MARKETING OPPORTUNITIES FOR MANITOBA FEEDER CATTLE PRODUCERS

By

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A Thesis
Submitted to the Faculty of Graduate Studies
in Partial Fulfillment of the Requirements
for the Degree of

Master of Science

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A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University of Manitoba in partial fulfillment of the requirements of the degree of

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ABSTRACT

The purpose of this research is to review and compare feeder cattle price recording efforts of auction marts and governmental agencies. The paper also provides three methods to evaluate the relationship of feeder cattle prices within Manitoba and in comparison to Alberta, Ontario and the U.S. This analysis of marketing opportunities for feeder cattle could therefore determine optimal timing of production and provides an evaluation of spatial marketing alternatives.

Price data from January 1994 to May 1998 were summarized from two sources. One source was actual sale sheets from rural Manitoba auction markets. The second data set, compiled from secondary sources, allowed an analysis of more distant markets. A three tiered analytical approach was undertaken for steers and heifers utilizing both sets of data. Seasonality, cointegration / spatial integration, and least significant difference testing were applied to price series. The reason for the three tiered approach was that each of the tests by themselves may not be strong enough to provide reliable results.

Seasonality results revealed that producers who decide to feed cattle to heavier weights need to take seasonal price variation into account more so than producers who sell calves at weaning. Further the results suggest that seasonal price patterns are similar across market regions. This finding is supported by the cointegration results found for Manitoba markets. These findings therefore suggest that in the long run producers would not benefit from evaluating spatial marketing strategies. Further analysis of more distant markets lead to rejection of market efficiency 21% and 43% of the time in steer and heifer

markets. While analysis of the causes behind these market imperfections is beyond the scope of this investigation, the price rankings across market regions do not suggest that transportation cost is the only factor contributing to price differences in regional markets.

Manitoba Agriculture may be advised that the current record keeping methods are satisfactory. Further, results from the mean group rankings across market regions show that a large number of markets are either not separable or rank Manitoba markets as a high paying province. This suggests that producers could be advised to market their cattle at the closest auction mart.

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CHAPTER 1

INTRODUCTION

1.1. Introduction

Chapter 1 outlines the reasons of why a study involving marketing opportunities for Manitoba feeder cattle producers was undertaken. A hypothesis is clearly stated in this chapter and defines the area of analysis. With the hypothesis stated, study objectives are identified and a description of the remaining chapters is given.

1.2. Problem Statement

The purpose of this research is to review and evaluate the relationship of feeder cattle prices across regional cattle markets within Manitoba and in comparison with Alberta, Ontario and the U.S. Changing market and agricultural policy conditions may have lead to further attention being paid to feeding cattle in Manitoba.

Grain prices have become more volatile with the introduction of changing agricultural policy both within Canada, the changes associated with the Western Grain Transportation Act, the termination of transport subsidies for grains, and the United States, the introduction of the Federal Agricultural Improvement and Reform Act allowing for more planting flexibility. In Manitoba another impact is that producers are weighing different options to add value to their grains through further processing. Included in these options is the feeding of cattle to heavier weights. This requires an analysis of marketing opportunities for feeder cattle which would look to determine optimal timing of

production and evaluation of spatial marketing alternatives. In other words, when should calves be produced, bought or sold and which market terminals should be used to sell or buy cattle.

To this end, cattle price series from auction marts within Manitoba will be compared against one another. For example, Figure 1.1 on page 7 shows a comparison of weekly #5-600 steer prices across the four major markets of Brandon, Winnipeg, Grunthal and Ste. Rose. While prices for this weight group may move in a similar fashion, it can not be determined from this graph which market, if any, consistently pays the highest or lowest price. Figure 1.2 shows the steer price relationship across weight categories for the Brandon market alone. While lower weight categories typically sell at higher prices this may not always be the case as shown in 1996 when feed prices were exceptionally high. Farmers interested in feeding cattle may in fact want prices for #50 increments to make better feeding decisions. They may also be happy with #200 categories as long as price gaps between weight categories would provide sufficient information to identify optimal feeding strategies. As outlined below, this analysis attempts to answer some of these questions.

Since a large number of feedlots are located outside of Manitoba, price comparisons will also extend to Alberta, Ontario, and U.S. feeder markets. The analysis will consist of three interrelated testing methods which will include an examination of seasonality, spatial market integration and efforts to rank various market outlets by price across weight categories and gender.

Results of seasonality testing will describe the seasonal price pattern for feeder cattle in Manitoba. Seasonal variations are studied because of an interest primarily centered on price movements. Knowledge of a stable seasonal pattern can help producers adjust production practices so that animals will be ready for sale during high price periods rather than low price periods.

Spatial market integration test results will determine if feeder cattle markets throughout Manitoba; and between Alberta, Manitoba, Ontario, and the U.S. are spatially integrated, that is, do price fluctuations in one market simultaneously carry over to all markets. Overall, it is expected that feeder cattle markets within a close proximity to one another will be spatially integrated and thereby support the law of one price. This is done by examining whether price changes in one market are reflected by similar price changes in other regional markets. These expectations are due to the free movement of livestock between markets and free access to information concerning the market regions in question. What does this mean for marketing practices of the producer? If the law of one price holds, it may be fair to say that on average producers would not be better off by seeking marketing opportunities across market regions as price differentials between markets are merely a function of transaction costs such as transportation costs. For the producer this means transporting market cattle to the closest auction mart, as a search for higher market prices would not yield additional returns in the long run.

Third, statistical tests will be performed to rank various market regions by price to determine if certain market regions can be consistently identified as top paying. In this ranking process a second objective is to identify whether price reporting may be

streamlined by combining price information from #100 weight categories into #200 weight categories without a loss of information to the producer.

Finally, results from these three testing procedures are used in conjunction to determine if producers should look for marketing and production alternatives for their cattle. Since this analysis covers only a relatively short period, January 1994 to May 1998, it is expected that the interrelationship of the results will play a key role. In other words, test results of the various testing procedures need to point to the same conclusion to strengthen the outcome of this research.

1.3. Hypothesis

The null hypothesis for this study is stated as follows:

- There is no difference in feeder cattle prices between markets except for transportation costs, fixed transaction costs and differences in exchange rates.

This hypothesis contends that if markets are not integrated and/or offer different seasonal patterns, then cattle producers may have profitable options to consider in the marketing of animals. Producers may be able to choose between selling their calves at weaning, retaining their calves over the winter months, and/or grazing them for a summer to maximize profits by analyzing prices across regional markets and/or various weight categories. The analysis thus considers the impact of gender, weight, and region on the level of prices paid to producers.

1.4. Specific Study Objectives

This study of feeder cattle markets will provide information on whether market prices for feeder cattle are uniform across markets or if gains may be made by transporting cattle further distances. Results may provide producers with the knowledge of when and where to sell and at what weight the cattle should be sold to maximize profits. Specific objectives are outlined as follows:

Objective #1:

> Analyze seasonality in Manitoba cattle price to determine if seasonality differs across market regions and or weight categories. This should answer whether market prices behave in a similar fashion across regions and are therefore spatially integrated and whether seasonality in prices may lead to changes in the timing of production, especially in light of expected feeding of cattle to heavier weights.

Objective #2:

> Provide marketing suggestions to producers on the basis of long run spatial market integration tests. Do market effects in one region translate to equal effects in other regions or do price series diverge over time and thus offer an opportunity for marketing cattle in more distant market regions?

Objective #3:

> Identify whether market regions can be ranked according to price and thus provide directions for producers to purchase/sell in the lowest/highest paying markets.

Objective #4:

> Provide suggestions for Manitoba Agriculture on what prices to report given their current record keeping activities vis a vis the US reporting system.

1.5. Study Overview

Each of the following chapters in this research describes the process of bringing the previously stated objectives to completion. Chapter 2 provides background information on the sources of price data and the data adjustments that were necessary. Chapter 3 outlines the statistical and mathematical testing procedures involved to arrive at the results and discussion presented in Chapter 4. Chapter 5 summarizes the results found in this research highlighting study implications and giving suggestions for further research.

Figure 1.1. Weekly Price Comparison of #5-600 Steers across Brandon, Grunthal, Ste. Rose and Winnipeg Markets, January 1994 to April 1998.

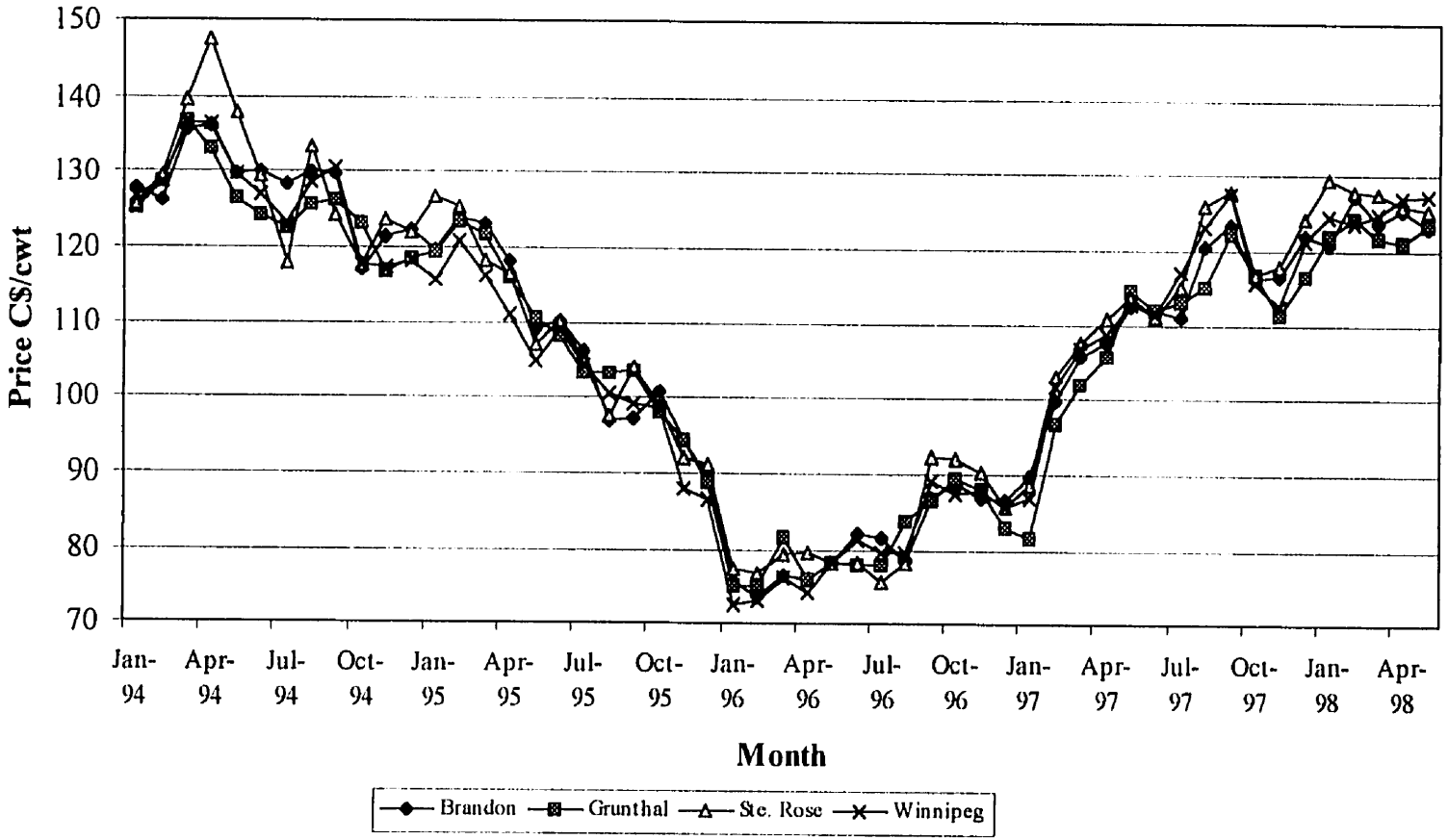
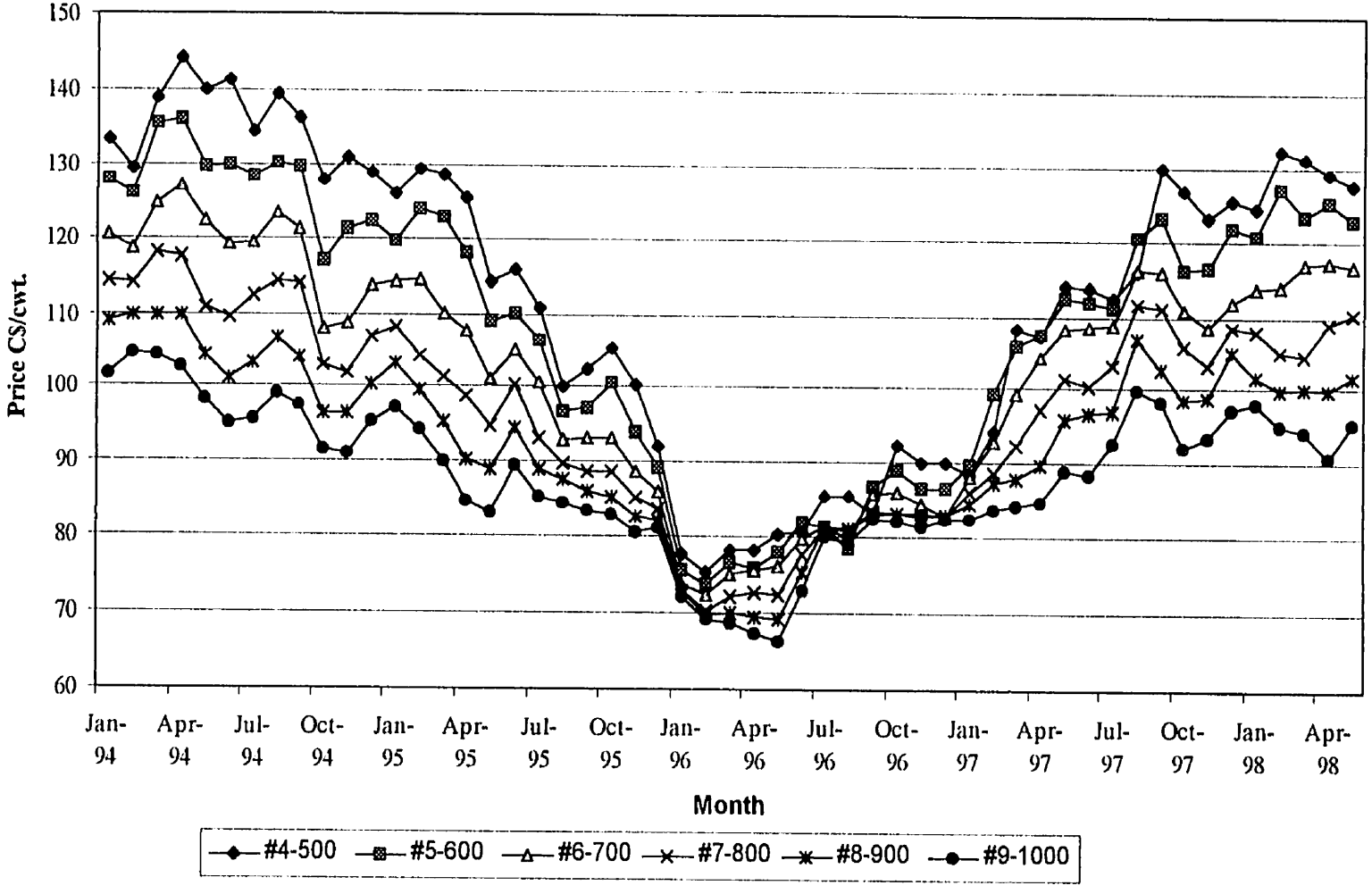


Figure 1.2 Weekly Brandon Steer Price Comparison across #4-500 to #9-1000, January 1994 to April 1998.



CHAPTER 2

DATA

2.1. Introduction

In addition to outlining the source of price information the following section details the adjustments that were made to the data to convert from daily auction mart sale data to monthly price data. The discussion continues with a review of conversions that were made to the monthly data to allow for impartial testing across regions. Among these changes are accounting for the exchange rate in the U.S. data and converting price data into logarithmic price data.

2.2. Data Sources

Price series for #3-400, #4-500, #5-600, #6-700, #7-800, #8-900, #9-1,000, and #1,000+ feeder steers and heifers were entered from sales sheets of rural auction markets in Manitoba that were provided by Manitoba Agriculture (see Appendix A). The sale sheets contain a considerable amount of information for each sale day which would occur anywhere from one to four times per week. In addition to recording high and low prices for feeder heifers and steers, auction marts also report on high and low prices for various groups of slaughter animals -- i.e. heifers, steers, cows and bulls. The quantity of animals sold are listed as separate totals for slaughter and feeder cattle which made quantity weighted average comparisons between weight categories and gender impossible. Price series for each weight category were generated by taking the mid-point of the high and

low price with the assumption that the price distribution would be symmetric in the absence of more detailed information.

As some markets are selling a higher percentage of dairy cattle, which tend to trade at lower prices, it may be argued that it would be better to take the high end of the price range as representative of the top quality beef cattle across all markets whereas a midpoint is representative of all types of cattle. In other words, using the midpoint may introduce bias because of different cattle types sold in the market. A further issue, however, is that the top price may not necessarily go to top quality cattle but cattle that is available in the appropriate quantity (i.e. selling a truck load instead of a single animal or just a few head). Further, some Manitoba markets do not provide the top price but provide instead the most likely or representative price for that trading day. In light of all these factors to consider, the midpoint of given price ranges is a reasonable alternative given that some of the effects mentioned above would cancel each other out in a large data set. Using the midpoint or average price is also a common practice used by Manitoba Agriculture and Agriculture Canada.

The Manitoba price data from January 1994 through May 1998 contained a total of 11,268 observations. To simplify analysis simple weekly and monthly averages were taken of the observations, thereby giving 9,378 weekly and 1,381 monthly observations for Brandon, Grunthal, Ste. Rose, and Winnipeg markets resulting in 46 complete price series for feeder steer and heifers across various weight categories.

Monthly data for the Alberta, Manitoba, and Ontario markets was obtained from Canfax in Calgary, Alberta with complete data series on prices for #3-400 to #8-900

heifers and #4-500 to #9-1,000 steers. Daily data for the greater Wyoming market area was obtained from the Livestock Marketing Information Center in Lakewood, Colorado. 4,144 weekly observations in #50 increments were condensed into 477 monthly observations by taking simple monthly averages. These monthly prices were then converted to Canadian dollars from exchange rates obtained from the Canfax Website. The final transformation of the monthly data was to convert it into logarithmic form for reasons discussed in *Section 3.3.2*.

2.3. Data Issues

The starting date of 1994 was used as consistent data across weight categories and markets were only available from that date forward. Further, market intervention in the form of tripartite payments effect data prior to 1994 making analysis across market regions difficult.

Market regions were also chosen on the basis of data availability and market access. Deciding what areas to compare was based on the ability to find consistent data for as many years as possible. In addition, markets had to be close enough so that producers would consider them given the incentive.

