed. Lee R. Martin, (Minneapolis: University of Minnesota Press, 1977), pp. 366-367.

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APPENDIX

Appendix

This appendix will briefly describe the Box-Jenkins time series analysis procedure. A more detailed description of the procedure can be found in Box and Jenkins[1]; Nelson[2]; Pindyck and Rubenfeld[3]; and Nerlove, Grether and Carvalho[4]. The logic applied in estimating the equations will be outlined.

Pindyck and Rubenfeld differentiate forecasts using Box-Jenkins procedure from those employing other techniques on the following basis:

> ... time series analysis presumes that the series to be forecasted has been generated by a stochastic process with a structure that can be characterized and described, i.e. a time series model provides a description of the random nature of the stochastic process that generated the sample of observations under study. The description is given not in terms of cause and effect relationship (as would be the case in a regression model), but rather in terms of the way that randomness is embodied in the process.[5]

Nelson describes time series analysis in the following manner:

> The corner stone of time series analysis is the concept of the sequence of observations making up a time series as a

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[1] G.P. Box and G.M. Jenkins, "Time Series Analysis: Forecasting and Control," (San Fransisco: Holden-Day, 1970), pp. 173-333.

[2] C.R. Nelson, Applied Time Series Analysis for Managerial Forecasting, (San Fransisco: Holden-Day, 1973), pp. 69-200.

[3] R.S. Pindyck and D.L. Rubenfeld, Econometric Models and Economic Forecasts, (New York: McGraw-Hill, 1973), pp. 452-518.

[4] M. Nerlove, D.M. Grether and J.L. Carvalho, Analysis of Economic Time Series, (New York: Academic Press, 1979), pp. 201-228.

[5] Op. cit., p. 421.

> realization of jointly distributed random variables ... Our ultimate objective will be to use this joint distribution to make probability statements about future observations ... the information that we have about the relationships between Z_1, ..., Z_t and Z_{t+1} from their joint distribution permits us to use Z_1, ..., Z_t to make statements about the likely outcome of Z_{t+1}.[6]

As stated above, the objective in estimating this process is not to identify structural parameters which are thought a priori to affect slaughter hog prices on the four major Canadian markets but rather to use information about the way the price series have behaved during the estimation period to make predictions about future prices. That is, hog prices will be explained on the basis of own past prices and a weighted sum of current and lagged random disturbances.

Box Jenkins time series analysis is based on three general types of models: autoregressive, moving average or a combination of the two. The autoregressive model can be expressed in the following form:[7]

$$P_t = \phi_1 P_{t-1} + \phi_2 P_{t-2} + \ldots + \phi_i P_{t-p} + a_t$$

where P_t is a finite linear sum of past values; a_t is a random shock or white noise term assumed to be independently and identically distributed $N(0,\sigma^2)$; ϕi, $(i = 1, 2, \ldots, p)$ are parameters of the model and P_t is assumed to be stationary. The moving average model can be expressed in the following form:[8]

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[6] Op. cit., pp. 18-19.

[7] R.A. Oliveira, C.W. O'Connor and G.W. Smith, "Short-Run Forecasting Models of Beef Prices," Western Journal of Agricultural Economics, Vol. 4, No. 1 (July 1979), p. 46.

[8] Ibid.

$$P_t = a_t - \theta_1 a_{t-1} - \theta_2 a_{t-2} - \ldots - \theta_j a_{t-q}$$

where P_t is linearly dependent upon the weighted sum of current and past values of the random shock series and the θ_j ($j = 1, 2, \ldots, q$) are the moving average parameters.

A mixed autoregressive moving average can be represented in the following manner and has the same assumptions as before:[9]

$$P_t = \phi_1 P_{t-1} + \ldots + \phi_p P_{t-p} - \theta_1 a_{t-1} - \ldots - \theta_q a_{t-q}$$

The above can be written in a more convenient form using the back shift operator B.

$$_p(B)P_t = {}_q(B)a_t$$

The operator B imposes a one period lag each time it is applied to a variable.[10]

Autoregressive moving average models can be extended to model time series data which have recurrent seasonal patterns.

One of the major assumptions underlying Box-Jenkins time series analysis is that the underlying stochastic process that generated the series can be assumed to be invariant with respect to time. That is, the data is assumed to be stationary with a constant mean and constant variance. This assumption is similar to the one made for regression models; that is, the structural relationships described by the equation have not changed over the estimation and forecasting period.[11]

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[9] Ibid., p. 47.

[10] Pindyck and Rubenfeld, op. cit., p. 468.

[11] Ibid., p. 435.

Often economic time series data will contain a significant trend factor thus violating the above assumption of stationarity. Differencing is used to transform the data into a stationary time series. The following transformation is made for first differencing time series data:

$$\Delta P_t^1 = P_t - P_{t-1}$$

Similarly, the data may contain a significant seasonal component. This can be removed by seasonal differencing (in this case for weekly data):

$$\Delta P_t^{52} = P_t - P_{t-52}$$

Identifying the correct degree of differencing is based on the results of the autocorrelation function and will be dealt with more fully in the next section.

Nelson indicates that often differencing by itself will not be sufficient to obtain stationary time series data.[12] In the cases of some time series data, it is the relative or percentage changes that are homogeneous. Since changes in logarithms are essentially percentage changes, one suggestion for achieving homogeneity is to use natural logarithms of the raw data.

There are four steps involved in estimating Box Jenkins time series analysis. The first step is identification. The autocorrelation and paritial autocorrelation function are used to (1) identify the degree of differencing needed to make the data stationary, (2) indicate the orders of the autoregressive and moving average components and (3) provide initial estimates of the model's parameters. The second stage of

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[12] Op. cit., pp. 58-59.

the model development is the actual estimation of the parameters. The third stage is the diagnostic checking of the model to ensure the original data series has been modelled correctly. The final stage involves using the estimated model to forecast.

The initial stage in estimating an autoregressive moving average is to identify the amount of differencing required to make the data stationary and the correct order of the autoregressive and moving average components of the model. The tools used in identifying the models are the autocorrelation and partial autocorrelation functions.

The first step in the identification stage is to decide whether the data is stationary. This is done by observing the autocorrelation function to determine if the data dampens around the zero mean within a relatively short number of lags. In all cases, the autocorrelation failed to dampen and therefore, first differencing was necessary to make the data stationary. The autocorrelation for the first differenced data dampened relatively quickly. No spikes were observed at lags that were multiples of fifty two indicating seasonal differencing was not necessary. First differencing was enough to make the data stationary.