The ability to chose markets based on price received is important for producers. The added costs of shipping and loss of weight that occurs during longer hauls needs to be less than or equal to the profit gained from shipment before a profit maximizing producer will consider shipping animals to distant markets. Table 2.1 shows the mileage a producer would be willing to travel if offered an extra dollar per hundred weight. The table

illustrates that the number of cattle per load is dependent on the weight of animals. The total value increase per dollar per hundred weight is calculated by the number of animals per load, multiplied by the weight divided by 100. This value divided by the total variable cost of hauling per mile provides the marginal increase in distance a producer is willing to travel if offered an additional dollar per hundredweight. For example, if a producer were to look at hauling cattle where the average weight was #650, the calculation would use the number of cattle hauled at that weight, 14, multiplied by 650 divided by 100. This works out to the producer receiving an extra $91.00 for this load of cattle. Taking this value and dividing by the total variable cost of $1.17 per load per mile, traveled back and forth, indicates that the producer would haul within a radius of 78 km for the gain. Comparing this to the actual kilometers between markets in Table 2.2, we can see the only reasonable trade off would be between Winnipeg and Grunthal. The distance between markets and the price being offered for cattle in the other markets does not justify the added transportation costs of hauling to the Ste. Rose or Brandon markets for the price difference of one dollar per hundred weight.

Table 2.1 Impact of Price Change on Market Radius.

Assumptions: Truck charges $0.70/km return, with a driver charge of $12.00/hr traveling at an average speed of 80km/hr which amounts to $0.30/km return. Trailer charge @ 25% of truck charge or $0.17/km return for a total variable cost of $1.17/km return. A 7'x20' gooseneck cattle trailer is assumed.			
# of Animals per Load	**Average Weight of Animal**	**Total Value Increase per $/cwt Increase in Price**	**Change in Market Radius in km**
18	#450	$81.00	69
16	#550	$88.00	75
14	#650	$91.00	78
12	#750	$90.00	77
10	#850	$85.00	73
8	#950	$76.00	65

Table 2.2 Mileage Between Markets (in km).

	Brandon	**Grunthal**	**Ste. Rose**	**Winnipeg**
Brandon				
Grunthal	277			
Ste. Rose	165	338		
Winnipeg	214	62	275	

Markets chosen for Manitoba were based foremost on whether or not a complete data series could be obtained. The markets chosen all had substantial cattle sale volumes and are all located central to prominent cattle producing areas within Manitoba. The total quantity of feeder cattle marketed during the 53 month period under review was 1,879,055 head. The Brandon market received 20% of the total quantity of feeder cattle

marketed in the province, Winnipeg marketed 17%, Ste Rose 11%, and Grunthal 7%. These markets thus represented 55% of the feeder cattle marketed during this period. This makes this analysis reasonably representative of conditions within Manitoba.

The price series for feeder cattle had fifty six missing observations, which accounted for about 4% of the total data points for the Manitoba market. Since unknown variables found in a steady state series, without disturbances, are able to take on the same values as the previous variable ($P_t = P_{t-1}$), unrecorded consecutive observations of three or less were given a value equal to the preceding price (Griffiths, Hill and Judge, 1993). Series with more than three consecutive missing observations were considered insufficient and omitted from further analysis. This lead to the loss of the #3-400, and #1,000+ weight categories for both heifers and steers in all markets as well as the #9-1,000 category for the Grunthal market.

To meet the above criteria of availability and market access, feeder cattle price series representative of Eastern Wyoming and Western Nebraska were chosen as a U.S. market outlet. The weight increments recorded for the U.S. cattle auction marts are in #50 increments. To allow for comparison and testing to be done with Canadian markets, these weight categories were combined into #100 increments by averaging the #50 weight categories in the #100 category. Even though the U.S. market had 28% of its price series missing, it provided the best records of the two U.S. markets considered (Wyoming/Eastern Nebraska and Iowa/Southern Minnesota/Southeastern South Dakota and Western Nebraska).

Important information was missing in the form of price gaps from markets used for

this study. For the most part gaps appeared around major holidays when auction markets would be closed. The reasoning behind other missing information is not clear. It is plausible that the person responsible for recording transactions was absent. Also, during summer months, cattle are on pasture and perhaps cattle numbers offered for sale were low or nonexistent in certain weight categories making the price received an unreasonable representation of market conditions.

Breaking the model estimation up into short periods to account for gaps would not have avoided the problem for all markets. It also would have resulted in models using small data samples, thereby limiting the choice of statistical procedures and compromising the value of the results.

2.4. Conclusions

Data were summarized from two sources. One source was actual sale sheets from rural Manitoba auction markets. This data set had very few missing observations and should aid in the analysis of answering questions as they pertain to marketing within Manitoba. A second data set was compiled from secondary sources. The U.S. data had more missing observations but provided quantity weighted average prices. This second data set will be used to make comparison across further distances as producers may wish to market inter-provincially or internationally.

If possible, it would have been nice to gather more data and to calculate quantity weighted averages for the Canadian data. Implications of differences in cattle quality (beef

vs. dairy) and non-normal distributions in cattle prices in each of the weight and gender categories are thus not testable and present an issue for further research.

CHAPTER 3

METHODOLOGY

3.1. Introduction

Cattle producers are interested to know if they are maximizing profits at their current selling time and or market location. For example, comparisons of prices at different times of the year are necessary to show when sales may be maximized and if differences in cattle weights or market regions lead to different seasonal price peaks and troughs. Answers to these questions would provide producers with information on when to sell or hold cattle and/or whether profitable opportunities exist to ship cattle to different markets.

A three tiered analytical approach is provided in this paper. First, graphical representations of the variation in seasonal indices indicate whether a change in production practices will be profitable and to what extent prices differ across the marketing year in each of the Manitoba market regions analyzed. Second, cointegration testing is performed to examine whether long-run pricing differences exist across all market regions to see if ranchers need to evaluate if market pricing differs sufficiently to make transportation cost and risk in transport a feasible option. Finally, least significant difference tests allow for a price ranking of market regions across all weight and gender categories in order to identify the highest/lowest paying markets.

The reason for the three tiered approach is that each of the tests by themselves may not be strong enough to provide reliable results. If results would point in the same

direction for all the tests, however, the analysis would provide valuable and reliable information for producers. These three analysis techniques are presented in turn in the following sections.

3.2. Seasonality

Seasonality is the component of price movement that occurs within a year. Seasonal variation in cattle prices is often related to climate patterns and associated production practices as well as consumer tastes and preferences reflected in changing demand for various types of cattle by feedlots and beef packing plants (Goodwin, 1994) .

To capture seasonality, economists often calculate a seasonal index which captures monthly deviations from the annual average price[1]. A stable seasonal pattern is one where the peaks and troughs generally occur in the same months of the year. Given several years of monthly price data, a seasonal index value can be calculated for each month as follows

$$\text{Seasonal Index}_{\text{Month}} = \frac{\text{Monthly Price}}{\text{Average Annual Price}} \qquad (3.1)$$

Index values for the same month may then be averaged across years to remove the irregular component of price movements (Hamburg, 1983). An index value of 1 implies that the monthly price is equal to the average annual price, values below 1 indicate a monthly price that is weak relative to the annual price and values above 1 show a monthly

[1] A monthly seasonal index was chosen as the daily variation in prices within months was less on average than the monthly variation in prices within a year. For Brandon #5-600 steers the within month and within year price variance from 1994 to 1998 was $9.39/cwt and $70.73/cwt, respectively. In other words, monthly deviations from the average annual price are much larger than daily price deviations from the average monthly price.

price that is strong relative to the annual price. The seasonal index thus shows relative price strengths / weaknesses across a marketing year. It provides a signal for a producer to sell when index values are above one and to buy when index values are below one.

To compute a seasonal index, a 12-month moving average is often used as the annual average price as it accounts for trend and cyclical components in the price data (Hamburg, 1983). By comparison a simple annual average price, calculated by averaging January through December prices, may introduce biases across years as trends are not taken into account (Goodwin, 1994).

Given the cyclical nature of cattle prices, price trends are expected in the data and therefore the method of calculating a 12-month moving average annual price is chosen even in light of the following two caveats noted with this procedure. One, a 12-month moving average lags behind turning points, and two, the seasonal index series is truncated by six observations at both the beginning and end of the price series. For example, in Excel, if the data started in cell B9 (January) the seasonal index cannot be calculated until cell C15 (July), as the formula would be 0.5*B9+sum(B10:B20)+0.5*B21.

The difference between the highest and lowest monthly seasonal index value or the band width on a seasonal index chart indicates whether or not a change in production practice may be profitable. A range or bandwidth of 20% of annual average price between low and high price months for example would provide a stronger signal to producers to change their timing of production to have cattle available for sale in the high price month than a range of 2%. What is of interest here is whether this range of seasonal indices changes across weight categories and how large that range is. For example, a five percent

range for a #4-500 steer seasonal index with an average price of $1.05 per pound would lead to a range of revenue of nearly $24 per head. At the same time, a five percent range for a #8-900 steer seasonal index with an average price of $0.90 per pound would lead to a range of revenue of approximately $38 per head. While a complete analysis of additional costs and revenues is beyond the scope of this thesis, at least background information on the revenue side of this production timing decision will be shown.

3.3. Spatial Market Integration or Cointegration Tests

Modeling of time series data can identify whether the stochastic process that generated the data varies with time. For example, performing co-integration tests on cattle prices provides a framework to consider long run price relationships among cattle markets. Weekly and monthly prices tend to be highly variable and often possess significant trends, which suggests the potential for nonstationarity or non-mean reverting behavior in the long run (Gujarati, 1995). Simple correlations and regressions across prices in different market areas which are required to test for market efficiency may therefore be biased as common trends in the price series may lead to spurious regression results.

Cointegration tests have been designed with this phenomenon in mind. They can be used to check for a long-run equilibrium relationship among spatially separated markets by testing for co-movement in the price data. In other words, do disturbances that occur in one market region translate to equal effects in other regions or do the price series diverge over time? The perception is that economic forces should prohibit persistent long-

run deviations from equilibrium conditions, even though short run disturbances may occur[2]. For example, under the LOOP, two price series are expected to move together in the long run differing only by fixed transaction costs such as transportation costs. Therefore, even though individual market prices may vary extensively on their own, when paired, they should not diverge from one another in the long run.

Cointegration tests such as those found in Goodwin and Schroeder (1991) and Ardeni (1989) appeal to this logic and are thus used to test for the LOOP as a long-run relationship. Cointegration procedures work on the basis that deviations from equilibrium conditions for two economic variables can be tested by checking on the stationarity of the residual term that is obtained through a linear combination of the two data series that are integrated of the *same* order and may or may not be stationary by themselves. Testing for spatial market linkage thus requires a two-step procedure: 1) run individual tests on each of the price series to check on their order of integration; and 2) check the stationarity of the residuals obtained by regressing the two series against each other.

3.3.1. Testing for Stationarity

A stationary time series is one whose basic properties don't change over time, while non-stationary variables have some sort of upward or downward trend. A stationary time series therefore must satisfy the following three criteria:

- mean of X_t constant over time

[2] In this analysis the short run is a period less than one year as breeding decisions and therefore timing of production decisions are made on an annual basis. Long run may thus be defined as any period longer than one year.

- variance of X_t constant over time
- simple correlation coefficient between X_t and X_{t-k} (autocorrelation function) depends on length of the lag (k) but on no other variable (for all k). (Studenmund, 1997)

Testing for stationarity may be done simply by looking at a graphical representation of the series or by utilizing more complex computational methods that involve the autocorrelation function (ACF) or Augmented Dickey Fuller tests (ADF). Other tests include the standard Durbin-Watson test statistic from the first-stage OLS estimate and the estimation of a vector error correction model to test for cointegration as in Goodwin and Schroeder (1991).

The autocorrelation function of lag k, is achieved by computing a simple correlation coefficient between X_t and X_{t-k}, over n-k such pairs in the data set of n observations (Studenmund, 1997).

$$ACF(k) = \frac{\sum \left(X_t - \overline{X}\right)\left(X_{t-k} - \overline{X}\right)}{\sum \left(X_t - \overline{X}\right)^2} \qquad (3.2)$$

If ACF values tend toward zero quickly as k increases the variable is said to be stationary (Studenmund, 1997).

The Augmented Dickey Fuller test (ADF) uses the hypothesis that the variable in question has a unit root or is nonstationary. Estimating:

$$\Delta Y_t = (Y_t - Y_{t-1}) = B_0 + B_1 Y_{t-1} + B_2 t + \epsilon_t \qquad (3.3)$$

where t is a time trend variable, Y is the data series in question and ϵ is an error term.

Now the null hypothesis of non-stationarity or the existence of a unit root can be tested with a special t-test on the B_1 coefficient as follows (Studenmund, 1997):

$$H_0: \quad B_1 = 0$$

$$H_A: \quad B_1 < 0$$

If the estimated B_1 coefficient is less than zero, that is the estimated t-statistic is greater than the critical value, the null hypothesis of non-stationarity is rejected and it can be concluded that the series is stationary. Note that McKinnon critical t-values differ from normal statistical t-values in that they tend to be about 60% higher (Studenmund, 1997). Enders (1995) notes that in checking for stationarity a person should start with the least restrictive model assumption that includes both a constant term (B_0 in equation 3.3) for drift in the series and a time trend variable (B_2t in equation 3.3) for a trend component. Also, as the ADF test has weak power in rejecting the null-hypothesis of non-stationarity, further testing with alternative models is not necessary if the least restrictive model is able to reject the null hypothesis.

Finally, if $B_1 = 1$ then, the variable has a unit root, and Y_t is a random walk process where ΔY_t is drawn from a stationary distribution with mean zero (Studenmund, 1997). Differencing the data therefore usually makes a series with a unit root stationary. This is important, as series may have to be differenced several times before they become stationary. Series that need to be differenced once to become stationary are referred to as integrated of order one. Similarly, series that have to be differenced *n* times to become stationary are integrated of order *n*. Testing for order of integration of the

initial price data is necessary to identify whether series are integrated of the same order and ultimately to test for the LOOP.

For this study the Augmented Dickey Fuller test was used to run order of integration tests on the original price series (recall that series to be regressed against each other have to be integrated of the same order in order for the residual term to be stationary) and also to test the residual series for stationarity. The tests were performed using EVIEWS econometric software where adjusted McKinnon critical t-values are available.

3.3.2. Dealing with Nonstationarity

Initial ADF tests revealed that all price series to be evaluated were nonstationary and integrated of order one (see Appendix B). Since all price series were integrated of the same order they could be regressed against each other to see if they were co-integrated (moving together in parallel fashion in the long run so as to indicate that differences in prices were simply a function of transactions costs). Linear combinations of two price series (P^1 and P^2) would produce a residual series ϵ_t that could be tested for stationarity using the ADF test shown in equation 3.3 in order to test for the LOOP:

$$P^1_t - \alpha - B\, P^2_t = \epsilon_t \qquad (3.4)$$

If the residual series, ϵ, is stationary then P^1 and P^2 are said to be cointegrated, having a cointegrating parameter B. With P^1 and P^2 co-integrated, ordinary least squares estimation of equation 3.4 describes the long run, steady state equilibrium relationship between P^1 and P^2 in a spatially integrated market (Ardeni, 1989) -- i.e., the markets are

efficient and do not offer opportunities for producers to take advantage of marketing their cattle in different markets in the long run.

As no causation in price movements between two markets is implied, cointegration tests for the relationship between two markets involved the following two regressions,

$$P^1_t = a_0 + B_I P^2_t + \epsilon_t \qquad (3.5)$$

$$P^2_t = a_0 + B_{II} P^1_t + \mu_t \qquad (3.6)$$

Where P^1 and P^2 are first differenced, logarithmic market prices from two regional markets with residual terms ϵ_t and μ_t. The price series are transformed to their natural logarithm in order to obtain coefficient estimates ($B_{I/II}$) that are elasticities and to account for overly erratic price movements. If the cointegration test shows rejection of the null hypothesis in one specification but not the other, markets are assumed to be efficient as ADF tests have weak power to reject market inefficiency.

To this point the discussion has centered around long run market equilibrium or spatial integration. Examination of short run deviations from the LOOP, as demonstrated by Ravallion, were not tested in this paper as short run deviations from market equilibrium are expected to offset each other in the long run. In other words, producers not completely aware of short run market imperfections would be no worse off in the long run as they would experience both short run gains and losses that would offset each other. Only if long-run market imperfections persist would producers become interested in analyzing regional markets for improved profitability.

3.4. Ranking Markets and Weight Categories by Price Level

The interest of ranking markets from the producer perspective, is to have a reliable estimate of the gains that may be realized by selling to alternative markets. While the analysis provided in Table 2.1 shows that relatively minor price differences can make alternative markets attractive to producers within Manitoba, the question remains which markets consistently show such differences to producers to make further transport worthwhile. From an industry perspective it enables auction marts to comprehend where they stand in terms of competitive pricing for their customers.

A second objective for this type of ranking, albeit this time not across markets but weight categories instead, is to see if sufficient price differences exist across #100 weight categories to maintain data series to that detail. For example, if a #4-600[3] price is similar enough to the #4-500 and #5-600 price, then price reporting standards may be lowered without a loss of information. Price rankings across weight categories thus can be used to review whether or not the data keeping methods of auction marts and Manitoba Agriculture are sufficient to capture important pricing information across weight categories.

The following section details the use of ANOVA and least significant difference (LSD) testing to allow for appropriate price rankings to be made. ANOVA tests are used to identify whether means differ across market regions as well as weight and gender

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[3] The #200 price series is calculated by taking the mid-point of the higher of the price highs and the lower of the price lows of each of the adjoining #100 price series. For example, if the high of the #4-500 price was $1.35 and the high of the #5-600 price was $1.37, the latter price high would be used for the #4-600 price series.

categories over time. These tests are performed prior to running multiple pair-wise comparisons of price series that show whether prices in various subgroups are statistically significantly different from one another and therefore may be ranked.

3.4.1. Analysis of Variance Testing

Analysis of Variance (ANOVA) is used here to compare whether sample means are statistically significantly different from one another by comparing the within sample variation to the between sample variation (Ott, 1988). By assuming that data sets are normally distributed, with means given by $\mu_1, \mu_2 \ldots . \mu_t$, and a common variance σ^2,

$$S^2w = \frac{(n_1 - 1)s_1{}^2 + \ldots\ldots\ldots + (n_t - 1)s_t{}^2}{(n_1 - 1) + \ldots\ldots\ldots + (n_t - 1)} \qquad (3.7)$$

equation 3.7 represents the within sample variance or an estimate of the common variance σ^2, where $n_{1 \ldots t}$ and $s_{1 \ldots t}$ are the sample size and variance of each of the t subgroups (Ott, 1988). The common variance, σ^2, describes the variability of observations *within* all data points.

Another quantity measuring the variability between means is also needed and is calculated as follows (Ott, 1988):

$$S_B^2 = \frac{\sum \left(\overline{Y}_i - \frac{\sum \overline{Y}_i}{n} \right)^2}{n-1} \cdot n \qquad (3.8)$$

Where $\overline{Y}_i$ are the means of the various sub categories, and n is the sample size. The test

statistic used to test the equality of population means is $F = \frac{S_B^2}{S_W^2}$. If the F statistic assumes a value near one, the null hypothesis cannot be rejected and

$\mu_1 = \mu_2 = \ldots\ldots = \mu_t$ (Ott,1988).

These tests are performed to test whether prices differ across weight classes and market regions over time. Statistically significant differences across time allow the use of multiple pair-wise comparisons to be made across market region or weight class to determine which subcategories of prices are statistically significantly different and therefore rankable. This ranking procedure is detailed in the next section.

3.4.2. Pair-wise Comparison of Means

A comparison of price means can be performed using an ANOVA F test, which indicates whether means are significantly different from one another. A process called multiple comparison methods will be used to analyze mean differences. Multiple comparison tests refer to methods that test one comparison among three or more means. This process provides more detailed information about the differences in means than in a standard pair-wise comparison.

The most straightforward manner to test multiple comparisons is to do a t-test on each set of means. Following SAS, for the *i*th and *j*th means you can reject the null hypothesis that the population means are equal if:

$$\left|\overline{y_i} - \overline{y_j}\right| / s\sqrt{1/n_i + 1/n_j} \geq t(\alpha; \nu) \qquad (3.9)$$

Where y_i and y_j are the means, n_i and n_j are the number of observations in each of the cells, s is the root mean square error based on v degrees of freedom, α is the significance level, and $t(\alpha;v)$ is the two-tailed critical value from the t-distribution. If sample sizes are equal, then the above equation can be rewritten as:

$$\left|\overline{y_i} - \overline{y_j}\right| \geq t(\alpha; v)s\sqrt{2/n} \qquad (3.10)$$

where the value of the right hand side is Fisher's least significant difference (LSD).

The Least Significant Difference (LSD) test procedure in SAS is used as a control-wise error rate and provides price rankings across various subcategories after performing multiple pair wise comparisons of prices deemed appropriate only after the F-test has shown significant differences over time. The LSD is defined as the observed difference between two sample means necessary to declare corresponding population means different (Ott, 1988). By comparing specified means of the same months throughout the time frame of the study, the results will show if there is a statistical difference between market regions or weight classes and if mean group rankings may be established. For a specified value of alpha, the least significant difference for comparing sample means is

$$LSD = t_{\frac{\alpha}{2}}\sqrt{\frac{2s_w^{\,2}}{n}} \qquad (3.11)$$

where $t_{\frac{\alpha}{2}}$ is the critical value at a significance level of α set at 5 %. If subcategory means of prices ($\overline{Y_i}$) differ by more than the LSD value calculated in 3.11 it maybe concluded that 95% of the time it would be correct to state that these means differ and

therefore are rankable. Thus, when $\overline{Y_i} - \overline{Y_j} >$ LSD for i≠j, the mean price difference is significant and a ranking order can be established.

Following SAS (1982), in testing more than three means one must distinguish between the experiment-wise error rate under the complete null hypothesis, in which all population means are equal, and the experiment-wise error rate under a partial null hypothesis, in which some means are equal but others differ. A preliminary F test controls the experiment-wise error rate under the complete null hypothesis (EERC) but not the experiment-wise error rate under a partial null hypothesis (EERP) or under the maximum experiment-wise error rate under any complete or partial null hypothesis (MEER). By setting the comparison-wise error rate (CER) to a sufficiently small value, the MEER can be controlled at the α level. The Bonferroni inequality has been used in many studies for this control, and follows as:

$$CER = \alpha / c \qquad (3.12)$$

where c is the number of comparisons, and the MEER is less than α. The use of a Bonferroni t-test with the option of MEER < α declares two means to be significantly different if :

$$\left|\overline{y_i} - \overline{y_j}\right| / s\sqrt{1/n_i + 1/n_j} \geq t(\varepsilon; \nu) \qquad (3.13)$$

where ϵ=α/(k(k-1)/2) for the comparison of k means. If there is an equality in the sample size, then this test can be reduced to:

$$\left|\overline{y_i} - \overline{y_j}\right| \geq t(\varepsilon, \nu) s\sqrt{2/n} \qquad (3.14)$$

3.4.3. Conclusions on Price Rankings

Both ANOVA, minimum significant difference (MSD) and LSD tests will be performed on the price series which are taken over time and grouped by market region and weight class. Price rankings can then be established across various markets within each weight and gender class of feeder cattle to satisfy the objective of ranking various markets. To test for the efficiency of price information in #100 increments, new #200 price series are generated and tested for LSD in Brandon and Winnipeg markets for both steers and heifers. Sub group rankings will therefore reveal if certain markets (defined by sex and location) offer consistently higher prices when compared to other markets and whether prices may be grouped into #200 categories.

3.5. Methodology Summary

In summary, this chapter outlines three methods of analysis that are used to review differences in prices and pricing efficiency in spatially separated feeder cattle markets. Seasonality testing enables us to identify whether differences exist between auction marts and weight ranges. The Augmented Dickey Fuller tests permit the testing of stationarity of price and residual series required to draw conclusions about whether the law of one price holds in the long run. Finally, analysis of variance and mean group rankings through the establishment of least significant differences, and minimum significant differences allow ranking of market regions and weight classes by price.

Reviewing of results across these interrelated analysis techniques should lead to concurrent justification of market efficiency conclusions and marketing suggestions for producers. For example, if markets are considered co-integrated (the law of one price holds and prices are expected to move in a parallel fashion), they should also exhibit similar seasonal price variation across market regions. Finally, price rankings should be possible if markets are efficient, as the LSD, MSD and BonFerroni procedures utilize multiple pair-wise comparison techniques -- i.e. differences in market prices across regions are tested at the same point in time and thus transactions costs should provide for stable differences across market regions. However, markets could also be co-integrated and not rankable if price differences between markets are very small. Finally, the reverse does not hold. Markets that are separable/not separable in means do not have to be efficient/inefficient. The ranking process thus may confirm cointegration results but cointegration tests cannot confirm the ranking process. Given these limitations, LSD and MSD results will only be used to identify market rankings for producers and to test the efficiency of the current price reporting procedures.

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Introduction

This chapter presents the results obtained from the data analysis of feeder cattle prices. The first section covers the analysis of seasonality in feeder cattle prices. The second looks at the analysis of spatial market integration. Finally, the third and fourth sections cover the rankings of markets and weight categories found through least significance difference testing. The concluding section summarizes the findings by discussing the interrelationship of all the test results.

The following notation is used throughout this chapter. All price series are identified with two letters and two or three numbers. The first letter denotes the market location or region (B = Brandon, G = Grunthal, R = Ste. Rose, W = Winnipeg, A = Alberta, M = Manitoba, O = Ontario and U.S. = U.S. market -- greater Wyoming region). The second letter identifies the gender of the cattle (H = heifer, S = steer). Finally, the weight classes are represented by the last two digits (34 = #3-400, 45 = #4-500, 56 = #5-600, 67 = #6-700, 78 = #7-800, 89 = #8-900, and 910 = #9-1000).

4.2. Analysis of Seasonality in Manitoba Feeder Cattle Prices

Seasonality Tables C.1 through C.8 in Appendix C show the seasonal index values for feeder steers and heifers for Brandon, Grunthal, Ste. Rose and Winnipeg terminal markets using monthly price data from January 1994 to May 1998. The index values are

presented for each weight category for each marketing month in the year. A calculated value of one/less than one/more than one indicates that the price in that month is equal to/less than/more than the annual average price. The last column in each table describes the range of seasonal index values that were observed across the marketing year. Recall that the range in seasonal index values provides a proxy for the profitability of a change in the timing of production. A large range implies a greater justification for change and, ceteris paribus, the same range in seasonal index values represents a larger impact on sales per head in heavier weight categories than lighter weight categories.

Tables C.1 through C.4 show the results for feeder steers. All markets show the same trend of a larger range in the lighter and heavier weight categories and a smaller range of index values for the middle weights. This may be an important signal for backgrounding operations that feed calves to heavier weights in particular. First, a relatively large range indicates that timing of production is important and second, the sales impact per head is much larger for the heavier cattle. Compared to cow/calf operations that would sell their calves at weaning, backgrounding operations would therefore be advised to pay more attention to the timing of their production. For example, the heavier weight animals tend to have price peaks earlier than the lighter weight categories (August vs. September or October).

In the heifer market, portrayed in Tables C.5 through C.8, the trend is not as strong as range values do not change much across weight categories. Large and small ranges of index values are apparent in all weight categories. Price peaks in these markets tend to occur in August and September across all weight categories.

To compare seasonality across market regions, index values from Tables C.1 through C.8 are also presented in graphical form in Appendix D. Figures D.1 through D.12 show differences in seasonality across market regions by cattle gender and for each weight category. From visual inspection of figures D.1 through D.12, there does not appear to be a great deal of variation between markets. Price patterns show similar seasonal deviations in all markets for the same weight categories. With that result in mind, prices across markets are expected to behave according to the LOOP – i.e. prices are expected to be cointegrated.

4.3. Analysis of Spatial Market Integration

Goodwin and Schroeder (1991) and Ardeni (1989) show that spatial price behavior in regional cattle markets is an important indicator of overall market performance. Markets not integrated may convey inaccurate price information that may distort producer marketing decisions and contribute to inefficient product movements. As discussed in chapter 3, performing cointegration tests on the data has provided a framework to consider long run price relationships among cattle markets. Two sets of price data were analyzed in this section. The first set undertook the analysis of four markets within Manitoba, while the second set included markets further removed from one another.

4.3.1. Spatial Integration in Manitoba Markets

Regional cattle markets for steers and heifers were compared with one another in the same weight division across each market and across weight categories in each market. This lead to a total of 132 regressions of the type indicated in equations 3.5 and 3.6 where each comparison across two markets is conducted under two specifications with market designation reversed between dependent and independent variables. Residuals from these regression equations were then tested for stationarity to identify whether the LOOP holds in the long run. Since all Manitoba cattle price series proved to be integrated of order 1, (see Appendix Table B.1) they could be regressed against each other with the expectation of a stationary residual series. Coefficient estimates of the cointegrating parameters $B_{I/II}$ as in equations 3.5 and 3.6, associated standard errors as well as the t-stat on the residual stationarity tests are shown for each set of market comparisons. In addition, R^2 values which were nearly identical across specifications[4] and market efficiency conclusions are presented in the last two columns of Tables E.1 and E.2 for Manitoba steer and heifer markets. For example, testing of Brandon and Grunthal #4-500 steer markets lead to cointegrating parameter estimates of 0.97 and 0.99 indicating that a one percent change in prices in either market was reflected in the other market. Price movements in one market explained 96% of price changes in the other market and the residual series was considered stationary as both t-stats were above the 3.5 Dickey Fuller critical value. These two markets were thus judged to uphold the LOOP.

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[4] R^2 values are nearly identical as they are similar to partial correlation coefficients except for the constant term.

In summary, all but five combinations lead to stationary residual terms and therefore it may be concluded that the LOOP holds or that the Manitoba markets were spatially integrated from 1994 to 1998. While only five pairs of residuals were nonstationary across all sixty six paired comparison for steers and heifers these observations all occurred in relation with the Grunthal market. Further investigation of this phenomenon was not undertaken but may be worthwhile. Reasoning may lie in the fact that the Winnipeg and Grunthal markets are only 62 km apart and therefore non-competitive pricing schemes may be used to attract market cattle.

While the test results indicate support for the hypothesis that spatial integration exists in regional Manitoba steer and heifer markets, they also show that the estimates of cointegration parameters are consistent. The fluctuations of cointegrating parameters around unity, ranging from a low of 0.82 to a high of 1.12, adds further credence to the spatial integration hypothesis as similar percentage price changes across markets are evident.

4.3.2. Alberta, Manitoba, Ontario, and the U.S.

An equivalent analysis was undertaken for the provinces of Alberta, Manitoba, Ontario, and the U.S.. This comparison was conducted to determine whether or not prices diverge between further removed markets and thus possibly offer marketing opportunities. Provincial and state cattle markets for steers and heifers were tested for stationarity. With the price series integrated of order 1, (see Appendix Table B.2) the series were then regressed against each other using equations 3.5 and 3.6 with the

expectation of stationary residual series. Again, cointegrating parameters ($B_{I/II}$), standard errors, residual t-statistics, R^2, and market efficiency statistics are recorded in Appendix Tables E.3 and E.4 for steers and heifers, respectively.

Residual testing lead to the conclusion that not all markets were spatial integrated over the period of analysis. Review of the cointegrating parameters and t-values for steers and heifers across the four markets showed that market imperfections or non-stationary residual terms existed for:

- #4-500 and #6-700 Ontario / United States steer markets,
- #4-500, #5-600 and #6-700 Alberta / United States steer markets,
- #6-700 and #8-900 Ontario / Alberta steer markets,
- #4-500, #5-600 and #6-700 Manitoba / United States heifer markets,
- #4-500, #5-600 and #7-800 Alberta / United States heifer markets,
- #5-600, #6-700 and #8-900 Manitoba / Ontario heifer markets,
- #6-700, #7-800 and #8-900 Ontario / Alberta heifer markets,
- #6-700 Ontario / United States heifer markets.

Approximately 21% of the steer market combinations and 43% of the heifer market combinations proved to be non-stationary. The larger proportion of market inefficiency in heifer markets may be a function of heifer prices being influenced by changes in breeding herd populations which vary across regions. Also changes in agricultural policy such as the phase-out of grain transport subsidies through the WGTA may affect prairie provinces differently than Ontario or U.S. markets. The results also show that further distances between markets may lead to market imperfections that may

be attributable to a lack of or costly access to information across markets. For example, observations on market combinations between Manitoba and Alberta show no market imperfections. This is the only combination that holds true throughout the analysis and is an expected result as the two markets are the closest to one another among this set of markets. On the other hand, combinations including Ontario and U.S. markets do show some market imperfections. In the Ontario case slow roads and high provincial trucking fees may keep the Ontario market separate from the Western provinces. The reduced speed limit and road conditions through Ontario may mean stock will be in transport for a greater length of time than if transporting across the prairies. The increased time on the trailer sums up to a loss in revenue as the cattle will have weight loss and an increased chance of health problems on the way. Ontario too, may be influenced more by cattle pricing related to feedlots in the Central and Eastern U.S. market regions. For the U.S. market it may be contended that market imperfections across Canadian and U.S. markets may be a function of data inconsistency as price series are simple averages and quantity weighted averages, respectively. Agricultural policy changes may also lead to market disequilibrium..

The fluctuations of cointegrating parameters around unity, have a much larger range, from a low of 0.47 to a high of 1.37 than the range of values observed in the more integrated Manitoba markets. This adds further credibility to dismissing the LOOP for a larger percentage of market combinations.

4.4. Market Rankings by Price Levels across Market Regions

ANOVA analyses and LSD tests were performed on steer and heifer price data from January 1994 to May 1998. Two sets of data, one for price data within Manitoba, and one for price data from Alberta, Manitoba, Ontario and the U.S. are represented in this section.

4.4.1. Rankings within Manitoba

As outlined in chapter 3, ANOVA analyses and LSD tests were performed to identify whether cattle producers in Manitoba could be advised to look into marketing alternatives for their cattle (i.e. identifying and shipping to the highest paying market). In order to do this, ANOVA models were run to evaluate which variables significantly influenced the dependent variable. Monthly feeder steer and heifer prices (PFC) in various market regions and across various weight categories were regressed against sale month (m) and market region (l):

$$PFC = f(m, l) \qquad (4.1)$$

Since there are six different weight categories for both heifers and steers, twelve models analyzed the effect of the same two independent variables, market location (l) and month (m), on the dependent variables. A statistically significant impact of the month of sales justifies the use of a multiple paired comparison in the LSD, and MSD procedures to rank mean groupings. Tables F.1 and F.2 in Appendix F show the ANOVA results for feeder steers and heifers, respectively. Drawing particular attention to the F-values and their associated probabilities, to the right of the sale month columns, the null hypothesis that

sale months do not impact sale prices is rejected at the 1% level of significance across all weight categories for both steers and heifers. This indicates that pair-wise comparisons of month to month feeder cattle prices across various market outlets is appropriate in all cases. In addition, the ANOVA results suggest that the means differ across market location and that, overall, the model suggests that each observation is different from the overall mean.

With these significant ANOVA results, LSD and MSD tests were performed to analyze which market regions showed top price performance for each of the different weight classes in both feeder heifer and feeder steer markets. Tables G.1 and G.2 show the MSD rankings for the feeder steer and heifer markets, respectively. Listed are mean rankings which are based on the observed average price, minimum and maximum prices as well as the standard deviation as a measure of riskiness. Coefficient of Variation (CV) are also listed and are calculated by dividing the standard deviation by the mean of a set of values. The coefficient of variation therefore captures the relative variability of different data sets. A high CV value implies high relative variability while a low CV value indicates less relative variability. The market and weight category with the lowest CV value would be considered the least variable and therefore the least risky. The group rankings in the right most column of the table exhibit the rankings provided by the SAS output using the MSD procedure. The letter A represents the highest ranking and C the lowest ranking. Two letters appear in cases where market regions could not be differentiated to belong to the price class above or below. For example, the results in the #4-500 steer category suggest that Brandon is the top paying market on the basis of average price. The group

ranking 'A' suggests that it is in the top price class but that it is also not statistically significantly higher than the Ste. Rose, or Grunthal markets as they too have the letter 'A' under the group rank heading. Further Ste. Rose and Grunthal markets may not be differentiated from the Winnipeg market.

Assigning a numerical ranking scheme to the letter rank of the MSD tests allows us to sum the rankings and determine regional steer and heifer market price leaders across all weight categories. The following point scheme was implemented for this purpose: A = 4, AB = 3.5, B = 3, BC = 2.5, and C = 2. Assigning the numerical values to the letter rankings provided by the MSD test results and adjusting for Grunthal not reporting on #9-1000 cattle, we are able to complete a price-based ranking for steers and heifers by averaging the letter rankings across the weight ranges as follows.

Table 4.1. Steer Market Price Rankings within Manitoba

Market Location	Average of Letter Rankings
Ste. Rose	3.58
Brandon	3.42
Winnipeg	3.33
Grunthal[1]	2.70

Notes: [1] The Grunthal average is based on #4-500 to #8-900 category results only.

The highest steer prices were received by producers that sold to Ste. Rose, followed by Brandon, Winnipeg and Grunthal. The difference in average prices paid across markets varied from $0.98/cwt in the #9-1,000 category to a maximum of

$4.72/cwt in the #8-900 category.

A similar analysis in the heifer market offers the following ranking by again calculating an average ranking across all weight categories.

Table 4.2. Heifer Market Price Rankings within Manitoba

Market Location	Average of Letter Rankings
Brandon	3.83
Winnipeg	3.50
Ste. Rose	3.28
Grunthal[1]	2.60

Notes: [1] The Grunthal average is based on #4-500 to #8-900 category results only.

The highest heifer prices were received by producers that sold to Brandon, followed closely by Ste. Rose, Winnipeg and distantly by Grunthal. The difference in average prices paid across markets varied from $0.95/cwt in the #9-1,000 category to a maximum of $4.63/cwt in the #8-900 category. Further, the average rankings appear closer in the heifer market than the steer market with Grunthal the distant lowest paying market in both steer and heifer markets.