Models using data prior to 1969 were stationary using actual data. Preliminary estimates of the models using data after 1969 and subsequent diagnostic checks indicated these models however were not stationary. As a result of this, it was hypothesized that the models would be stationary if they were analyzed in terms of percentage changes. To accomplish this, the models were re-estimated after converting the raw data into natural logarithms. Subsequent estimation demonstrated this to be a suitable transformation.

The next step in identification is to identify the correct orders of autoregressive, seasonal autoregressive, moving average and seasonal moving average components of the four time series. This is done by comparing the autocorrelation functions of the actual time series with theoretical ones obtained from autoregressive moving average models of different orders.

Box and Jenkins describe these theoretical characteristics in the following manner:

> ... whereas the autocorrelation function of an autoregressive process of order p tails off, its partial autocorrelation function has a cutoff after lag p. Conversely, the autocorrelation function of a moving average process or order q has a cutoff after lag q while its partial autocorrelation tails off. If both the autocorrelations and partial autocorrelations tail off, a mixed process is suggested. Furthermore, the autocorrelation function for a mixed process, containing a p^{th} order autoregressive component and a q^{th} order moving average component, is a mixture of exponentials and dampened sine waves after the first q - p lags. Conversely, the partial autocorrelation for a mixed process is dominated by a mixture of exponentials and dampened sine waves after the first p - q lags.[13]

A brief summary of the above is illustrated in Table 20.

Table 20. Characteristic Behavior of Autocorrelations and Partial Autocorrelations for Three Classes of Processes

Class of processes	Autocorrelations	Partial Autocorrelations
Moving Average	Spikes at lags 1 through q, then cut off	Tail off
Autoregressive	Tail off according to $p_j = \phi_1 p_j + \ldots + \phi_p p_{j-p}$	Spikes at lags 1 through p, then cut off
Mixed Autoregressive-Moving Average	Irregular pattern at lags 1 through q, then tail off according to $p_j = \phi_1 p_{j-1} + \ldots + \phi_p p_{j-p}$	Tail off

Source: C.R. Nelson, Applied Time Series Analysis for Managerial Forecasting, (San Francisco: Holden-Day, Inc., 1973), p. 89.

The autocorrelation and partial autocorrelation functions did not appear to exhibit any consistent patterns when comparing different time periods or markets. Based on the criteria outlined in Table 20, several different models were estimated for each market and time period. The best model was then selected based on the criteria of minimum autocorrelation in the residuals.

The next step after initially identifying the order of the ARIMA model is to calculate initial estimates of the parameters. The estimates provide starting points for the iterative procedure used in the maximum likelihood method. The initial estimates are obtained from the estimated values of the autocorrelation function.

As a result of applying maximum likelihood estimation procedure, the results illustrated in Tables 21-38 were obtained. The following diagnostic checks were made to determine the adequacy of the model. Firstly, the autocorrelations of residuals were checked to determine if in fact the time series had been reduced to white noise. If this were not the case, the model was re-estimated using the information obtained concerning non-zero autocorrelations in the previous equation. Another procedure which tests for the presence of residual autocorrelation in lags one through K is the Q statistic. The Q statistic is calculated in the following manner:

$$Q = T \sum_{j=1}^{K} r_j^2$$

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[13] Op. cit., p. 175.

which is approximately a chi square distributed with (k-p-q) degrees of freedom. The ESP computer package calculates Q statistics for lags twelve, twenty-four and thirty-six.

A check was made to determine if there were high correlations between the disturbance terms and the past values of the time series data. The cross correlations indicated only small correlations between the residuals and the lagged values of the price time series data and thus would tend to support the models estimated in all cases.

One step ahead forecasts were calculated for each of the markets under study and for each of the time periods. The residuals were calculated by subtracting the actual prices from the predicted prices. These residuals are used in calculating the cross-correlations in sections 5.5 and 5.6.

Table 21.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Toronto, Winnipeg, Saskatoon and Edmonton Markets; January 1, 1951 to May 7, 1961 (Actual Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Toronto						
A	0.24	-.12	-.06	.08	.06	.00	-.03	-.06	.02	.00	-.02	-0.01
P	0.24	-.19	.02	.07	.01	.00	-.02	-.05	.04	-.04	.00	0.00
						Winnipeg						
A	0.36	.04	.01	.01	.03	.03	-.05	-.06	-.04	.01	.12	0.04
P	0.36	-.10	.04	-.01	.03	.01	-.07	-.01	-.02	.03	.12	-0.05
						Saskatoon						
A	0.33	.03	.01	.02	.02	.00	-.06	-.06	-.02	-.03	.09	0.08
P	0.33	-.09	.03	.01	.01	-.02	-.06	-.03	.01	-.04	.13	0.01
						Edmonton						
A	0.17	-.07	.04	.06	.01	.06	-.05	-.07	-.04	.06	.01	0.06
P	0.17	-.10	.07	.04	.00	.07	-.08	-.04	-.03	.06	.00	0.08

Note: Standard errors at low lags are approximately .04. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 21.2. Estimated Time Series Models

Estimated Equation[a]	Q(12)[b]	r.s.e[c]
Toronto		
$(1-B)(1-B^{52})T_t = (1+0.273B-0.076B^2)(1+0.099B^{52})t_t$ (-6.4) (1.8) (-2.4)	9.8 (9)[d]	0.731
Winnipeg		
$(1-B)(1-B^{52})W_t = (1+0.33B)(1+0.085B^{52})w_t$ (-9.6) (-2.1)	13.1 (10)[e]	0.557
Saskatoon		
$(1-B)(1-B^{52})S_t = (1+0.352B)(1+0.067B^{52})s_t$ (-8.7) (-1.6)	12.4 (10)[e]	0.602
Edmonton		
$(1-B)(1-B^{52})E_t = (1+0.187B-0.062B^2)(1+0.133B^{52})e_t$ (-4.3) (1.4) (-3.2)	15.6 (9)[d]	0.797

Where T_t, W_t, S_t and E_t are past prices, and t_t, w_t, s_t and e_t are lagged random disturbances for Toronto, Winnipeg, Saskatoon and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 16.9.

[e] The critical value at .05 level is 18.3.