The coefficient of variation values within each weight range are very similar with a difference in values ranging from 0 to 0.02. This indicates that even though producer price risk is present, choosing one market over another within a certain weight range does not warrant analysis of price risk across market regions in both steer and heifer markets.

4.4.2. Market Rankings across Alberta, Manitoba, Ontario and U.S.

A similar set of rankings as those provided in the previous section was also calculated for Canadian and U.S. markets. ANOVA tests were performed to indicate whether individual monthly price observations where different across market region, month of sale or from the overall average feeder cattle price. The analysis is again presented first for steers and second for heifers.

The ANOVA results in tables F.3 and F.4 for steers and heifers, respectively, suggest that sale month and market location both influence price levels at least at the 5% significance level except for market location differences in the #8-900 heifer category. Thus a multiple pair-wise testing procedure such as the MSD rankings are allowable. Although these markets are less spatially integrated they can still be ranked by price level as shown in tables G.3 and G.4.

Applying the same valuation scheme as in the previous section (4.4.1), the steer market, with information from four market regions in all weight categories except the #9-1,000 U.S. market, exhibits the following information.

Table 4.3. Steer Market Price Rankings across Provinces and the U.S.

Market Location	Average of Letter Rankings
Manitoba	3.83
Alberta	3.67
Ontario	3.33
U.S.[1]	3.10

Notes: [1] The U.S. average is based on #4-500 to #8-900 category results only.

The highest steer prices were received by producers in Manitoba, followed by Alberta, Ontario and U.S. markets. The difference in average prices paid across markets varied from $2.29/cwt in the #9-1,000 category within Canada to a maximum of $10.46/cwt in the #4-500 category across Canada and the U.S. These price ranges are larger than those observed in local Manitoba markets and are likely a function of transportation and transactions costs.

A similar analysis in the heifer market offers the following ranking by again calculating an average ranking across all #3-400 to #8-900 weight categories.

Table 4.4. Heifer Market Price Rankings across Provinces and the U.S.

Market Location	Average of Letter Rankings
Manitoba	4.00
Alberta	3.92
Ontario	2.92
U.S.[1]	2.75

Notes: [1] The U.S. average is based on #4-500 to #7-800 category results only.

The highest heifer prices were received by producers in Manitoba, followed by Alberta, Ontario and the U.S. markets. This time rankings are more spread out than the steer rankings. The difference in average prices paid across markets varied from $1.05/cwt in the #8-900 category within Canada to a maximum of $13.16/cwt in the #3-400 category across Canada. The small price range in the #8-900 category within Canada raises the suspicion that transportation costs are not the only cost differences between

markets.

Coefficient of variation results were more significant in the more distant markets than in the local Manitoba markets. The difference in CV values within a certain weight category ranged from 0.02 to 0.12. The largest CV values were consistently associated with the U.S. market in each category. This implies that the U.S. market has the most variation in price and therefore signifies higher price risk for producers. This high value could be due to exchange rates, the number of gaps in price information that were assumed in the absence of actual price data or the price gathering technique (quantity weighted vs. simple average prices in the U.S. vs. Canada).

4.5. Weight Category Analysis

Manitoba Agriculture is interested in knowing whether price reporting can be reduced to two hundred pound categories without sacrificing producer information obtained from price analysis across weight categories. This question can be answered with two successive MSD tests. First, a ranking of prices by weight classes needs to show the expected results that 1) weight categories show statistically significantly different means and 2) that the lowest weight category provides the highest price with successively higher weight categories ranking successively lower in price. Second, new #200 weight classes are introduced such as a #4-600, #5-700, #6-800, #7-900 and #8-1,000. ANOVA and MSD tests are performed on these new, as well as old series, to see if the above two rules of mean separation by weight class and orderly ranking from lowest weight class to highest weight class hold. If the order or the mean separation does not hold, a producer

would be faced with insufficient information as weight categories would no longer truly reflect the value of an animal within that weight category. This section proceeds by first testing the efficiency of the current weight reporting system and secondly by testing the efficiency of the second system with the new #200 price interval.

4.5.1. Efficiency of Original Price Reporting System

To provide answers for Manitoba Agriculture as to what level of detail to present price information to producers, ANOVA, MSD, and LSD tests were performed on the Manitoba price data on feeder steers and heifers. This time the testing occurred across weight categories within one market location. The model thus becomes:

$$PFC = g(wc, m) \qquad (4.2)$$

where *wc* is the weight class of the animal and *m* is again the sale month. Tables F.5 and F.6 provide the results of the ANOVA analysis and tables G.5 and G.6 show the MSD test results for feeder steers and heifers, respectively.

Results for both the feeder steers and heifers concluded that the current weight category record keeping system shows statistically significant differences in price between categories. Similarly, there is consistency in the ranking of the price level of each category in each market. Tables G.5(Steers) and G.6 (Heifers), both show that the #4-500 weight categories are consistently higher priced with the heavier categories following in the expected order -- the lighter the animal the higher dollar value per pound received.

4.5.2. Efficiency of the Proposed #200 Price Interval System

Price categories for the #200 range were established utilizing existing price series. The price series for Brandon and Winnipeg, Manitoba were used to evaluate whether or not weight ranges could be grouped without losing price information in the process. The current #100 increments were aggregated to #200 increments by combining information from the relevant #100 categories. For example, minimum and maximum prices from the #4-500 and #5-600 series were recorded for the new #4-600 category. A simple average was then taken of the minimum and maximum numbers. New price series thus consist of an additional five weight ranges to a total of eleven weight categories in each market.

Tables F.7 and F.8 show ANOVA results and tables G.7 and G.8 provide the LSD rankings for steer and heifer markets, respectively. Looking at the Winnipeg steer market we discover that the new #4-600 category is not significantly different from the #4-500 and #5-600 categories from which it was derived. This indicates that the new larger range could be used without losing price information. The outcome of the #4-600 range also applies to the Winnipeg heifer market. Additionally, the heifer market would also allow for the grouping of the #7-900 category, by finding no significant difference between the #7-800 and #8-900 ranges. Strangely, the #6-800 and #7-800 categories in the Winnipeg heifer market become reversed during the transformation, that is the #7-800 category ranked higher than the #6-800 range. However, this difference is so small that they are not ranked as being significantly different from one another. This reversal is a function of the derivation of the new #200 category (see footnote in chapter 3 section 3.4 on page 25). The Brandon market analysis showed all categories except the #8-900 and #8-1,000

categories as being significantly different from one another.

The overall finding from this analysis is that the current #100 weight increments used are necessary to record feeder cattle prices. Choosing to use the larger #200 range would lead to misrepresentations of price and mislead the industry.

4.6. Conclusions

Seasonality results revealed that producer who decide to feed cattle to heavier weights need to take seasonal price variation into account more so than producers who sell calves at weaning. Further the results suggest that seasonal price patterns are similar across market regions. This finding is supported by the cointegration results found for Manitoba markets. Regression results supported the rejection of the law of one price in the long run for only five of sixty six market comparisons, or 7.6% of the time. These findings therefore suggest that in the long run producers would not benefit from evaluating spatial marketing strategies. Further analysis of more distant markets lead to rejection of market efficiency 21% and 43% of the time in steer and heifer markets, respectively. While analysis of the cause behind these market imperfections is beyond the scope of this investigation, the price rankings across market regions do not suggest that transportation cost is the only factor contributing to price differences in regional markets. Further, results from the mean group rankings across market regions show that a large number of markets are either not separable or rank Manitoba markets as a high paying province. This suggests that producers could be advised to market their cattle at the closest auction mart. In that sense results support the market efficiency conclusion that producers likely

would not stand to gain from evaluating spatially separated market outlets.

Finally, mean group rankings of prices across weight categories suggest that the current #100 price reporting system is efficient and cannot be replaced with a #200 price reporting system without a loss of information. Specific recommendations to producers and Manitoba Agriculture are provided in chapter 5.

CHAPTER 5

CONCLUSIONS

5.1. Introduction

This chapter summarizes the procedures outlined in previous chapters and highlights important conclusions from this study. The role seasonality, spatial integration and least significant difference tests played in the determination of conclusions drawn on feeder cattle price series is presented here. Chapter 5 also discusses the implications from these results to producers and Manitoba Agriculture, describes this study's limitations and suggests areas for future research.

5.2. Summary of Major Findings and Implications toward the Study Objectives

The purpose of this research was to evaluate alternative production and marketing strategies for Manitoba's feeder cattle producer. This study utilized the results from seasonality testing, cointegration / spatial integration testing, and least significance difference testing on price series from January 1994 to May 1998 across weight categories ranging from #3-400 to #9-1,000 for steers and heifers for four Manitoba auction marts and also across Manitoba, Alberta, Ontario and a U.S. market region.

Results as they pertain to the specific study objectives outlined in chapter 1 are now presented to provide producers with information on whether market prices for feeder cattle are sufficiently different across markets to allow for profitable opportunities from transporting cattle further distances:

Objective #1:

Analyze seasonality in Manitoba cattle price to determine if seasonality differs across market regions and or weight categories. This should answer whether market prices behave in a similar fashion across regions and are therefore spatially integrated and whether seasonality in prices may lead to changes in the timing of production, especially in light of expected feeding of cattle to heavier weights.

- ✓ Seasonality findings for Manitoba show that a similar seasonal trend is evident throughout the four market locations considered.
- ✓ Cointegration tests performed on the Manitoba markets prove that indeed the markets are spatially integrated, with the exception of the Grunthal market in some weight classes. This indicates that the LOOP holds over ninety percent of the time and that gains from transporting cattle to other cattle markets are likely not available in the long run. This also strengthens the results of no changes in seasonal price patterns.
- ✓ Seasonal index value range findings show a greater range and therefore a larger sales impact per head in heavier than lighter weight categories of steers. This is true to a lesser extent in the heifer market. Producers interested in feeding cattle to heavier weights should therefore pay attention to have heavier cattle available for sale from August to October.

Objective #2:

Provide marketing suggestions to producers on the basis of long run spatial market integration tests. Do market effects in one region translate to equal effects in other regions or do price series diverge over time and thus offer an opportunity for marketing cattle in more distant market regions?

- ✓ Regional markets within Manitoba exhibit similar pricing for feeder cattle.

Brandon, Grunthal, Ste. Rose and Winnipeg markets follow the LOOP over ninety percent of the time. The only notable exception are market comparisons with Grunthal.

✓ Cointegration testing has also revealed market efficiency between Manitoba and Alberta. Further removed markets were less likely to behave according to the law of one price. Differential agricultural policy impacts, infrastructure, exchange rate distortions and other market imperfections were hypothesized to effect these results.

Objective #3:

Identify whether market regions can be ranked according to price and thus provide directions for producers to purchase/sell in the lowest/highest paying markets.

✓ Mean group rankings provided by the MSD procedure in SAS showed that mean separation and price rankings were similar for many markets within Manitoba and across Canada and the U.S. Producers would therefore likely not gain from evaluating spatial marketing strategies. Notable exclusions are the Grunthal and U.S. markets which garnered the lowest market prices across most weight categories.

✓ MSD rankings of Manitoba prices in relation to the other provinces and the U.S. market region revealed that Manitoba producers are receiving relatively high prices for their cattle. Therefore, little incentive exists for Manitoba producers to ship cattle out of province.

Objective #4:

Provide suggestions for Manitoba Agriculture on what prices to report given their current record keeping activities vis a vis the U.S. reporting system.

- ✓ Manitoba Agriculture may be advised that the current reporting system of #100 increments for feeder cattle is a meaningful measurement of the price information producers require to make decisions. A proposed #200 price reporting system shows that #200 prices are significantly different from the #100 price categories they are derived from. This provides support that reporting price in #200 increments is insufficient or even misleading.
- ✓ On the basis of the study results, Manitoba Agriculture may be advised to report full market details on a single market as results from that market would be applicable to most markets in Manitoba. This could entail providing information on all weight categories for one market region only, with aggregate price information across several weight categories being reported for regional markets.

5.3. Study Limitations

The implications drawn from this research must be considered with limitations in mind. First, while the analysis did cover a cattle marketing period that experienced both cyclically high and low feeder cattle prices, results pertain to this period. Caution is thus advised in extending these results to the future. Second, while some expected

interrelationships between the three testing procedures were evident the results also showed some differences. Stronger testing of these interrelationships could thus be the subject of another study. Third, missing feeder steer and heifer market price data had to be generated using possibly simplistic assumptions. For example, price averages for analysis have been calculated by using the midpoint of high and low prices reported by auction marts. It would have been nice to have access to information to calculate quantity weighted averages to get a better idea of the price distributions that occur within the weight categories that are currently reported. Similarly, if auction marts could record separate totals for steer and heifer quantities, a quantity weighted average could have been calculated. Finally, the seasonality analysis, although meaningful, was limited in its current capacity. The test results would have been considered much more dependable if seasonal trends could be calculated on the basis of a complete cattle cycle using ten to twelve years of data.

5.4. Suggestions for Further Research

Further research of this subject is suggested by the limitations pointed out above, For example, analysis of price distributions could aid in determining whether symmetric price distributions should be used to calculated a representative cattle price for a weight category as the mid-point between the high and low prices. Revamping current record keeping practices at the auction marts to allow prices being recorded based on both quality and weight would eliminate any possible bias that may be introduced by simply grouping animals in weight categories, rather than discriminating by quality. Further

analysis that would consider a more rigorous approach to testing the interrelationship between seasonality parameters and cointegration tests should also provide new insights for testing spatial market integration.

5.5. Study Beneficiaries

Beneficiaries of this study include Manitoba Agriculture and local auction marts as they are provided with a comparison of two price reporting techniques. The within Manitoba analysis on market efficiency gives enough support to the idea that a single representative market could be used to gather detailed information on cattle prices and continue with reporting less detailed information for local markets.

Manitoba feeder cattle producers also benefit by being provided with an analysis that suggests optimal sale times for feeder cattle across all weight categories in several market regions. The data is of special interest to backgrounding operation, as they need to pay more attention to this information than cow/calf operations. Producers are also provided with peace of mind by knowing that the markets closest to home are as profitable as any.

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APPENDIX
" A"

REPRESENTATIVE SALES SHEET

Figure A.1. Sample Sales Sheet from Brandon Market for March 3rd and 5th, 1998.

Livestock Services

Brandon, Manitoba

Brandon Sun: fax 727-0385 CBC Radio: fax 1-204-788-3199

LIVESTOCK MARKET REPORT FOR [redacted] Tues + Thurs May 3 + 5 19 98

Slaughter 86 [redacted] Feeder [redacted] 255 Total [redacted] 341

SLAUGHTER CATTLE		MARKET TRENDS FOR SLAUGHTER CAT
U.S. CHOICE STRS.	80-82.50	
A1-A2 STEERS	78-80	
U.S. CHOICE HFRS.	[redacted] 78-81.50	
A1-A2 HEIFERS	76-79	
D1-D2 COWS	51-56	
D3 COWS	45-51	
FEEDER COWS	55-60	
GOOD BULLS	60-66.75	

FEEDER CATTLE		MARKET TRENDS FOR FEEDER CATTLE
STEERS		
900-1000 lbs		
800-900		
700-800		
600-700	107 - 115	
500-600	116 - 123	
400-500	120 - 128	
300-400		
HEIFERS		
900-1000 lbs		
800-900		
700-800		
600-700		
500-600	110 - 118	
400-500	110 - 120	

APPENDIX
" B "

ORDER OF INTEGRATION TESTS

Table B.1. Order of Integration Tests on Manitoba Steer and Heifer Market Prices, January 1994 to May 1998

Category[1]	I[2]	t-stat
BH45	0	0.127
	1	5.052
BH56	0	0.111
	1	4.603
BH67	0	0.127
	1	5.463
BH78	0	0.173
	1	5.384
BH89	0	0.135
	1	5.477
BH910	0	0.145
	1	6.038
BS45	0	0.161
	1	6.204
BS56	0	0.148
	1	6.019
BS67	0	0.136
	1	5.607
BS78	0	0.153
	1	5.638
BS89	0	0.280
	1	5.811
BS910	0	0.253
	1	5.730

Category[1]	I[2]	t-stat
GH45	0	0.133
	1	5.351
GH56	0	0.100
	1	5.893
GH67	0	0.074
	1	5.516
GH78	0	0.068
	1	5.989
GH89	0	0.013
	1	7.255
GS45	0	0.099
	1	5.735
GS56	0	0.073
	1	5.677
GS67	0	0.130
	1	5.990
GS78	0	0.051
	1	5.961
GS89	0	0.070
	1	5.767

Category[1]	I[2]	t-stat
RH45	0	0.119
	1	6.472
RH56	0	0.024
	1	6.816
RH67	0	0.007
	1	6.226
RH78	0	0.052
	1	6.173
RH89	0	0.052
	1	6.956
RH910	0	0.093
	1	7.246
RS45	0	0.139
	1	7.332
RS56	0	0.152
	1	6.638
RS67	0	0.086
	1	7.588
RS78	0	0.076
	1	7.389
RS89	0	0.280
	1	6.545
RS910	0	0.169
	1	6.482

Category[1]	I[2]	t-stat
WH45	0	0.102
	1	6.281
WH56	0	0.035
	1	5.934
WH67	0	0.012
	1	5.270
WH78	0	0.136
	1	6.024
WH89	0	0.319
	1	7.653
WH910	0	0.209
	1	7.761
WS45	0	0.120
	1	5.702
WS56	0	0.032
	1	6.441
WS67	0	0.133
	1	6.252
WS78	0	0.051
	1	6.123
WS89	0	0.268
	1	7.463
WS910	0	0.246
	1	7.438

Notes: [1]The first letter identifies the market location, B = Brandon, G = Grunthal, R = Ste. Rose, W = Winnipeg. The second letter represents gender S=Steer, and H=Heifers. The last two digits correspond with the following weight categories. 45 = #4-500, 56 = #5-600, 67 = #6-700, 78 = #7-800, 89 = #8-900, 910 = #9-1000.

[2]I=order of integration of variables. All price series (Y_t) were analyzed first in original logarithmic form. If t-stats were greater than the McKinnon critical value of 1.95 then the original series were judged stationary or integrated of order 0. If the t-stats were lower than the critical McKinnon value then the price series were first differenced and again subjected to the Augmented Dickey Fuller test of the form $\Delta Y_t = (Y_t - Y_{t-1}) = B_0 + B_1 Y_{t-1} + B_2 t + \epsilon_t$. This procedure was repeated until t-stats were greater than the critical value of 1.95. Results of integration testing show that first differencing was required to identify each series as integrated of order 1.

Table B.2. Order of Integration Tests on Provincial / State Steer and Heifer Market Prices, January 1994 to May 1998.

Category[1]	I[2]	t-stat
AH34	0	0.305
	1	4.307
AH45	0	0.432
	1	4.420
AH56	0	0.385
	1	5.424
AH67	0	0.416
	1	4.779
AH78	0	0.330
	1	5.048
AH89	0	0.365
	1	5.161
AS45	0	0.471
	1	4.258
AS56	0	0.468
	1	4.479
AS67	0	0.411
	1	4.756
AS78	0	0.364
	1	4.910
AS89	0	0.355
	1	4.925
AS910	0	0.402
	1	5.865

Category[1]	I[2]	t-stat
MH34	0	0.232
	1	6.842
MH45	0	0.394
	1	5.219
MH56	0	0.401
	1	4.760
MH67	0	0.444
	1	5.105
MH78	0	0.422
	1	4.858
MH89	0	0.463
	1	6.060
MS45	0	0.327
	1	7.332
MS56	0	0.376
	1	6.354
MS67	0	0.474
	1	5.748
MS78	0	0.488
	1	5.875
MS89	0	0.494
	1	5.475
MS910	0	0.505
	1	5.694

Category[1]	I[2]	t-stat
OH34	0	0.071
	1	4.064
OH45	0	0.122
	1	6.612
OH56	0	0.131
	1	6.043
OH67	0	0.013
	1	6.786
OH78	0	0.220
	1	5.822
OH89	0	0.035
	1	7.150
OS45	0	0.197
	1	6.287
OS56	0	0.315
	1	5.882
OS67	0	0.348
	1	6.055
OS78	0	0.243
	1	6.592
OS89	0	0.105
	1	5.947
OS910	0	0.142
	1	6.101

Category [1]	I[2]	t-stat
USH45	0	0.065
	1	4.323
USH56	0	0.132
	1	5.429
USH67	0	0.158
	1	5.872
USH78	0	0.067
	1	5.126
USS45	0	0.118
	1	5.625
USS56	0	0.243
	1	6.285
USS67	0	0.363
	1	4.527
USS78	0	0.043
	1	6.658
USS89	0	0.133
	1	6.228

Notes: [1]The first letter identifies the market location, A = Alberta, M = Manitoba, O = Ontario, US = United States. The second letter represents gender S=Steer, and H=Heifers. The last two digits correspond with the following weight categories. 45 = #4-500, 56 = #5-600, 67 = #6-700, 78 = #7-800, 89 = #8-900, 910 = #9-1000.

[2]I=order of integration of variables. All price series (Y_t) were analyzed first in original logarithmic form. If t-stats were greater than the McKinnon critical value of 1.95 then the original series were judged stationary or integrated of order 0. If the t-stats were lower than the critical McKinnon value then the price series were first differenced and again subjected to the Augmented Dickey Fuller test of the form $\Delta Y_t = (Y_t - Y_{t-1}) = B_0 + B_1 Y_{t-1} + B_2 t + \epsilon_t$. This procedure was repeated until t-stats were greater than the critical value of 1.95. Results of integration testing show that first differencing was required to identify each series as integrated of order 1.

APPENDIX
" C "

MONTHLY SEASONAL PRICE VARIATION TABLES

Appendix Table C.1. Monthly Seasonal Indices[1] for Feeder Steers in Brandon, MB, January 1994 to May 1998.

Weight Category	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Range[3]
#4-500	0.93[2]	0.95	1.01	1.00	0.99	1.00	1.00	0.99	1.01	1.03	1.01	0.99	0.10
#5-600	0.94	0.98	1.01	1.00	1.00	1.01	1.00	0.99	1.02	1.00	0.99	0.98	0.08
#6-700	0.95	0.97	0.99	1.00	0.99	1.02	1.01	1.01	1.03	0.99	0.97	0.98	0.08
#7-800	0.97	0.96	0.97	0.98	0.98	1.02	1.02	1.03	1.04	1.00	0.98	1.00	0.08
#8-900	0.99	0.97	0.96	0.95	0.96	1.01	1.01	1.04	1.03	1.00	0.99	1.01	0.09
#9-1000	1.00	0.98	0.96	0.94	0.94	0.99	1.01	1.04	1.04	1.00	1.00	1.03	0.10

Notes: [1] Indices were calculated using a 12-month centered moving average annual price.
[2] Average index values represent percentages. For example, a value of 0.95 for January #4-500 steers would indicate that those steers are trading 5% below the average annual price in January.
[3] Range values indicate the difference between high and low (band width) of monthly seasonal index values.

Appendix Table C.2. Monthly Seasonal Indices[1] for Feeder Steers in Grunthal, MB, January 1994 to May 1998.

Weight Category	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Range[3]
#4-500	0.90[2]	0.9	0.99	0.97	1.00	0.99	0.98	1.01	1.04	1.05	1.01	0.98	0.15
#5-600	0.91	0.9	1.02	0.99	1.01	1.00	0.98	1.01	1.04	1.02	0.98	0.96	0.13
#6-700	0.93	0.9	1.01	0.97	1.00	1.02	0.99	1.03	1.03	1.01	0.98	0.97	0.10
#7-800	0.94	0.9	0.98	0.94	0.99	1.01	1.00	1.04	1.04	1.02	1.00	0.98	0.10
#8-900	0.97	1.0	0.97	0.94	0.97	0.98	0.99	1.04	1.05	1.03	1.01	0.99	0.11

Notes: [1] Indices were calculated using a 12-month centered moving average annual price.
[2] Average index values represent percentages. For example, a value of 0.95 for January #4-500 steers would indicate that those steers are trading 5% below the average annual price in January.
[3] Range values indicate the difference between high and low (band width) of monthly seasonal index values.

Appendix Table C.3. Monthly Seasonal Indices[1] for Feeder Steers in Ste. Rose, MB, January 1994 to May 1998.

Weight Category	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Range[3]
#4-500	0.93[2]	0.97	0.97	0.97	0.97	0.95	0.95	1.05	1.06	1.05	1.00	0.98	0.13
#5-600	0.95	1.00	1.00	1.01	0.98	0.99	0.96	1.00	1.04	0.99	0.99	0.98	0.09
#6-700	0.93	0.99	1.01	1.01	0.99	1.01	0.99	1.02	1.02	0.98	0.97	0.97	0.09
#7-800	0.96	0.95	0.97	0.98	0.99	1.00	1.01	1.05	1.03	1.00	0.99	1.01	0.10
#8-900	0.98	0.96	0.97	0.96	0.97	1.00	1.00	1.05	1.03	1.02	1.01	0.99	0.09
#9-1000	0.97	0.98	0.98	0.94	0.95	0.99	1.00	1.06	1.03	1.02	1.02	0.99	0.12

Notes: [1] Indices were calculated using a 12-month centered moving average annual price.
[2] Average index values represent percentages. For example, a value of 0.95 for January #4-500 steers would indicate that those steers are trading 5% below the average annual price in January.
[3] Range values indicate the difference between high and low (band width) of monthly seasonal index values.

Appendix Table C.4. Monthly Seasonal Indices[1] for Feeder Steers in Winnipeg, MB, January 1994 to May 1998.

Weight Category	Jan	Feb	Mar	Apr	Ma	June	July	Aug	Sept	Oct	Nov	Dec	Range[3]
#4-500	0.92[2]	0.97	0.98	0.99	0.98	1.01	1.00	1.03	1.05	1.01	0.97	0.97	0.13
#5-600	0.92	0.98	1.00	0.98	0.99	1.02	1.00	1.02	1.05	1.00	0.96	0.97	0.13
#6-700	0.93	0.98	1.01	1.00	1.01	1.02	1.02	1.03	1.03	0.98	0.95	0.96	0.10
#7-800	0.95	0.96	0.97	0.97	0.99	1.02	1.02	1.04	1.04	0.99	0.97	0.98	0.09
#8-900	0.95	0.99	0.95	0.94	0.97	1.00	1.00	1.05	1.04	1.02	1.00	1.05	0.10
#9-1000	0.96	0.96	0.96	0.95	0.96	1.00	0.99	1.05	1.04	1.01	1.03	1.03	0.10

Notes: [1] Indices were calculated using a 12-month centered moving average annual price.
[2] Average index values represent percentages. For example, a value of 0.95 for January #4-500 steers would indicate that those steers are trading 5% below the average annual price in January.
[3] Range values indicate the difference between high and low (band width) of monthly seasonal index values.

Appendix Table C.5. Monthly Seasonal Indices[1] for Feeder Heifers in Brandon, MB, January 1994 to May 1998.

Weight Category	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Range[3]
#4-500	0.93[2]	0.95	0.98	0.99	0.99	1.02	1.01	1.01	1.03	1.01	0.99	0.97	0.10
#5-600	0.94	0.96	0.98	0.99	0.98	1.03	1.02	1.02	1.02	1.00	0.99	0.97	0.09
#6-700	0.95	0.97	0.97	0.98	0.99	1.02	1.02	1.04	1.03	0.99	0.97	0.98	0.09
#7-800	0.97	0.96	0.96	0.96	0.97	1.02	1.02	1.04	1.04	1.00	0.98	1.00	0.08
#8-900	0.98	0.97	0.97	0.95	0.96	1.00	1.01	1.05	1.03	1.00	0.99	1.02	0.10
#9-1000	0.99	0.98	0.97	0.95	0.95	0.99	1.01	1.03	1.03	1.00	0.99	1.02	0.08

Notes: [1] Indices were calculated using a 12-month centered moving average annual price.
[2] Average index values represent percentages. For example, a value of 0.95 for January #4-500 heifers would indicate that those heifers are trading 5% below the average annual price in January.
[3] Range values indicate the difference between high and low (band width) of monthly seasonal index values.

Appendix Table C.6. Monthly Seasonal Indices[1] for Feeder Heifers in Grunthal, MB, January 1994 to May 1998.

Weight Category	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Range[3]
#4-500	0.92[2]	0.95	0.98	0.97	1.01	1.00	0.99	1.02	1.05	1.01	0.99	0.98	0.13
#5-600	0.92	0.96	1.00	0.98	1.00	1.00	0.99	1.03	1.04	1.00	0.99	0.98	0.12
#6-700	0.95	0.96	0.99	0.98	0.99	1.00	1.00	1.04	1.04	1.00	0.98	0.97	0.09
#7-800	0.96	0.97	0.97	0.95	0.98	1.00	0.99	1.04	1.05	1.02	1.00	0.98	0.10
#8-900	0.99	0.98	0.94	0.99	0.97	0.98	0.99	1.02	1.05	1.02	1.02	0.99	0.11

Notes: [1] Indices were calculated using a 12-month centered moving average annual price.
[2] Average index values represent percentages. For example, a value of 0.95 for January #4-500 heifers would indicate that those heifers are trading 5% below the average annual price in January.
[3] Range values indicate the difference between high and low (band width) of monthly seasonal index values.

Appendix Table C.7. Monthly Seasonal Indices[1] for Feeder Heifers in Ste. Rose, MB, January 1994 to May 1998.

Weight Category	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Range [3]
#4-500	0.96[2]	0.97	0.99	0.96	0.96	0.98	0.99	1.04	1.04	1.00	1.01	1.01	0.08
#5-600	0.94	0.96	1.00	1.01	1.00	1.00	0.98	1.01	1.03	0.99	0.98	0.98	0.09
#6-700	0.93	0.96	1.00	1.01	1.00	1.02	1.00	1.04	1.02	0.99	0.97	0.96	0.09
#7-800	0.98	0.97	0.97	0.97	0.97	1.00	1.00	1.06	1.04	1.00	0.97	0.96	0.09
#8-900	0.96	0.97	0.99	0.96	0.96	0.98	0.99	1.04	1.04	1.00	1.01	1.01	0.08
#9-1000	0.96	0.97	0.97	0.94	0.97	0.98	1.00	1.04	1.04	1.01	1.03	1.03	0.10

Notes: [1] Indices were calculated using a 12-month centered moving average annual price.
[2] Average index values represent percentages. For example, a value of 0.95 for January #4-500 heifers would indicate that those heifers are trading 5% below the average annual price in January.
[3] Range values indicate the difference between high and low (band width) of monthly seasonal index values.

Appendix Table C.8. Monthly Seasonal Indices[1] for Feeder Heifers in Winnipeg, MB, January 1994 to May 1998.

Weight Category	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Range [3]
#4-500	0.93[2]	0.95	0.99	0.98	0.98	1.00	1.00	1.04	1.03	1.00	0.98	0.98	0.11
#5-600	0.93	0.95	0.98	0.99	0.99	1.02	1.02	1.04	1.03	0.99	0.97	0.98	0.11
#6-700	0.94	0.96	0.98	0.98	1.01	1.03	1.03	1.05	1.03	0.97	0.95	0.98	0.11
#7-800	0.94	0.96	0.96	0.94	0.99	1.00	1.02	1.05	1.05	1.01	0.99	0.99	0.11
#8-900	0.96	0.97	0.96	0.94	0.96	1.00	1.00	1.05	1.02	1.03	1.01	1.01	0.11
#9-1000	0.97	0.98	0.98	0.93	0.96	1.00	1.01	1.04	0.99	1.03	1.02	1.03	0.11

Notes: [1] Indices were calculated using a 12-month centered moving average annual price.
[2] Average index values represent percentages. For example, a value of 0.95 for January #4-500 heifers would indicate that those heifers are trading 5% below the average annual price in January.
[3] Range values indicate the difference between high and low (band width) of monthly seasonal index values.

APPENDIX
" D "

MONTHLY SEASONAL PRICE VARIATION GRAPHS

Figure D.1. Comparison of Seasonal Indices across Market Regions for #4-500 Feeder Steers in Manitoba 1994-1998.

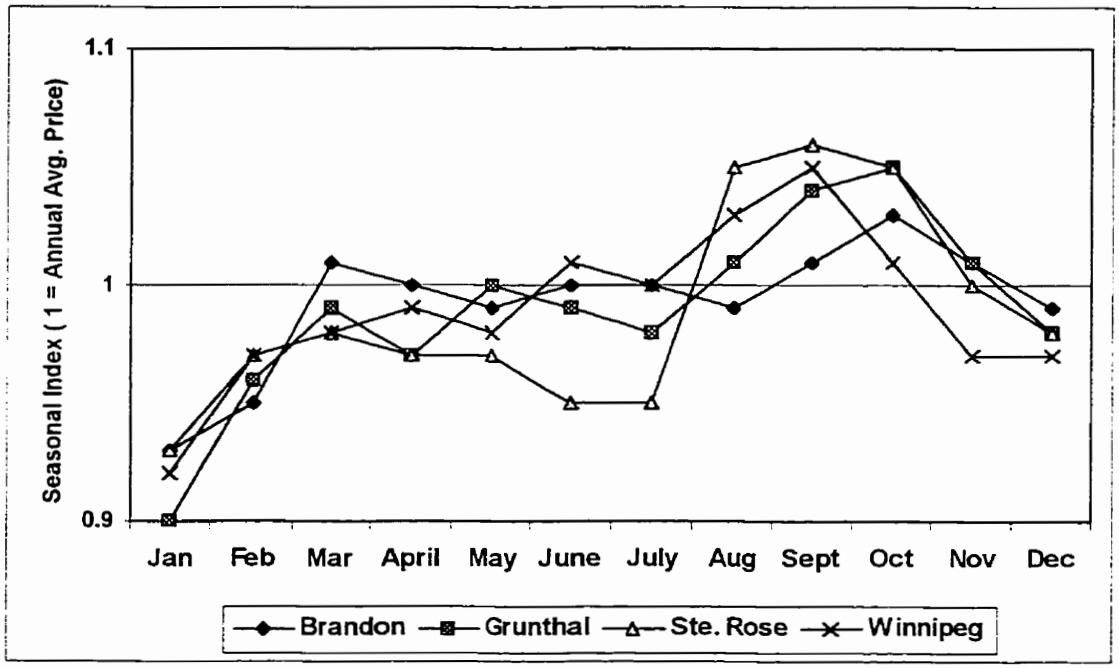


Figure D.2. Comparison of Seasonal Indices across Market Regions for #5-600 Feeder Steers in Manitoba 1994-1998.

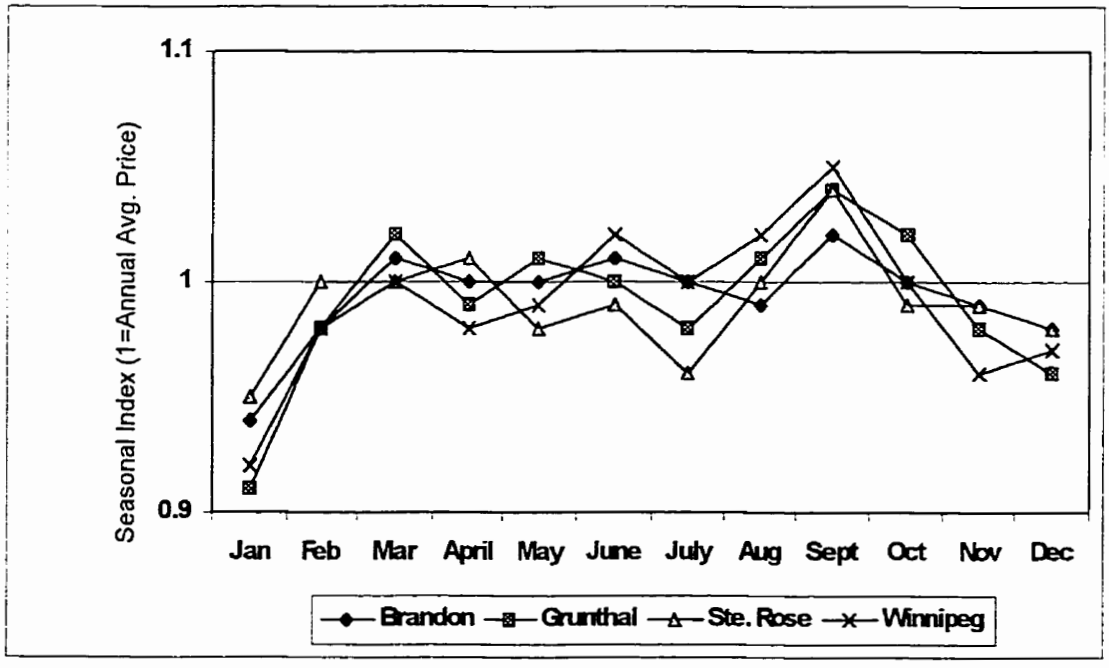


Figure D.3. Comparison of Seasonal Indices across Market Regions for #6-700 Feeder Steers in Manitoba 1994-1998.

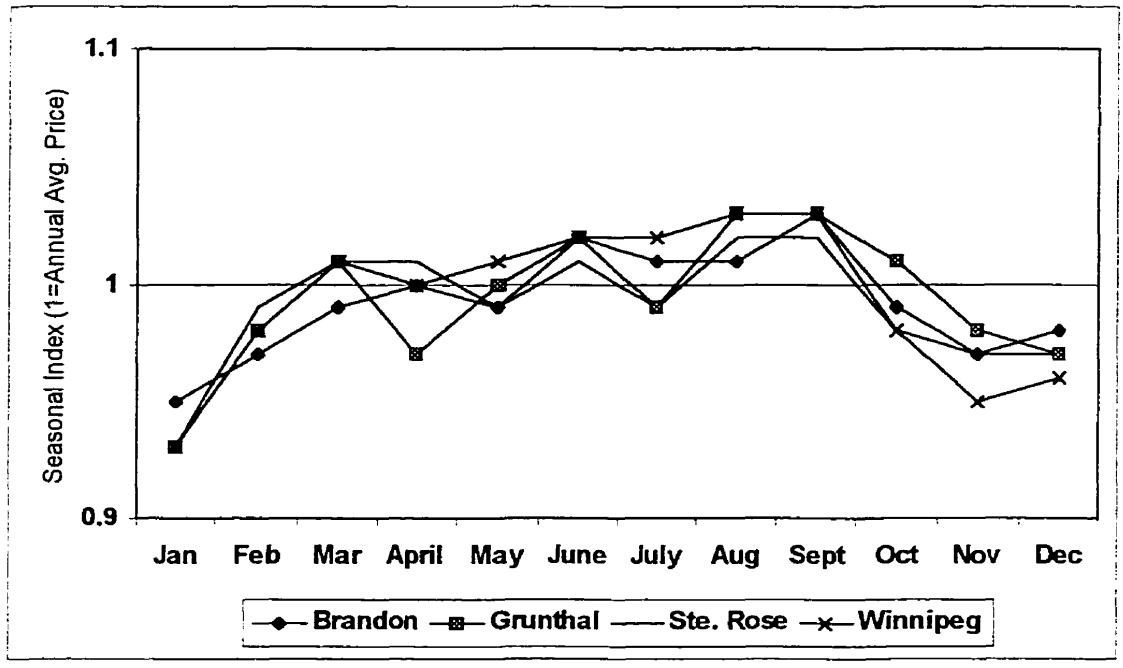


Figure D.4. Comparison of Seasonal Indices across Market Regions for #7-800 Feeder Steers in Manitoba 1994-1998.