Table 21.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Toronto						
0.01	-.03	-.07	.07	.04	.00	-.01	-.06	.03	-.01	-.01	-0.01
					Winnipeg						
0.01	.04	.00	.00	.01	.04	-.05	-.03	-.02	-.02	.13	0.00
					Saskatoon						
0.01	.02	.00	.01	.02	.01	-.04	-.05	.02	-.07	.10	0.05
					Edmonton						
0.00	.00	.03	.07	-.02	.08	-.05	-.05	-.05	.07	-.02	0.06

Note: Standard errors at low lags are approximately .04.

Table 22.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Toronto, Winnipeg, Saskatoon and Edmonton Markets; May 8, 1961 to February 24, 1965 (Actual Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Toronto						
A	0.05	-.11	.01	.03	.07	.02	-.01	-.14	-.02	-.06	.02	-0.10
P	0.05	-.11	.02	.01	.07	.02	.00	-.14	-.01	-.10	.03	-0.12
						Winnipeg						
A	0.24	-.04	.04	.02	.05	-.04	.04	-.05	-.11	.03	-.01	-0.07
P	0.24	-.10	.08	-.02	.07	-.08	.09	-.11	-.06	.05	-.04	-0.06
						Saskatoon						
A	0.27	.00	.05	-.03	.04	-.02	.05	-.02	-.07	.01	-.03	-0.13
P	0.27	-.08	.08	-.07	.08	-.07	.10	-.09	-.01	.01	-.03	-0.14
						Edmonton						
A	0.19	-.14	-.07	-.02	-.01	.03	.01	-.03	-.05	.14	.01	-0.07
P	0.19	-.18	.00	-.03	-.02	.03	-.01	-.02	-.04	.16	-.08	-0.01

Note: Standard errors at low lags are approximately .07. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 22.2. Estimated Time Series Models

Estimated Equation[a]	Q(12)[b]	r.s.e.[c]
Toronto		
$(1-B)(1-B^{52})T_t = (1-\underset{(2.5)}{0.168}B^2-\underset{(4.1)}{0.270}B^8)(1-\underset{(4.6)}{0.309}B^{52})t_t$	$\underset{(9)}{6.7}$[e]	0.745
Winnipeg		
$(1-B)(1-B^{52})W_t = (1+\underset{(-3.0)}{0.207}B-\underset{(2.0)}{0.136}B^9)(1+\underset{(-5.2)}{0.357}B^{52})w_t$	$\underset{(9)}{6.1}$[e]	0.569
Saskatoon		
$(1-\underset{(1.8)}{0.127}B)(1-\underset{(7.1)}{0.483}B^{52})S_t = (1-\underset{(1.9)}{0.134}B^4+\underset{(-1.3)}{0.092}B^5)(1-B^{52})s_t$	$\underset{(8)}{5.6}$[d]	0.555
Edmonton		
$(1-B)(1-B^{52})E_t = (1+\underset{(-2.6)}{0.185}B-\underset{(2.0)}{0.137}B^2+\underset{(-2.9)}{0.195}B^{10})(1+\underset{(-3.3)}{0.223}B^{52})e_t$	$\underset{(8)}{3.9}$[d]	0.665

Where T_t, W_t, S_t and E_t are past prices, and t_t, w_t, s_t and e_t are lagged random disturbances for Toronto, Winnipeg, Saskatoon and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 15.5.

[e] The critical value at .05 level is 16.9.

Table 22.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Toronto						
0.00	.06	.01	-.05	.03	.00	.05	.06	.00	-.09	.02	-0.10
					Winnipeg						
-0.03	-.07	.07	-.08	.07	-.04	.02	-.04	.03	.04	.03	0.07
					Saskatoon						
0.00	-.08	.06	-.01	.01	-.03	.03	-.02	-.08	-.01	-.01	-0.09
					Edmonton						
0.01	-.01	-.02	-.03	-.03	.05	-.02	.00	-.11	-.01	-.01	-0.05

Note: Standard errors at low lags are approximately .07.

Table 23.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Toronto, Saskatoon and Edmonton Markets; May 8, 1961 to October 30, 1969 (Actual Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Toronto						
A	0.16	.04	.09	.00	.07	-.03	-.08	-.17	-.10	-.06	-.04	-0.09
P	0.16	.02	.08	-.03	.08	-.06	-.06	-.16	-.04	-.04	.01	-0.08
						Saskatoon						
A	0.19	.07	.10	-.04	-.05	-.05	-.10	-.06	-.09	.03	-.09	-0.03
P	0.19	.04	.09	-.08	-.04	-.04	-.07	-.01	-.07	.08	-.12	0.01
						Edmonton						
A	0.30	.05	.06	-.04	-.04	-.08	-.10	-.05	-.05	.03	-.01	-0.01
P	0.30	-.04	.06	-.07	-.01	-.07	-.05	.00	-.04	.07	-.05	0.00

Note: Standard errors at low lags are approximately .05. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 23.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Toronto		
$(1-0.122B)(1-B^{52})T_t = (1+0.122B^3+0.124B^5-0.112B^8)(1+0.270B^{52})t_t$ (2.6) (-2.6) (-2.7) (2.4) (-5.7)	7.6 (7)[d]	0.763
Saskatoon		
$(1-B)(1-B^{52})S_t = (1+0.172B+0.137B^3-0.142B^7-0.064B^9)(1+0.285B^{52})s_t$ (-3.7) (-3.0) (3.1) (1.4) (-6.0)	6.4 (7)[d]	0.760
Edmonton		
$(1-B)(1-B^{52})E_t = (1+0.281B+0.095B^3-0.034B^6-0.114B^7)(1+0.141B^{52})e_t$ (-6.1) (-2.1) (0.7) (2.4) (-4.8)	4.8 (7)[d]	0.705

Where T_t, S_t and E_t are past prices, and t_t, s_t and e_t are lagged random disturbances for Toronto, Saskatoon and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 14.1.

Table 23.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Toronto						
0.00	.01	-.01	-.06	.00	-.03	.00	.00	-.06	-.06	.00	-0.07
					Saskatoon						
-0.01	.04	-.01	-.04	-.05	.01	.02	.01	.00	.03	-.08	-0.03
					Edmonton						
0.00	.03	-.01	-.02	-.02	.00	.01	-.03	-.05	.06	.04	0.02

Note: Standard errors at low lags are approximately .05.