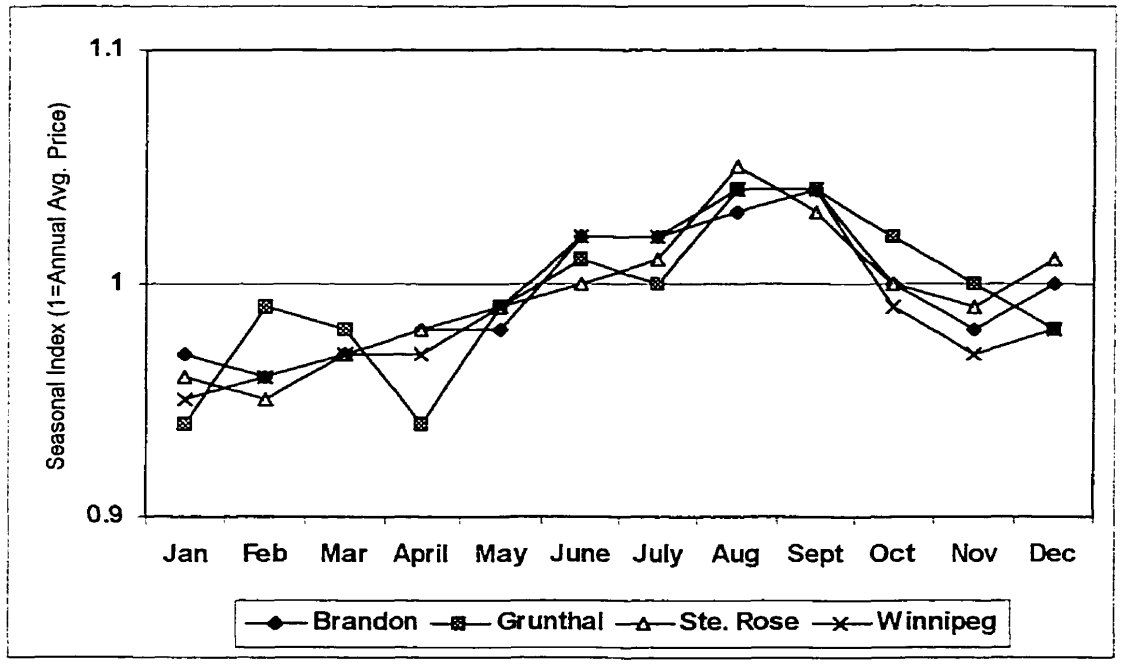


Figure D.5. Comparison of Seasonal Indices across Market Regions for #8-900 Feeder Steers in Manitoba 1994-1998.

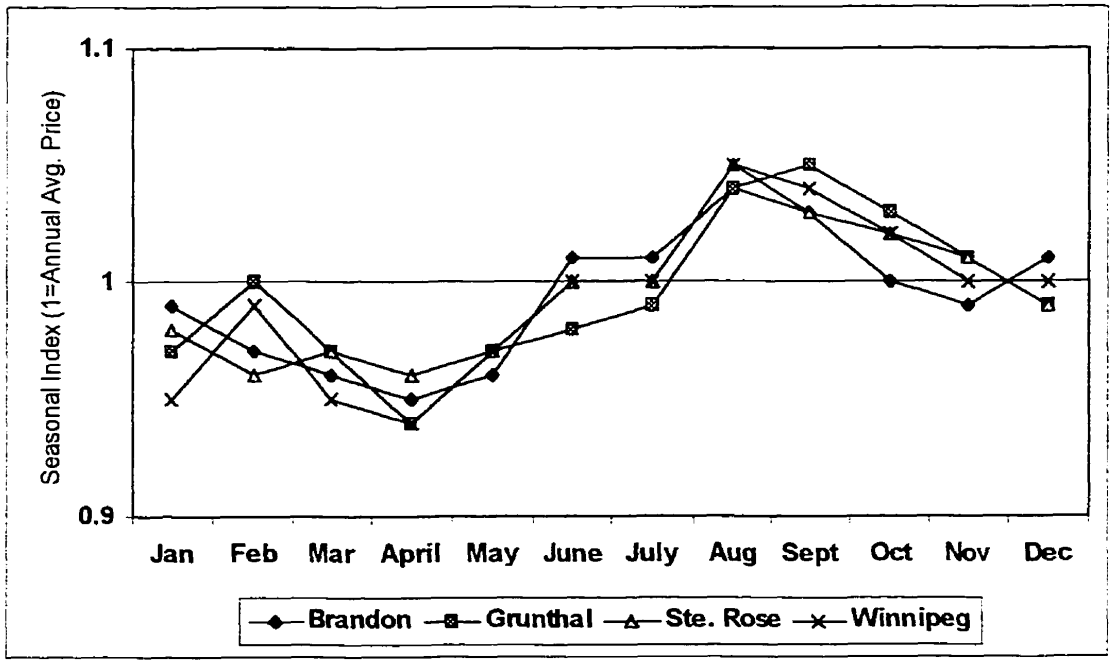


Figure D.6. Comparison of Seasonal Indices across Market Regions for #9-1000 Feeder Steers in Manitoba 1994-1998.

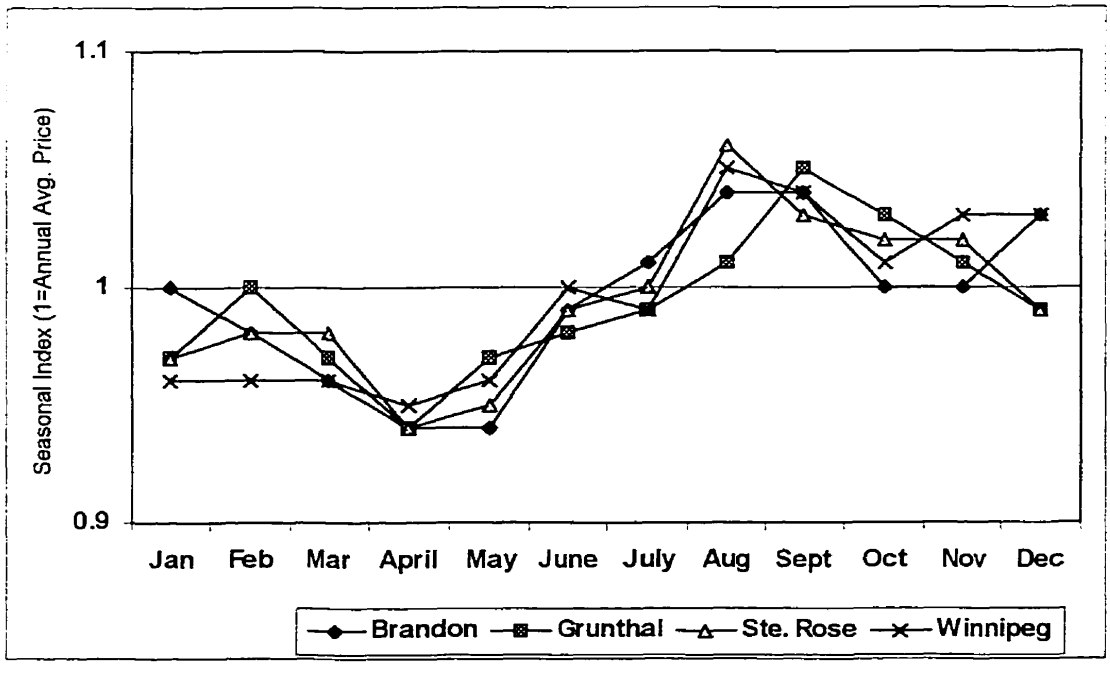


Figure D.7. Comparison of Seasonal Indices across Market Regions for #4-500 Feeder Heifers in Manitoba 1994-1998.

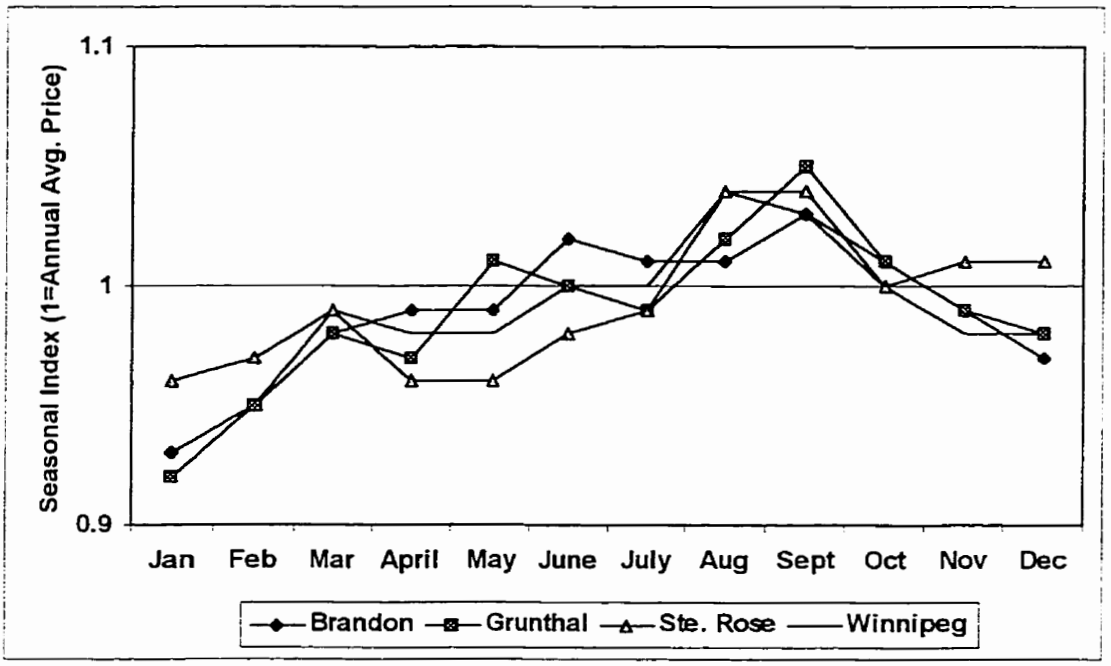


Figure D.8. Comparison of Seasonal Indices across Market Regions for #5-600 Feeder Heifers in Manitoba 1994-1998.

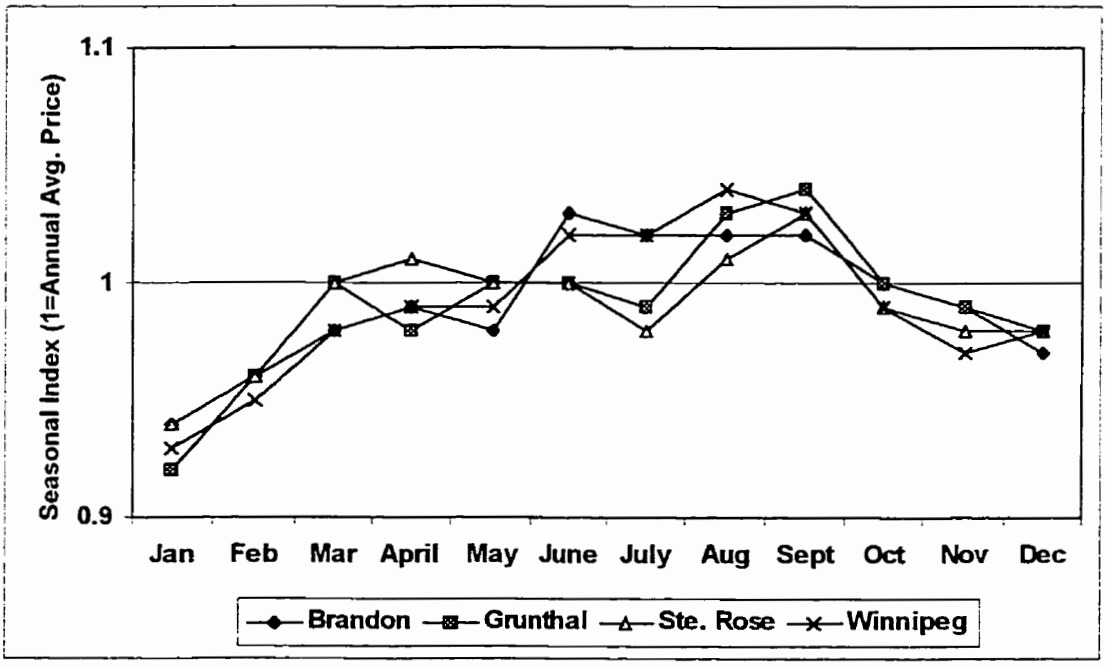


Figure D.9. Comparison of Seasonal Indices across Market Regions for #6-700 Feeder Heifers in Manitoba 1994-1998.

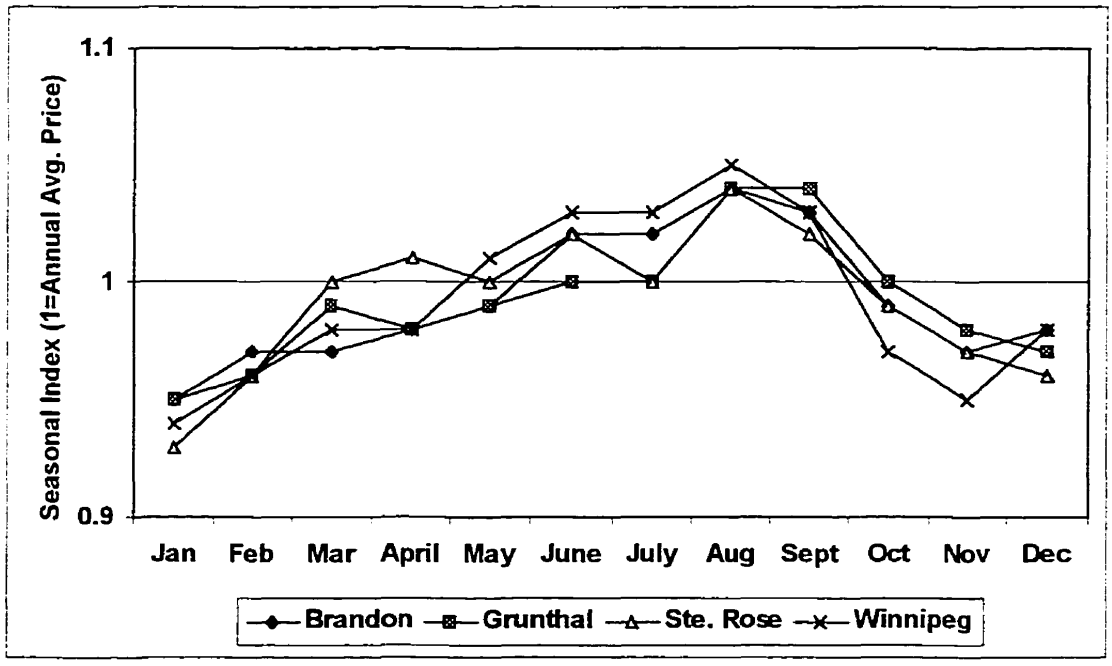


Figure D.10. Comparison of Seasonal Indices across Market Regions for #7-800 Feeder Heifers in Manitoba 1994-1998.

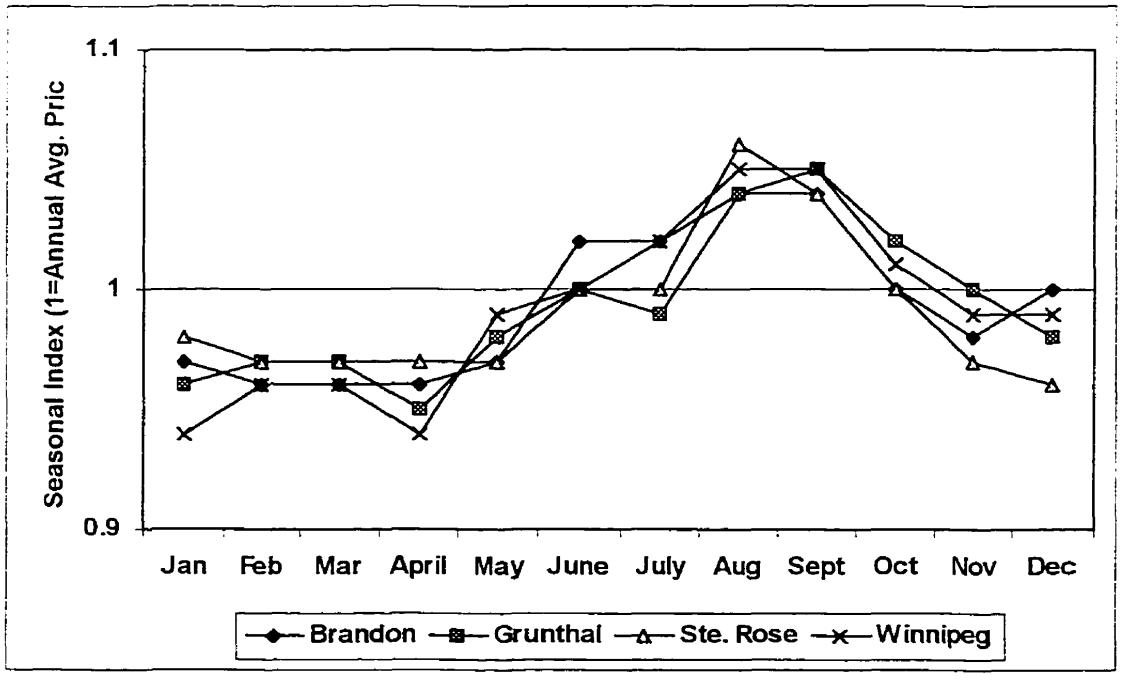


Figure D.11. Comparison of Seasonal Indices across Market Regions for #8-900 Feeder Heifers in Manitoba 1994-1998.