Table 24.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Toronto and Saskatoon Markets; May 8, 1961 to August 5, 1973 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Toronto						
A	0.19	.02	.03	.00	.03	.00	-.03	-.10	-.04	.00	-.01	-0.06
P	0.19	-.01	.03	-.01	.03	-.01	-.03	-.09	.00	.01	-.01	-0.06
						Saskatoon						
A	0.17	.07	.05	-.04	-.03	-.02	-.03	-.05	-.04	.06	-.06	-0.01
P	0.17	.04	.03	-.05	-.02	-.01	-.02	-.05	-.02	.08	-.08	0.00

Note: Standard errors at low lags are approximately .04. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 24.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Toronto		
$(1-B)(1-B^{52})T_t = \underset{(-3.4)}{(1+0.132B)}\underset{(-7.8)}{(1+0.293B^{52})}t_t$	$\underset{(10)}{8.8}$[d]	0.025
Saskatoon		
$(1-B)(1-B^{52})S_t = \underset{(-3.2)}{(1+0.126B)}\underset{(-6.3)}{(1+0.253B^{52})}s_t$	$\underset{(10)}{8.5}$[d]	0.029

Where T_t and S_t are past prices, and t_t and s_t are lagged random disturbances for Toronto and Saskatoon markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 18.3.

Table 24.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Toronto						
0.00	.02	.04	-.04	.05	-.01	.01	-.08	-.01	-.01	.01	-0.03
					Saskatoon						
0.00	.06	.04	-.05	.00	.00	-.02	-.02	-.03	.05	-.05	0.01

Note: Standard errors at low lags are approximately .04.

Table 25.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Winnipeg and Edmonton Markets; February 25, 1965 to October 30, 1969 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Winnipeg						
A	0.15	.13	.08	-.05	-.07	-.09	-.13	-.03	-.10	.04	-.06	-0.01
P	0.15	.11	.05	-.08	-.07	-.06	-.09	.02	-.07	.07	-.08	-0.01
						Edmonton						
A	0.33	.17	.12	-.04	-.04	-.14	-.16	-.07	-.05	-.01	-.01	0.05
P	0.33	.07	.05	-.12	-.01	-.13	-.07	.03	.00	.01	-.03	0.05

Note: Standard errors at low lags are approximately .06. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 25.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Winnipeg		
$(1-0.113B)(1-B^{52})T_t = (1+0.098B^{3}-0.104B^{7}-0.100B^{9})(1+0.380B^{52})t_t$ (1.7) (-1.5) (1.6) (1.5) (-6.4)	4.5 (7)[e]	0.027
Edmonton		
$(1-0.291B)(1-B^{52})E_t = (1+0.130B^{3}-0.058B^{4}-0.076B^{6}-0.129B^{7})(1+0.132B^{52})e_t$ (4.6) (-2.0) (0.9) (1.2) (2.0) (-2.0)	3.1 (6)[d]	0.024

Where W_t and E_t are past prices, and w_t and e_t are lagged random disturbances for Winnipeg and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 12.6.

[e] The critical value at .05 level is 14.1.

Table 25.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Winnipeg						
-0.01	.08	.00	-.02	-.07	-.03	.00	.03	-.01	-.01	-.02	-0.06
					Edmonton						
-0.03	.07	-.01	.00	.01	-.01	.00	.00	-.02	.02	-.04	0.06

Note: Standard errors at low lags are approximately .06.

Table 26.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Toronto, Winnipeg and Saskatoon Markets; February 25, 1965 to December 31, 1971 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Toronto						
A	0.23	.10	.06	-.03	-.01	-.01	-.08	-.10	-.08	.00	-.03	-0.02
P	0.23	.05	.03	-.06	.00	-.01	-.08	-.07	-.03	.05	-.03	-0.01
						Winnipeg						
A	0.16	.09	.04	-.08	-.07	-.06	-.07	-.01	-.05	.06	-.04	0.04
P	0.16	.07	.02	-.10	-.05	-.03	-.04	.01	-.05	.07	-.07	0.05
						Saskatoon						
A	0.13	.09	.03	-.07	-.07	-.05	-.07	-.04	-.04	.07	-.06	0.05
P	0.13	.07	.01	-.08	-.05	-.02	-.05	-.02	-.03	.08	-.08	0.05

Note: Standard errors at low lags are approximately .05. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 26.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Toronto		
$(1-0.182B)(1-B^{52})T_t = (1-0.315B^{8})(1+0.308B^{52})t_t$ (3.5) (5.9) (-5.9)	8.4 (9)[d]	0.023
Winnipeg		
$(1-0.121B)(1-0.421B^{52})W_t = (1-0.243B^{4})(1-B^{52})w_t$ (2.3) (8.3) (4.6)	2.2 (9)[d]	0.028
Saskatoon		
$(1-0.093B)(1-0.417B^{52})S_t = (1-B)(1-B^{52})s_t$ (1.8) (8.2)	3.1 (10)[e]	0.029

Where T_t, W_t and S_t are past prices, and t_t, w_t and s_t are lagged random disturbances for Toronto, Winnipeg and Saskatoon markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 16.9.

[e] The critical value at .05 level is 18.3.

Table 26.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Toronto						
-0.01	.04	.07	-.06	.06	.02	-.05	.00	-.07	.04	.00	0.01
					Winnipeg						
-0.01	.05	.03	.00	-.02	.01	-.02	.03	.00	.01	-.01	0.03
					Saskatoon						
-0.01	.07	.02	-.04	-.01	.01	-.01	.02	-.01	.02	-.02	0.03

Note: Standard errors at low lags are approximately .05.

Table 27.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Winnipeg and Edmonton Markets; October 31, 1969 to December 31, 1971 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Winnipeg						
A	0.17	.00	-.04	-.14	-.09	-.01	.03	-.01	.01	.08	-.01	0.11
P	0.17	-.03	-.04	-.13	-.04	.01	.03	-.05	.00	.07	-.03	0.12
						Edmonton						
A	-0.11	.07	-.04	-.09	-.15	.07	.06	.00	.05	.06	-.02	0.05
P	-0.11	.06	-.02	-.10	-.17	.05	.10	-.02	.01	.07	.02	0.06

Note: Standard errors at low lags are approximately .09. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 27.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Winnipeg		
$(1-B)(1-B^{52})W_t = \underset{(-1.8)}{(1+0.171B-0.114B^4)}\underset{(1.2)}{(1-B^{52})}w_t$	$\underset{(10)}{3.0}$[d]	0.031
Edmonton		
$(1-B)(1-B^{52})E_t = \underset{(0.8)}{(1-0.080B-0.129B^5)}\underset{(1.4)}{(1-B^{52})}e_t$	$\underset{(10)}{4.6}$[d]	0.036

Where W_t and E_t are past prices, and w_t and e_t are lagged random disturbances for Winnipeg and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 18.3

Table 27.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Winnipeg						
0.00	.00	-.02	-.02	-.08	.01	.03	-.01	.00	.08	-.04	0.10
					Edmonton						
-0.03	.07	-.03	-.10	-.03	.07	.09	.01	.05	.05	.00	0.06

Note: Standard errors at low lags are approximately .09.

Table 28.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Saskatoon and Edmonton Markets; October 31, 1969 to August 5, 1973 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Saskatoon						
A	0.13	.06	.00	-.01	-.02	.01	.03	-.06	.01	.10	-.05	0.01
P	0.13	.05	-.02	-.01	-.01	.02	.03	-.08	.02	.10	-.08	0.01
						Edmonton						
A	0.03	.05	.01	-.04	-.05	.08	.04	-.05	.02	.07	.03	0.05
P	0.03	.05	.01	-.04	-.05	.09	.04	-.06	.01	.09	.04	0.02

Note: Standard errors at low lags are approximately .07. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 28.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Saskatoon		
$(1-B)(1-B^{52})S_t = \underset{(-1.3)}{(1+0.094B)}\underset{(-3.9)}{(1+0.277B^{52})}s_t$	$\underset{(10)}{4.2}$[d]	0.035
Edmonton		
$(1-B)(1-B^{52})E_t = \underset{(-0.3)}{(1+0.019B)}\underset{(-2.1)}{(1+0.152B^{52})}e_t$	$\underset{(10)}{4.4}$[d]	0.035

Where S_t and E_t are past prices, and s_t and e_t are lagged random disturbances for Saskatoon and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom given in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 18.3.

Table 28.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Saskatoon						
0.00	.07	-.04	-.03	.02	.02	.05	-.04	.00	.07	-.05	0.05
					Edmonton						
-0.01	.02	.01	-.04	-.03	.08	.05	-.05	.01	.07	.03	0.04

Note: Standard errors at low lags are approximately .07.

Table 29.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Toronto and Edmonton Markets; October 31, 1969 to March 16, 1978 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Toronto						
A	0.20	-.04	-.09	.05	.15	.06	-.05	-.14	.05	.16	.01	-0.06
P	0.20	-.08	-.07	.09	.12	.00	-.04	-.11	.10	.11	-.07	-0.02
						Edmonton						
A	-0.12	.14	-.07	.03	.05	.00	-.03	-.01	.00	.09	-.02	0.02
P	-0.12	.12	-.05	.00	.07	.00	-.04	-.01	.00	.09	.00	-0.01

Note: Standard errors at low lags are approximately .05. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 29.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Toronto		
$(1-B)(1-B^{52})T_t = (1+\underset{(-4.0)}{0.189}B+\underset{(-2.0)}{0.092}B^5-\underset{(2.0)}{0.094}B^8+\underset{(3.4)}{0.161}B^{10})(1+\underset{(-2.9)}{0.150}B^{52})t_t$	7.8 (7)[d]	0.030
Edmonton		
$(1+\underset{(-2.5)}{0.119}B)(1-B^{52})E_t = (1+\underset{(-2.1)}{0.120}B^2+\underset{(-1.8)}{0.086}B^{10})(1+\underset{(-2.3)}{0.113}B^{52})e_t$	4.6 (8)[e]	0.043

Where T_t and E_t are past prices, and t_t and e_t are lagged random disturbances for Toronto and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 14.1.

[e] The critical value at .05 level is 15.5.

Table 29.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Toronto						
0.00	.00	-.08	.03	.02	.06	.00	-.03	.02	.01	.02	-.06
					Edmonton						
0.00	.00	-.07	.02	.06	.01	-.02	-.01	.01	.00	.00	.01

Note: Standard errors at low lags are approximately .05.

Table 30.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Winnipeg and Saskatoon Markets; January 1, 1972 to August 5, 1973 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Winnipeg						
A	0.27	.08	.08	.07	.08	-.01	-.13	-.12	-.07	.03	-.09	-0.19
P	0.27	.00	.06	.04	.05	-.05	-.13	-.07	-.02	.07	-.09	-0.14
						Saskatoon						
A	0.21	.07	.07	.07	.11	-.04	-.08	-.16	-.06	.02	-.12	-0.17
P	0.21	.02	.05	.05	.09	-.09	-.07	-.15	.00	.05	-.10	-0.12

Note: Standard errors at low lags are approximately .11. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 30.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Winnipeg		
$(1-B)(1-B^{52})W_t = \underset{(-2.5)}{(1+0.275B)}(1-B^{52})w_t$	$\underset{(11)}{4.4}$[d]	0.034
Saskatoon		
$(1-B)(1-B^{52})S_t = \underset{(-1.8)}{(0+0.199B)}(1-B^{52})s_t$	$\underset{(11)}{5.5}$[d]	0.038

Where W_t and S_t are past prices, and w_t and s_t are lagged random disturbances for Winnipeg and Saskatoon markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 19.7.

Table 30.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Winnipeg						
-0.05	.03	.06	.00	.04	.05	-.12	-.12	-.02	.05	-.08	-0.08
					Saskatoon						
-0.05	.03	.05	.00	.08	-.01	-.06	-.17	-.01	.05	-.12	-0.08

Note: Standard errors at low lags are approximately .11.