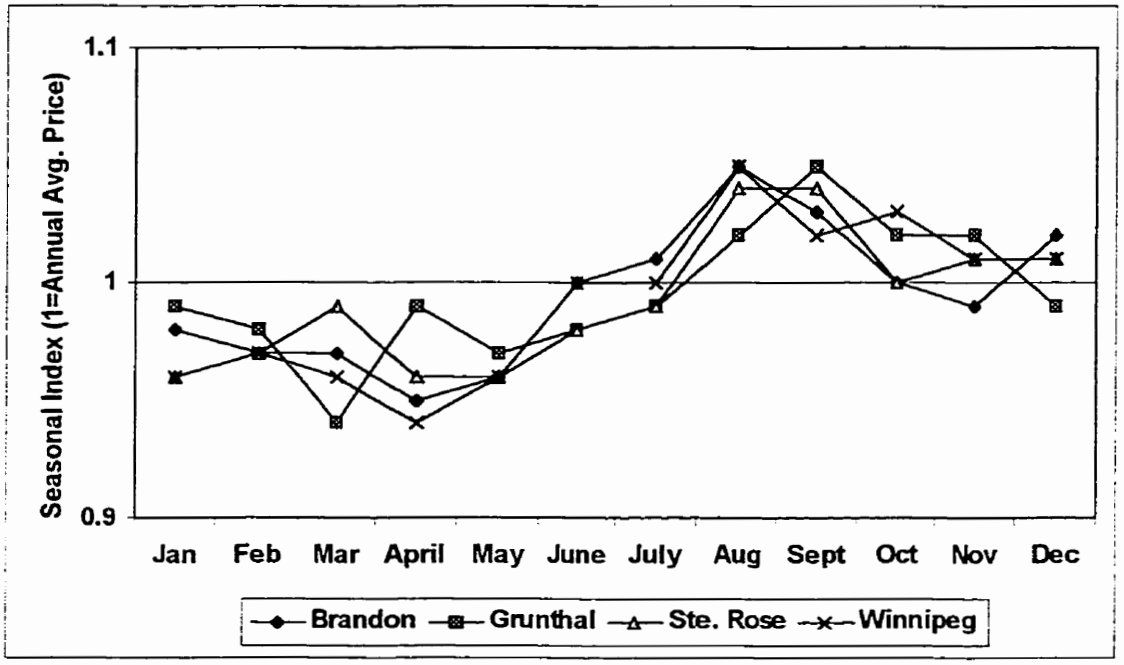
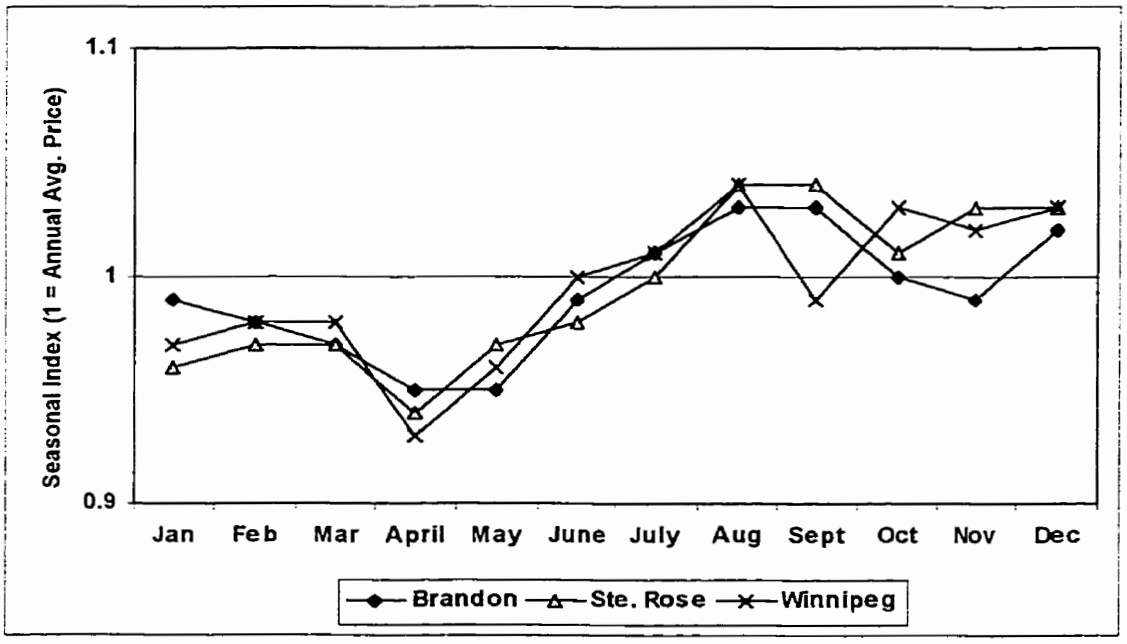


Figure D.12. Comparison of Seasonal Indices across Market Regions for #9-1000 Feeder Heifers in Manitoba, 1994-1998.



APPENDIX
" E "

SPATIAL MARKET INTEGRATION

or

COINTEGRATION TEST RESULTS

Appendix Table E.1 . OLS Estimates of Cointegrating Parameters for Manitoba Steers.

Market[1] Category		B_I	S.E.	Residual[2] t-stat	B_{II}	S.E.	Residual t-stat	R^2	LOOP Holds
B45	G45	0.97	0.03	3.95	0.99	0.03	4.09	0.96	Yes
	R45	0.93	0.03	4.84	1.02	0.03	4.87	0.95	Yes
	W45	0.98	0.04	4.44	0.95	0.04	4.20	0.93	Yes
G45	R45	0.94	0.03	2.87	1.01	0.03	2.84	0.94	No
	W45	0.98	0.20	3.31	0.93	0.04	3.04	0.91	No
R45	W45	1.03	0.04	3.77	0.91	0.03	3.53	0.94	Yes
B56	G56	1.01	0.03	5.33	0.93	0.03	4.91	0.97	Yes
	R56	0.96	0.03	5.05	1.00	0.03	5.14	0.97	Yes
	W56	0.97	0.02	4.58	1.01	0.02	4.54	0.98	Yes
G56	R56	0.93	0.03	4.91	1.03	0.03	4.86	0.96	Yes
	W56	0.94	0.02	4.13	1.03	0.03	3.98	0.97	Yes
R56	W56	0.99	0.02	4.12	0.98	0.02	4.00	0.97	Yes
B67	G67	0.99	0.02	5.29	0.99	0.02	5.40	0.97	Yes
	R67	0.94	0.02	5.56	1.03	0.03	5.47	0.97	Yes
	W67	1.01	0.03	4.17	0.95	0.03	4.08	0.96	Yes
G67	R67	0.94	0.02	4.69	1.03	0.03	4.54	0.97	Yes
	W67	1.00	0.03	3.65	0.95	0.03	3.53	0.95	Yes
R67	W67	1.06	0.03	4.64	0.91	0.02	4.62	0.97	Yes
B78	G78	0.99	0.03	5.80	0.98	0.03	5.77	0.97	Yes
	R78	0.96	0.02	4.94	1.01	0.02	4.85	0.97	Yes
	W78	0.94	0.02	4.07	1.04	0.02	4.00	0.98	Yes
G78	R78	0.95	0.03	5.80	1.01	0.03	5.70	0.96	Yes
	W78	0.93	0.02	3.85	1.04	0.03	3.79	0.97	Yes
R78	W78	0.97	0.02	4.53	1.01	0.02	4.51	0.98.	Yes
B89	G89	0.94	0.03	5.86	1.01	0.03	5.72	0.95	Yes
	R89	0.96	0.02	6.01	1.01	0.02	6.00	0.97	Yes
	W89	0.85	0.03	3.69	1.12	0.04	3.66	0.95	Yes
G89	R89	0.99	0.03	4.88	0.97	0.03	5.02	0.97	Yes
	W89	0.87	0.03	2.88	1.08	0.04	2.94	0.94	No
R89	W89	0.87	0.03	4.39	1.09	0.04	4.45	0.94	Yes
B910	R910	0.95	0.03	4.51	1.00	0.03	4.51	0.95	Yes
	W910	0.92	0.03	5.60	1.02	0.04	5.64	0.94	Yes
R910	W910	0.95	0.03	5.17	1.00	0.03	5.21	0.95	Yes

Notes: [1]The first letter identifies the market location, B = Brandon, G = Grunthal, R = Ste.Rose, W = Winnipeg. The last two digits correspond with the following weight categories. 45 = #4-500, 56 = #5-600, 67 = #6-700, 78 = #7-800, 89 = #8-900, 910 = #9-1000.

[2]Residual series generated by $P^1_t - \alpha - BP^2_t = \epsilon_t$ were tested for stationarity using the Augmented Dickey Fuller test at the 5% level of significance with a critical value of 3.50. T-stats are shown to accept or reject the null hypothesis of market inefficiency or nonstationarity. T-values less than the critical value indicate that the LOOP does not hold. Failure to reject in one of the two designations was considered evidence of market efficiency.

Appendix E.2. OLS Estimates of Cointegrating Parameters for Manitoba Heifers.

Market[1] Category		B_I	S.E.	Residual[2] t-stat	B_{II}	S.E.	Residual t-stat	R^2	LOOP Holds
B45	G45	0.99	0.02	5.61	0.99	0.02	5.59	0.98	Yes
	R45	0.97	0.03	4.82	0.97	0.03	4.81	0.95	Yes
	W45	1.06	0.03	3.96	0.90	0.03	3.81	0.95	Yes
G45	R45	0.98	0.03	3.71	0.99	0.03	3.76	0.96	Yes
	W45	1.06	0.04	3.81	0.90	0.03	3.69	0.95	Yes
R45	W45	1.06	0.04	4.85	0.89	0.03	4.67	0.95	Yes
B56	G56	0.98	0.02	5.50	1.00	0.02	5.55	0.98	Yes
	R56	0.97	0.02	5.00	1.00	0.03	4.95	0.97	Yes
	W56	1.02	0.02	3.73	0.96	0.02	3.68	0.98	Yes
G56	R56	0.99	0.02	4.00	0.99	0.02	3.95	0.98	Yes
	W56	1.03	0.02	3.77	0.95	0.02	3.67	0.97	Yes
R56	W56	1.03	0.02	4.32	0.95	0.02	4.29	0.98	Yes
B67	G67	0.98	0.02	4.86	1.00	0.02	4.81	0.98	Yes
	R67	0.94	0.02	4.55	1.03	0.02	4.14	0.97	Yes
	W67	1.02	0.03	4.19	0.94	0.03	4.16	0.96	Yes
G67	R67	0.96	0.02	3.39	1.02	0.02	3.34	0.98	No
	W67	1.04	0.03	3.99	0.92	0.03	4.02	0.96	Yes
R67	W67	1.08	0.02	4.60	0.90	0.02	4.67	0.98	Yes
B78	G78	0.93	0.03	5.13	1.04	0.03	5.02	0.96	Yes
	R78	0.95	0.02	6.52	1.02	0.02	6.33	0.97	Yes
	W78	0.94	0.02	4.20	1.03	0.03	4.16	0.97	Yes
G78	R78	1.01	0.02	4.50	0.96	0.02	4.53	0.97	Yes
	W78	1.00	0.03	3.37	0.97	0.03	3.44	0.96	No
R78	W78	0.98	0.02	4.12	1.00	0.02	4.16	0.97	Yes
B89	G89	0.96	0.04	5.36	0.94	0.04	5.28	0.90	Yes
	R89	0.93	0.03	5.56	1.04	0.03	5.49	0.96	Yes
	W89	0.86	0.03	4.37	1.09	0.04	4.37	0.94	Yes
G89	R89	0.89	0.04	5.25	1.02	0.05	5.25	0.89	Yes
	W89	0.82	0.04	4.00	1.07	0.06	4.10	0.88	Yes
R89	W89	0.91	0.03	4.08	1.04	0.03	4.19	0.95	Yes
B91	R910	0.94	0.04	4.89	0.97	0.04	4.79	0.92	Yes
	W910	0.96	0.04	5.37	0.94	0.04	5.80	0.89	Yes
R91	W910	0.98	0.04	4.37	0.93	0.04	4.82	0.91	Yes

Notes: [1]The first letter identifies the market location, B = Brandon, G = Grunthal, R = Ste.Rose, W = Winnipeg. The last two digits correspond with the following weight categories. 45 = #4-500, 56 = #5-600, 67 = #6-700, 78 = #7-800, 89 = #8-900, #9-1000.

[2]Residual series generated by $P^1_t - \alpha - BP^2_t = \epsilon_t$ were tested for stationarity using the Augmented Dickey Fuller test at the 5% level of significance with a critical value of 3.50. T-stats are shown to accept or reject the null hypothesis of market inefficiency or nonstationarity. T-values less than the critical value indicate that the LOOP does not hold. Failure to reject in one of the two designations was considered evidence of market efficiency.

Appendix Table E.3. Provincial / State OLS Estimates of Cointegrating Parameters for Steers.

Market [1] Category		B_I	S.E.	Residual[2] t-stat	B_{II}	S.E.	Residual t-stat	R^2	LOOP Holds
M45	O45	1.08	0.04	4.02	0.87	0.03	4.41	0.94	Yes
	A45	0.92	0.02	5.09	1.06	0.03	4.89	0.97	Yes
	US45	1.37	0.14	2.63	0.48	0.05	3.55	0.65	Yes
O45	A45	0.80	0.03	4.80	1.15	0.05	4.35	0.92	Yes
	US45	1.16	0.14	2.86	0.50	0.06	3.43	0.57	No
A45	US45	1.16	0.13	2.25	0.47	0.04	3.25	0.74	No
M56	O56	1.06	0.03	5.01	0.90	0.03	5.08	0.96	Yes
	A56	0.93	0.02	4.91	1.04	0.03	4.68	0.96	Yes
	US56	0.87	0.06	3.83	0.93	0.07	3.83	0.81	Yes
O56	A56	0.84	0.03	4.43	1.11	0.04	4.24	0.93	Yes
	US56	0.81	0.06	3.86	0.99	0.07	3.70	0.80	Yes
A56	US56	0.98	0.05	3.02	0.91	0.05	3.13	0.89	No
M67	O67	1.02	0.04	3.44	0.91	0.03	3.54	0.93	Yes
	A67	0.94	0.02	3.83	1.04	0.02	3.76	0.98	Yes
	US67	0.90	0.05	3.51	0.94	0.06	3.41	0.85	Yes
O67	A67	0.86	0.04	3.01	1.06	0.05	2.91	0.91	No
	US67	0.83	0.06	3.18	0.97	0.07	3.12	0.80	No
A67	US67	0.97	0.05	2.90	0.93	0.04	3.01	0.90	No
M78	O78	0.97	0.05	3.54	0.92	0.04	3.65	0.89	Yes
	A78	0.97	0.02	3.56	1.01	0.02	3.48	0.98	Yes
	US78	0.95	0.05	3.62	0.92	0.05	3.85	0.87	Yes
O78	A78	0.89	0.05	3.54	0.98	0.05	3.38	0.88	Yes
	US78	0.89	0.06	3.54	0.90	0.06	3.56	0.80	Yes
A78	US78	0.99	0.04	3.44	0.92	0.04	3.78	0.91	Yes
M89	O89	1.00	0.04	4.06	0.90	0.04	3.82	0.90	Yes
	A89	0.97	0.02	4.03	1.00	0.02	3.92	0.97	Yes
	US89	1.00	0.04	3.76	0.92	0.04	3.92	0.92	Yes
O89	A89	0.87	0.04	3.18	1.01	0.05	3.33	0.89	No
	US89	0.90	0.05	4.22	0.95	0.05	4.51	0.86	Yes
A89	US89	1.02	0.04	3.74	0.91	0.34	3.92	0.93	Yes
M910	O910	1.00	0.05	3.64	0.90	0.04	3.42	0.89	Yes
	A910	0.99	0.02	4.25	0.99	0.02	4.24	0.98	Yes
O910	A910	0.89	0.05	3.29	0.98	0.05	3.51	0.87	Yes

Notes: [1]The first letter identifies the market location, A = Alberta, M = Manitoba, O = Ontario, US = United States. The last two digits correspond with the following weight categories. 45 = #4-500, 56 = #5-600, 67 = #6-700, 78 = #7-800, 89 = #8-900, 910 = #9-1000.

[2] Residual series generated by $P^1_t - \alpha - BP^2_t = \epsilon_t$ were tested for stationarity using the Augmented Dickey Fuller test at the 5% level of significance with a critical value of 3.50. T-stats are shown to accept or reject the null hypothesis of market inefficiency or nonstationarity. T-values less than the critical value indicate that the LOOP does not hold. Failure to reject in one of the two designations was considered evidence of market efficiency.

Appendix Table E.4. Provincial / State OLS Estimates of Cointegrating Parameters for Heifers.

Market[1] Category		B_I	S.E.	Residual[2] t-stat	B_{II}	S.E.	Residual t-stat	R^2	LOOP Holds
M34	O34	1.08	.056	3.55	0.81	0.04	3.76	.88	Yes
	A34	0.92	0.03	4.46	1.02	0.04	4.32	.94	Yes
O34	A34	0.79	0.03	3.78	1.18	0.04	3.41	.93	Yes
M45	O45	1.06	0.04	3.92	0.90	0.03	4.15	.95	Yes
	A45	0.93	0.17	5.53	1.06	0.20	5.32	.98	Yes
	US45	0.94	0.08	2.55	0.78	0.07	2.17	.73	No
O45	A45	0.83	0.03	4.54	1.11	0.04	4.08	.93	Yes
	US45	0.89	0.07	4.70	0.87	0.07	4.05	.77	Yes
A45	US45	1.05	0.08	2.36	0.75	0.06	2.20	.78	No
M56	O56	1.05	0.04	3.41	0.90	0.03	3.47	.94	No
	A56	0.94	0.02	5.00	1.04	0.02	4.93	.98	Yes
	US56	0.91	0.08	2.71	0.79	0.07	2.94	.72	No
O56	A56	0.85	0.03	3.71	1.09	0.04	3.53	.92	Yes
	US56	0.91	0.07	3.52	0.84	0.06	3.36	.77	Yes
A56	US56	0.99	0.08	2.69	0.76	0.06	2.88	.76	No
M67	O67	1.03	0.04	2.67	0.91	0.03	2.74	.93	No
	A67	1.05	0.02	3.65	0.94	0.02	3.62	.98	Yes
	US67	1.04	0.07	2.94	0.78	0.05	2.54	.81	No
O67	A67	0.85	0.04	2.55	1.07	0.05	2.49	.91	No
	US67	1.00	0.08	3.29	0.77	0.06	3.35	.77	No
A67	US67	1.12	0.07	3.10	0.75	0.05	2.79	.84	Yes
M78	O78	1.04	0.04	3.59	0.88	0.04	3.71	.92	Yes
	A78	0.95	0.16	3.98	1.03	0.02	3.97	.98	Yes
	US78	0.85	0.06	3.35	0.95	0.07	3.55	.80	Yes
O78	A78	0.85	0.04	3.34	1.08	0.05	3.23	.92	No
	US78	0.97	0.08	3.89	0.79	0.06	4.08	.76	Yes
A78	US78	0.89	0.06	2.87	0.91	0.06	2.94	.81	No
M89	O89	1.04	0.05	3.16	0.85	0.04	3.27	.88	No
	A89	0.89	0.02	5.58	1.11	0.02	5.20	.98	Yes
O89	A89	0.76	0.04	2.97	1.15	0.06	2.92	.87	No

Notes: [1]The first letter identifies the market location, A = Alberta, M = Manitoba, O = Ontario, US = United States. The last two digits correspond with the following weight categories. 45 = #4-500, 56 = #5-600, 67 = #6-700, 78 = #7-800, 89 = #8-900.