Table 31.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Toronto, Winnipeg and Edmonton Markets; January 1, 1972 to September 5, 1977 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Toronto						
A	0.22	-.06	-.08	.06	.21	.08	-.07	-.16	.02	.14	-.01	-0.06
P	0.22	-.11	-.05	.09	.18	-.01	-.06	-.12	.06	.07	-.09	0.00
						Winnipeg						
A	0.27	.09	.05	.06	.09	.05	-.09	-.09	.07	.07	.00	-0.02
P	0.27	.02	.03	.04	.07	.01	-.12	-.04	.12	.03	-.04	-0.01
						Edmonton						
A	-0.13	.16	-.09	.07	.10	-.01	-.07	.00	-.03	.07	-.04	0.01
P	-0.13	.14	-.05	.03	.13	-.01	-.10	.00	-.02	.04	-.01	0.01

Note: Standard errors at low lags are approximately .06. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 31.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Toronto		
$(1-0.222B)(1-B^{52})T_t = (1+0.186B^5-0.141B^8+0.117B^{10})(1-B^{52})t_t$ (3.9) (-3.3) (2.5) (-2.0)	$4.9_{(8)}$[d]	0.032
Winnipeg		
$(1-0.264B)(1-B^{52})W_t = (1-0.104B^7+0.103B^9)(1+0.161B^{52})w_t$ (4.6) (1.8) (-1.8) (-2.6)	$5.3_{(8)}$[d]	0.031
Edmonton		
$(1-B)(1-B^{52})E_t = (1-0.094B+0.164B^2-0.093B^3+0.123B^5)(1-B^{52})e_t$ (1.6) (-2.9) (1.6) (-2.2)	$4.6_{(8)}$[d]	0.046

Where T_t, W_t and E_t are past prices, and t_t, w_t and e_t are lagged random disturbances for Toronto, Winnipeg and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 15.5.

Table 31.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Toronto						
0.01	-.05	-.06	.03	-.01	.05	-.02	-.01	.01	.02	-.07	-0.03
					Winnipeg						
-0.01	.03	.01	.02	.08	.05	.00	-.07	-.01	.05	.01	0.02
					Edmonton						
-0.01	.00	-.01	.08	-.01	-.03	-.06	-.02	-.01	.06	-.03	0.02

Note: Standard errors at low lags are approximately .06.

Table 32.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Winnipeg and Saskatoon Markets; August 6, 1973 to September 5, 1977 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Winnipeg						
A	0.26	.07	.00	.05	.12	.10	-.05	-.05	.10	.10	.04	0.01
P	0.26	.00	-.01	.06	.11	.04	-.10	-.02	.14	.03	-.02	0.02
						Saskatoon						
A	0.30	.09	.02	.10	.11	.03	-.05	-.09	.11	.11	.08	0.01
P	0.30	.00	-.01	.11	.05	-.02	-.06	-.07	.17	.04	.03	0.00

Note: Standard errors at low lags are approximately .07. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 32.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Winnipeg		
$(1-B)(1-B^{52})W_t = (1+0.218B+0.054B^5+0.100B^9)(1-B^{52})w_t$ $(-3.3)\ (-8.1)\ \ (-1.5)$	$8.2_{(9)}$[e]	0.031
Saskatoon		
$(1-B)(1-B^{52})S_t = (1+0.279B+0.195B^4+0.051B^5+0.209B^9)(1-B^{52})s_t$ $(-4.4)\ (-3.0)\ \ (-0.8)\ \ (-3.3)$	$8.7_{(8)}$[d]	0.030

Where W_t and S_t are past prices, and w_t and s_t are lagged random disturbances for Winnipeg and Saskatoon markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 is 15.5.

[e] The critical value at .05 is 16.9.

Table 32.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Winnipeg						
0.03	-.07	-.03	.04	.04	.10	-.08	-.05	.01	.09	.00	0.04
					Saskatoon						
0.04	.08	-.05	-.04	.03	-.01	-.05	-.11	-.03	.10	.04	0.05

Note: Standard errors at low lags are approximately .07.

Table 33.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Saskatoon and Edmonton Markets; August 6, 1973 to March 16, 1978 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Saskatoon						
A	0.23	.10	-.02	.08	.12	-.01	-.03	-.13	.14	.14	.08	-0.01
P	0.23	.05	-.05	.09	.10	-.08	-.03	-.11	.19	.09	.00	-0.02
						Edmonton						
A	-0.19	.16	-.12	.05	.09	-.03	-.05	.01	-.01	.10	-.02	0.02
P	-0.19	.13	-.08	.00	.13	-.01	-.08	.02	.01	.08	.02	0.00

Note: Standard errors at low lags are approximately .06. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 33.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Saskatoon		
$(1-0.259B-0.165B^{9})(1-B^{52})S_t = (1+0.040B^{5}-0.172B^{8})(1-B^{52})s_t$ (4.2) (2.7) (-0.6) (2.7)	3.9 (8)[d]	0.030
Edmonton		
$(1-B)(1-B^{52})E_t = (1-0.138B+0.149B^{2}-0.141B^{3}+0.089B^{10})(1-B^{52})e_t$ (2.2) (-2.3) (2.2) (-1.4)	4.5 (8)[d]	0.048

Where S_t and E_t are past prices, and s_t and e_t are lagged random disturbances for Saskatoon and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 15.5.

Table 33.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Saskatoon						
-0.03	.07	-.04	.08	.03	-.01	-.01	.01	.01	.03	.04	0.01
					Edmonton						
-0.02	.00	.01	.07	.09	-.03	-.04	.01	.02	.01	-.03	0.02

Note: Standard errors at low lags are approximately .06.

Table 34.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Toronto and Saskatoon Markets; August 6, 1973 to December 31, 1980 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Toronto						
A	0.14	-.08	-.08	.05	.14	.02	-.11	-.09	.03	.13	.03	-0.05
P	0.14	-.10	-.05	.06	.12	-.02	-.08	-.05	.03	.09	.01	-0.01
						Saskatoon						
A	0.31	.11	.01	.08	.07	-.04	-.07	-.10	.07	.09	.04	-0.01
P	0.31	.02	-.03	.10	.03	-.09	-.04	-.07	.13	.05	-.01	0.00

Note: Standard errors at low lags are approximately .05. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 34.2. Estimated Time Series Models

Estimated Equations	Q(12)[b]	r.s.e.[c]
Toronto		
$(1-0.084B-0.148B^{5})(1-0.310B^{52})T_t = (1-0.031B^{7}+0.128B^{10})(1-B^{52})t_t$ (1.7) (2.9) (5.8) (0.6) (-2.5)	3.1 (7)[d]	0.034
Saskatoon		
$(1-0.299B-0.120B^{4})(1-0.386B^{52})S_t = (1-0.140B^{8}+0.038B^{10})(1-B^{52})s_t$ (6.2) (2.5) (8.1) (2.8) (-0.8)	7.1 (7)[d]	0.028

Where T_t and S_t are past prices, and t_t and s_t are lagged random disturbances for Toronto and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 14.1.

Table 34.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Toronto						
0.00	-.06	-.02	.01	.00	.01	-.01	-.04	-.01	-.01	.01	-0.04
					Saskatoon						
-0.02	.06	-.06	-.01	.04	-.02	-.01	-.01	.09	.02	.04	-0.01

Note: Standard errors at low lags are approximately .05.

Table 35.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Toronto, Winnipeg, Saskatoon and Edmonton Markets; September 6, 1977 to September 8, 1978 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Toronto						
A	0.16	.02	-.07	-.02	.04	-.24	-.14	-.37	-.11	.01	.03	0.08
P	0.16	.00	-.08	.00	.05	-.27	-.07	-.36	-.05	-.01	-.01	0.01
						Winnipeg						
A	0.03	.11	-.12	-.04	.07	-.28	-.08	-.45	-.10	.07	.07	0.07
P	0.03	.11	-.13	-.05	.10	-.30	-.09	-.40	-.19	.09	.00	-0.09
						Saskatoon						
A	0.05	.13	-.09	-.04	.03	-.33	-.13	-.38	-.13	.06	.03	0.14
P	0.05	.13	-.11	-.04	.06	-.35	-.12	-.32	-.22	.07	-.03	-0.02
						Edmonton						
A	0.06	.09	.03	-.11	-.07	-.35	-.10	-.30	-.07	.07	.01	-0.02
P	0.06	.09	.01	-.12	-.06	-.33	-.06	-.29	-.06	.02	-.04	-0.26

Note: Standard errors at low lags are approximately 0.14. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 35.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Toronto		
$(1-B)(1-B^{52})T_t = \underset{(2.2)}{(1-0.274B^{6}} \underset{(3.7)}{-0.461B^{8})}(1-B^{52})t_t$	$\underset{(10)}{2.6}$[d]	0.029
Winnipeg		
$(1-B)(1-B^{52})W_t = \underset{(3.7)}{(1-0.411B^{6}} \underset{(5.0)}{-0.547B^{8})}(1-B^{52})w_t$	$\underset{(10)}{4.0}$[d]	0.031
Saskatoon		
$(1-B)(1-B^{52})S_t = \underset{(1.6)}{(1-0.234B^{6}} \underset{(2.5)}{-0.378B^{8})}(1-B^{52})s_t$	$\underset{(10)}{8.4}$[d]	0.030
Edmonton		
$(1-B)(1-B^{52})E_t = \underset{(3.9)}{(1-0.483B^{6}} \underset{(2.7)}{-0.323B^{8})}(1-B^{52})e_t$	$\underset{(10)}{2.9}$[d]	0.028

Where T_t, W_t, S_t and E_t are past prices, and t_t, w_t, s_t and e_t are lagged random disturbances for Toronto, Winnipeg, Saskatoon and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 18.3.

Table 35.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Toronto						
0.07	-.08	-.13	-.02	-.04	-.03	-.12	-.03	-.05	-.01	-.03	0.02
					Winnipeg						
-0.03	.02	-.20	-.02	.02	-.02	-.06	-.09	-.11	.10	.01	-0.01
					Saskatoon						
-0.09	.09	-.17	.06	-.04	-.10	-.16	-.09	-.18	.12	-.04	0.13
					Edmonton						
0.05	-.06	.04	-.13	.01	-.06	-.03	-.10	-.06	.05	.03	-0.10

Note: Standard errors at low lags are approximately .14.

Table 36.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Toronto, Saskatoon and Edmonton Markets; March 17, 1978 to December 31, 1980 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Toronto						
A	0.12	-.10	-.02	.04	-.03	-.07	-.15	.10	.03	.07	.01	-0.07
P	0.12	-.11	.00	.04	-.05	-.06	-.15	.13	-.03	.09	.00	-0.09
						Saskatoon						
A	0.44	.11	.04	.09	-.01	-.07	-.10	.00	-.01	.02	-.05	-0.04
P	0.44	-.09	.03	.08	-.11	-.03	-.07	.08	-.04	.04	-.07	-0.01
						Edmonton						
A	0.29	.11	.08	.02	-.04	-.08	-.08	.01	.00	-.07	-.06	-0.04
P	0.29	.02	.05	-.02	-.05	-.07	-.04	.07	-.01	-.07	-.03	-0.02

Note: Standard errors at zero lag are approximately 0.08. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 36.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Toronto		
$(1-B)(1-B^{52})T_t = (1+0.228B-0.247B^{7})(1-B^{52})t_t$ (-2.9) (3.1)	7.6 (10)[e]	0.037
Saskatoon		
$(1-B)(1-B)^{52}S_t = (1+0.414B+0.084B^{4})(1+0.411B^{52})s_t$ (-5.4) (-1.1) (-5.1)	5.7 (9)[d]	0.026
Edmonton		
$(1-B)(1-B^{52})E_t = (1+0.249B+0.112B^{4})(1+0.432B^{52})e_t$ (-3.1) (-1.4) (-5.6)	5.1 (9)[d]	0.030

Where T_t, S_t and E_t are past prices, and t_t, s_t and e_t are lagged disturbances for Toronto, Saskatoon and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 16.9.

[e] The critical value at .05 level is 18.3.

Table 36.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Toronto						
-0.06	-.09	.01	.06	-.08	-.02	.05	.11	-.01	.05	.01	-0.11
					Saskatoon						
0.07	.12	-.01	.04	.04	-.06	-.04	.04	.00	.08	-.04	0.01
					Edmonton						
0.04	.09	.05	.02	-.02	-.09	-.05	.08	.02	-.05	.03	-0.03

Note: Standard errors at low lags are approximately .08.

Table 37.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Toronto, Winnipeg, Saskatoon and Edmonton Markets; September 17, 1978 to December 31, 1980 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
						Toronto						
A	0.09	-.08	-.03	.00	-.04	-.03	-.12	.17	.07	.06	.00	-0.06
P	0.09	-.09	-.01	-.01	-.04	-.03	-.12	.19	.01	.08	.00	-0.06
						Winnipeg						
A	0.45	.11	.06	.01	-.10	-.09	-.03	.07	.03	.03	.02	-0.06
P	0.45	-.11	.08	-.05	.11	.00	.02	.09	-.05	.03	-.02	-0.09
						Saskatoon						
A	0.47	.13	.08	.06	-.03	-.05	-.06	.05	.10	.04	-.07	-0.07
P	0.47	-.11	.08	.01	-.08	.00	-.05	.13	.04	-.04	-.10	-0.02
						Edmonton						
A	0.28	.09	.08	.01	-.05	-.05	-.07	.08	.05	-.02	-.06	-0.05
P	0.28	.01	.05	-.03	-.05	-.03	-.04	.13	.00	-.05	-.07	-0.03

Note: Standard errors at low lags are approximately .09. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 37.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Toronto		
$(1-B)(1-B^{52})T_t = \underset{(-2.1)}{(1+0.185B^{8})}(1-B^{52})t_t$	$\underset{(11)}{7.1}$[d]	0.039
Winnipeg		
$(1-B)(1-B^{52})W_t = \underset{(-6.2)}{(1+0.486B)}(1-B^{52})w_t$	$\underset{(11)}{5.7}$[d]	0.028
Saskatoon		
$(1-B)(1-B^{52})S_t = \underset{(-6.0)}{(1+0.479B)}(1-B^{52})s_t$	$\underset{(11)}{6.6}$[d]	0.027
Edmonton		
$(1-B)(1-B^{52})E_t = \underset{(-3.1)}{(1+0.273B)}(1-B^{52})e_t$	$\underset{(11)}{3.8}$[d]	0.033

Where T_t, W_t, S_t and E_t are past prices and t_t, w_t, s_t and e_t are lagged random disturbances for Toronto, Winnipeg, Saskatoon and Edmonton markets respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 19.7.

Table 37.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
					Toronto						
0.10	-.09	-.01	.00	-.05	-.02	-.16	-.01	.08	.08	.00	-0.03
					Winnipeg						
0.03	.10	.01	.05	-.11	-.03	-.06	.10	-.02	.02	.05	-0.08
					Saskatoon						
0.05	.11	.01	.09	-.06	.00	-.09	.07	.06	.05	-.09	-0.01
					Edmonton						
0.01	.07	.06	.01	-.05	-.02	-.09	.10	.03	-.02	-.05	-0.02

Note: Standard errors at low lags are approximately .09.

Table 38.1. Estimated Autocorrelations and Partial Autocorrelations of First Differenced Weekly Slaughter Hog Prices on Seven United States Markets Combined, Toronto, Winnipeg, Saskatoon and Edmonton Markets; January 1, 1973 to December 31, 1980 (Logarithmic Data)

	Lags											
	1	2	3	4	5	6	7	8	9	10	11	12
	Seven United States Markets Combined											
A	0.27	.19	.05	.00	-.04	-.02	.03	.06	-.06	-.07	-.10	-0.03
P	0.27	.12	-.03	-.03	-.05	.01	.05	.05	-.11	-.06	-.05	0.03
	Toronto											
A	0.02	-.07	-.05	.00	.17	-.04	-.10	-.06	.06	.05	.04	-0.08
P	0.02	-.08	-.05	.00	.16	-.05	-.07	-.05	.05	.01	.05	-0.05
	Winnipeg											
A	0.29	.12	.02	.05	.07	-.03	-.07	-.11	.03	.06	.03	-0.04
P	0.29	.03	-.03	.06	.04	-.08	-.05	-.07	.09	.04	.00	-0.04
	Saskatoon											
A	0.33	.14	.05	.10	.08	-.06	-.09	-.11	.05	.06	.00	-0.05
P	0.33	.04	-.01	.09	.02	-.12	-.05	-.07	.12	.05	-.03	-0.03
	Edmonton											
A	-0.06	.15	-.06	.05	.07	-.04	-.07	-.01	-.02	.05	-.04	-0.01
P	-0.06	.15	-.05	.02	.09	-.05	-.10	.01	.00	.04	-.02	-0.02

Note: Standard errors at low lags are approximately .05. Autocorrelations are given by rows labeled A; partial autocorrelations are given by rows labeled P.

Table 38.2. Estimated Time Series Models

Estimated Equations[a]	Q(12)[b]	r.s.e.[c]
Seven United States Markets Combined		
$(1-0.231B-0.135B^{2}+0.039B^{10})(1-0.121B^{52})U_t = (1+0.088B^{8})(1-B^{52})u_t$ (4.7) (2.8) (-0.8) (2.4) (-1.7)	5.2 (7)[d]	0.036
Toronto		
$(1-0.120B-0.131B^{5})(1-0.253B^{52})T_t = (1-0.037B^{7}+0.138B^{10})(1-B^{52})t_t$ (2.5) (2.7) (4.9) (0.7) (-2.8)	3.9 (7)[d]	0.034
Winnipeg		
$(1-0.239B-0.064B^{2})(1-0.210B^{52})W_t = (1-0.110B^{8})(1-B^{52})w_t$ (4.8) (1.3) (4.4) (2.2)	5.5 (8)[e]	0.031
Saskatoon		
$(1-0.305B-0.124B^{4})(1-0.334B^{52})S_t = (1-0.135B^{8})(1-B^{52})s_t$ (6.6) (2.7) (7.2) (2.8)	6.9 (8)[e]	0.029
Edmonton		
$(1-B)(1-B^{52})E_t = (1-0.036B+0.153B^{2}-0.088B^{3})(1+0.089B^{52})e_t$ (0.7) (-3.2) (1.8) (-2.5)	7.1 (8)[e]	0.043

Where U_t, T_t, W_t, S_t and E_t are past prices and u_t, t_t, w_t, s_t and e_t are lagged random disturbances for seven United States markets combined, Toronto, Winnipeg, Saskatoon and Edmonton respectively.

[a] t values for parameters in parenthesis.

[b] Chi square statistic with degrees of freedom in parenthesis.

[c] Residual standard error.

[d] The critical value at .05 level is 14.1.

[e] The critical value at .05 level is 15.5.

Table 38.3. Estimated Autocorrelations of Residuals Obtained from Estimated Models

Lags											
1	2	3	4	5	6	7	8	9	10	11	12
Seven United States Markets Combined											
0.00	.01	.01	-.03	-.07	-.02	.03	.00	-.05	.01	-.04	0.02
Toronto											
0.01	-.05	-.02	.03	.00	-.01	-.01	-.06	-.01	-.01	.00	-0.05
Winnipeg											
0.00	.00	-.03	.04	.07	.00	-.03	.00	.03	.05	.04	-0.01
Saskatoon											
-0.02	.06	-.01	-.02	.05	-.06	-.02	.00	.05	.06	.01	-0.01
Edmonton											
-0.01	.00	.01	.06	.08	-.04	-.06	.00	-.01	-.04	-.03	-0.01

Note: Standard errors at low lags are approximately .05.