[2]Residual series generated by $P^1_t - \alpha - BP^2_t = \epsilon_t$ were tested for stationarity using the Augmented Dickey Fuller test at the 5% level of significance with a critical value of 3.50. T-stats are shown to accept or reject the null hypothesis of market inefficiency or nonstationarity. T-values less than the critical value indicate that the LOOP does not hold. Failure to reject in one of the two designations was considered evidence of market efficiency.

APPENDIX
" F "

ANALYSIS OF VARIANCE RESULTS

Table F.1. Analysis of Variance by Market Location and Sale Month for Manitoba #4-500 to #900-1,000 Feeder Steer Prices.

Dependent Variable: Price of Feeder Steers										
Weight Category	Df[1] Market Location (l)	F-Value	Proba-bility (%)	Df Sale Month (m)	F-Value	Proba-bility (%)	Df Model	F-Value	Proba-bility (%)	R^2
#4-500	3	4.56	0.43	52	115.44	0.01	55	109.39	0.01	97.47
#5-600	3	10.14	0.01	52	214.15	0.01	55	203.02	0.01	98.62
#6-700	3	22.36	0.01	52	180.30	0.01	55	171.68	0.01	98.37
#7-800	3	36.49	0.01	52	239.82	0.01	55	228.72	0.01	98.78
#8-900	3	38.69	0.01	52	112.17	0.01	55	108.16	0.01	97.44
#9-1,000	2	4.78	1.03	52	93.44	0.01	54	90.15	0.01	97.91

Note: Grunthal data was not available for the #9-1,000 weight category.
[1] Df denotes degrees of freedom

Table F.2. Analysis of Variance by Market Location and Sale Month for Manitoba #4-500 to #900-1,000 Feeder Heifer Prices.

Dependent Variable: Price of Feeder Heifers										
Weight Category	Df[1] Market Location (l)	F-Value	Proba-bility (%)	Df Sale Month (m)	F-Value	Proba-bility (%)	Df Model	F-Value	Proba-bility (%)	R^2
#4-500	3	11.02	0.01	52	156.18	0.01	55	148.26	0.01	98.12
#5-600	3	12.82	0.01	52	335.33	0.01	55	317.74	0.01	99.11
#6-700	3	13.16	0.01	52	223.22	0.01	55	211.76	0.01	98.68
#7-800	3	26.01	0.01	52	248.57	0.01	55	236.43	0.01	98.81
#8-900	3	34.33	0.01	52	79.41	0.01	55	76.95	0.01	96.45
#9-1,000	2	3.31	4.04	52	55.25	0.01	54	53.33	0.01	96.51

Note: U.S. data was not available for the #9-1,000 weight category.
[1] Df denotes degrees of freedom.

Table F.3. Analysis of Variance by Market Location and Sale Month for Western Canadian and U.S. #4-500 to #900-1,000 Feeder Steer Prices.

Dependent Variable: Price of Feeder Steers										
Weight Category	Df[1] Market Location (l)	F-Value	Proba-bility (%)	Df Sale Month (m)	F-Value	Proba-bility (%)	Df Model	F-Value	Proba-bility (%)	R^2
#4-500	3	20.82	0.01	52	26.31	0.01	55	26.01	0.01	90.17
#5-600	3	9.87	0.01	52	27.49	0.01	55	26.52	0.01	90.34
#6-700	3	9.97	0.01	52	9.44	0.01	55	9.47	0.01	76.95
#7-800	3	9.86	0.01	52	16.76	0.01	55	16.38	0.01	85.24
#8-900	3	9.03	0.01	52	12.71	0.01	55	12.51	0.01	81.52
#9-1,000	2	20.63	1.03	52	72.31	0.01	54	70.40	0.01	97.34

Note: U.S. data was not available for the #9-1,000 weight category.
[1] Df denotes degrees of freedom.

Table F.4. Analysis of Variance by Market Location and Sale Month for Western Canadian and U.S. #3-400 to #8-900 Feeder Heifer Prices.

Dependent Variable: Price of Feeder Heifers										
Weight Category	Df[1] Market Location (l)	F-Value	Proba-bility (%)	Df Sale Month (m)	F-Value	Proba-bility (%)	Df Model	F-Value	Proba-bility (%)	R^2
#3-400	2	112.24	0.01	52	50.80	0.01	54	53.08	0.01	96.50
#4-500	3	19.45	0.01	52	33.68	0.01	55	32.90	0.01	92.06
#5-600	3	14.38	0.01	52	24.09	0.01	55	23.56	0.01	89.26
#6-700	3	14.62	0.01	52	16.99	0.01	55	16.86	0.01	85.60
#7-800	3	12.39	0.01	52	12.01	0.01	55	12.03	0.01	80.92
#8-900	2	2.85	6.22	52	47.70	0.01	54	46.03	0.01	95.98

Note: U.S. data was not available for the #3-400 and #8-900 weight categories.
[1] Df denotes degrees of freedom.

Table F.5. Analysis of Variance by Weight Category and Sale Month for Manitoba Feeder Steer Prices.

Dependent Variable: Price of Feeder Steers										
Weight Category	Df[1] Weight Category (wc)	F-Value	Proba-bility (%)	Df Sale Month (m)	F-Value	Proba-bility (%)	Df Model	F-Value	Proba-bility (%)	R^2
Winnipeg	5	168.71	0.01	52	67.72	0.01	57	76.58	0.01	94.38
Brandon	5	187.60	0.01	52	53.22	0.01	57	65.01	0.01	93.44
Grunthal	4	212.42	0.01	52	64.09	0.01	56	74.68	0.01	95.26
Ste. Rose	5	163.02	0.01	52	47.44	0.01	57	57.58	0.01	92.66

Note: Grunthal data was not available for the #9-1000 category.
[1] Df denotes degrees of freedom

Table F.6. Analysis of Variance by Weight Category and Sale Month for Manitoba Feeder Heifer Prices.

Dependent Variable: Price of Feeder Heifers										
Weight Category	Df[1] Weight Category (wc)	F-Value	Proba-bility (%)	Df Sale Month (m)	F-Value	Proba-bility (%)	Df Model	F-Value	Proba-bility (%)	R^2
Winnipeg	5	107.52	0.01	52	61.29	0.01	57	65.35	0.01	93.48
Brandon	5	121.32	0.01	52	48.29	0.01	57	54.69	0.01	92.30
Grunthal	4	109.64	0.01	52	56.18	0.01	56	60.00	0.01	94.17
Ste. Rose	5	102.23	0.01	52	53.95	0.01	57	58.18	0.01	92.73

Note: Grunthal data was not available for the #9-1000 category.
[1] Df denotes degrees of freedom.

Table F.7. Analysis of Variance by Augmented Weight Categories and Sale Month for Winnipeg and Brandon Feeder Steer Prices.

Dependent Variable: Price of Feeder Steers										
Weight Category	Df[1] Weight Category (wc)	F-Value	Proba-bility (%)	Df Sale Month (m)	F-Value	Proba-bility (%)	Df Model	F-Value	Proba-bility (%)	R^2
Winnipeg	10	162.32	0.01	52	151.26	0.01	62	153.04	0.01	94.80
Brandon	10	188.61	0.01	52	123.72	0.01	62	134.19	0.01	94.12

Note: [1] Df denotes degrees of freedom.

Table F.8. Analysis of Variance by Augmented Weight Categories and Sale Month for Winnipeg and Brandon Feeder Heifer Prices.

Dependent Variable: Price of Feeder Heifers										
Weight Category	Df[1] Weight Category (wc)	F-Value	Proba-bility (%)	Df Sale Month (m)	F-Value	Proba-bility (%)	Df Model	F-Value	Proba-bility (%)	R^2
Winnipeg	10	95.22	0.01	52	130.24	0.01	62	124.59	0.01	93.69
Brandon	10	118.69	0.01	62	110.34	0.01	62	111.69	0.01	93.02

Note: 1 Df denotes degrees of freedom.

APPENDIX
" G "

LEAST SIGNIFICANT DIFFERENCE TEST RESULTS

Table G.1. Summary of Sub-sample Statistics and Rankings for Winnipeg, Brandon, Grunthal and Ste. Rose #4-500 to #900-1,000 Feeder Steer Markets by Price.

Weight Class	Mean[1] Rank	Location	N	Min $/cwt	Max $/cwt	Std. Dev. $/cwt	Mean $/cwt	CV	Mean[2] Group
	1	Brandon	53	75.20	144.25	20.68	112.81	0.18	A
#4-500	2	Ste. Rose	53	72.75	152.17	21.43	112.22	0.19	AB
LSD=1.45	3	Grunthal	53	72.92	140.38	20.31	110.95	0.18	AB
MSD=1.96	4	Winnipeg	53	69.92	136.46	19.63	110.41	0.18	B
	1	Ste. Rose	53	75.50	147.50	19.45	109.84	0.18	A
#5-600	2	Brandon	53	73.63	136.13	18.69	108.47	0.17	B
LSD=0.98	3	Winnipeg	53	72.63	136.46	18.88	107.76	0.18	B
MSD=1.32	4	Grunthal	53	75.00	136.63	17.93	107.28	0.17	B
	1	Ste. Rose	53	70.50	129.38	16.93	103.98	0.16	A
#6-700	2	Brandon	53	72.45	127.13	15.96	102.67	0.16	B
LSD=0.90	3	Winnipeg	53	70.44	122.65	15.14	100.87	0.15	C
MSD=1.22	4	Grunthal	53	71.92	126.63	15.69	100.82	0.16	C
	1	Ste. Rose	53	69.25	120.75	14.05	97.45	0.14	A
#7-800	2	Winnipeg	53	69.29	122.55	14.42	97.32	0.15	A
LSD=0.68	3	Brandon	53	70.34	117.94	13.73	97.29	0.14	A
MSD=0.92	4	Grunthal	53	65.25	116.47	13.17	94.40	0.14	B
	1	Winnipeg	53	68.03	122.55	13.80	94.70	0.15	A
#8-900	2	Ste. Rose	53	68.96	110.81	11.84	92.87	0.13	B
LSD=0.87	3	Brandon	53	69.31	110.00	11.55	92.69	0.12	B
MSD=1.18	4	Grunthal	53	63.79	107.18	11.52	89.98	0.13	C
	1	Winnipeg	53	66.75	108.03	10.36	89.11	0.12	A
#9-1,000	2	Brandon	53	66.31	104.50	9.70	88.29	0.11	AB
LSD=0.68	3	Ste. Rose	53	65.75	103.25	9.80	88.13	0.11	B
MSD=0.83									

Note: Grunthal data was not available for the #9-1,000 category.

[1] Mean rankings are based on mean price levels.

[2] Mean groupings are based on the MSD values. Only means that differed by more than the MSD values could be ranked into separate groups represented by the different letter. Markets with two letters could not be differentiated from the category above or below.

Table G.2. Summary of Sub-sample Statistics and Rankings for Winnipeg, Brandon, Grunthal and Ste. Rose #4-500 to #900-1,000 Feeder Heifer Markets by Price.

Weight Class	Mean[1] Rank	Location	N	Min $/cwt	Max $/cwt	Std. Dev. $/cwt	Mean $/cwt	CV	Mean[2] Group
	1	Brandon	53	67.19	132.75	20.90	104.50	0.20	A
#4-500	2	Ste.Rose	53	63.50	135.83	20.24	102.22	0.20	B
LSD=1.21	3	Winnipeg	53	64.75	126.16	18.58	102.01	0.18	B
MSD=1.64	4	Grunthal	53	65.83	129.75	20.08	101.11	0.20	B
	1	Brandon	53	67.06	126.08	18.35	100.51	0.18	A
#5-600	2	Winnipeg	53	67.29	126.16	17.65	99.43	0.18	B
LSD=0.76	3	Ste.Rose	53	66.58	128.75	18.38	99.39	0.18	B
MSD=1.02	4	Grunthal	53	64.42	125.75	18.01	98.15	0.18	C
	1	Brandon	53	67.39	119.75	15.59	95.86	0.16	A
#6-700	2	Ste.Rose	53	65.29	121.50	16.25	95.40	0.17	A
LSD=0.79	3	Winnipeg	53	66.10	112.81	14.58	94.04	0.16	B
MSD=1.07	4	Grunthal	53	65.00	118.56	15.39	93.75	0.16	B
	1	Brandon	53	65.59	110.88	13.16	91.86	0.14	A
#7-800	2	Winnipeg	53	63.25	112.81	13.74	91.82	0.15	A
LSD=0.65	3	Ste.Rose	53	65.50	112.63	13.55	91.51	0.15	A
MSD=0.88	4	Grunthal	53	61.18	111.75	13.47	89.37	0.15	B
	1	Winnipeg	53	65.03	112.81	12.63	89.44	0.14	A
#8-900	2	Ste.Rose	53	64.38	107.75	11.49	88.56	0.13	AB
LSD=0.96	3	Brandon	53	64.50	105.25	10.80	87.77	0.12	B
MSD=1.30	4	Grunthal	53	62.88	99.88	10.27	84.81	0.12	C
	1	Winnipeg	53	64.75	105.19	9.41	84.97	0.11	A
#9-1,000	2	Ste.Rose	53	62.38	98.25	9.32	84.08	0.11	A
LSD=0.82	3	Brandon	53	62.85	101.50	9.32	84.02	0.11	A
MSD=1.01									

Note: Grunthal data was not available for the #9-1,000 category

[1] Mean rankings are based on mean price levels.

[2] Mean groupings are based on the MSD values. Only means that differed by more than the MSD values could be ranked into separate groups represented by the different letter. Markets with two letters could not be differentiated from the category above or below.

Table G.3. Summary of Sub-sample Statistics and Rankings for Alberta, Manitoba, Ontario and U.S. #4-500 to #900-1,000 Feeder Steer Markets by Price.

Weight Class	Mean[1] Rank	Location	N	Min $/cwt	Max $/cwt	Std. Dev. $/cwt	Mean $/cwt	CV	Mean[2] Group
#4-500	1	Alberta	53	74.44	144.61	21.87	111.94	0.20	A
LSD=2.96	2	Manitoba	53	75.50	146.88	20.49	110.74	0.19	A
MSD=4.00	3	U.S.	53	48.77	135.72	23.70	105.58	0.22	B
	4	Ontario	53	71.38	132.42	16.84	101.48	0.17	C
#5-600	1	Alberta	53	72.50	137.89	19.46	106.82	0.18	A
LSD=2.63	2	Manitoba	53	73.63	141.48	18.51	106.24	0.17	A
MSD=3.56	3	U.S.	53	41.27	128.79	21.24	103.39	0.21	AB
	4	Ontario	53	73.00	129.54	16.19	100.38	0.16	B
#6-700	1	Alberta	53	69.96	129.10	16.79	101.57	0.17	A
LSD=4.05	2	Manitoba	53	71.00	128.71	16.00	101.06	0.16	A
MSD=5.75	3	Ontario	53	73.25	124.95	14.67	96.75	0.15	AB
	4	U.S.	53	25.16	120.75	25.14	91.72	0.27	B
#7-800	1	Alberta	53	68.49	118.86	13.87	96.28	0.14	A
LSD=2.58	2	Manitoba	53	69.50	118.77	13.60	96.16	0.14	A
MSD=3.49	3	Ontario	53	71.75	122.83	13.10	92.88	0.14	AB
	4	U.S.	53	53.65	113.51	18.60	90.23	0.21	B
#8-900	1	Alberta	53	67.22	108.61	11.59	91.92	0.13	A
LSD=2.52	2	Ontario	53	68.30	110.47	10.67	91.78	0.12	A
MSD=3.41	3	Manitoba	53	67.86	110.77	11.54	91.75	0.13	A
	4	U.S.	53	48.60	107.12	17.25	86.39	0.20	B
#9-1,000	1	Ontario	53	67.90	105.38	8.91	88.81	0.10	A
LSD=0.71	2	Manitoba	53	66.90	102.43	9.43	87.41	0.11	B
MSD=0.88	3	Alberta	53	65.79	100.65	9.33	86.52	0.11	C

Note: U.S. data was not available for the #9-1,000 category.

[1] Mean rankings are based on mean price levels.

[2] Mean groupings are based on the MSD values. Only means that differed by more than the MSD values could be ranked into separate groups represented by the different letter. Markets with two letters could not be differentiated from the category above or below.

Table G.4 Summary of Sub-sample Statistics and Rankings for Alberta, Manitoba, Ontario and U.S. #3-400 to #8-900 Feeder Heifer Markets by Price.

Weight Class	Mean[1] Rank	Location	N	Min $/cwt	Max $/cwt	Std. Dev. $/cwt	Mean $/cwt	CV	Mean[2] Group
#3-400	1	Manitoba	53	63.50	142.75	21.69	105.95	0.20	A
LSD=1.88	2	Alberta	53	65.50	138.29	22.44	104.04	0.22	A
MSD=2.31	3	Ontario	53	65.50	123.06	16.93	92.79	0.18	B
#4-500	1	Manitoba	53	67.83	133.63	19.91	101.75	0.20	A
LSD=2.53	2	Alberta	53	64.26	131.93	20.66	101.23	0.20	A
MSD=3.42	3	U.S.	53	58.23	131.45	21.92	97.01	0.23	B
	4	Ontario	53	65.80	125.01	17.10	93.23	0.18	C
#5-600	1	Manitoba	53	68.19	127.42	18.03	98.20	0.18	A
LSD=2.77	2	Alberta	53	63.59	126.44	18.53	97.56	0.19	A
MSD=3.74	3	Ontario	53	66.75	121.19	15.71	91.90	0.17	B
	4	U.S.	53	41.10	119.03	22.21	90.95	0.24	B
#6-700	1	Manitoba	53	66.75	121.15	15.61	94.19	0.17	A
LSD=2.84	2	Alberta	53	63.32	119.42	16.05	93.94	0.17	A
MSD=3.84	3	Ontario	53	63.88	118.12	14.00	88.47	0.16	B
	4	U.S.	53	46.74	113.85	19.93	86.49	0.23	B
#7-800	1	Manitoba	53	64.38	113.44	13.15	90.65	0.15	A
LSD=2.92	2	Alberta	53	63.51	111.03	13.50	90.52	0.15	AB
MSD=3.95	3	Ontario	53	66.00	111.05	11.73	86.64	0.14	BC
	4	U.S.	53	34.59	105.92	19.42	82.92	0.23	C
#8-900	1	Manitoba	53	63.25	103.03	10.40	85.93	0.12	A
LSD=0.98	2	Alberta	53	60.38	102.24	11.21	84.94	0.13	A
MSD=1.20	3	Ontario	53	63.60	103.74	9.21	84.88	0.11	A

Note: U.S. data was not available for the #8-900 category.

[1] Mean rankings are based on mean price levels.

[2] Mean groupings are based on the MSD values. Only means that differed by more than the MSD values could be ranked into separate groups represented by the different letter. Markets with two letters could not be differentiated from the category above or below.

Table G.5 Summary of Mean and Mean Group Rankings of Manitoba Markets Across #4-500 to #900-1,000 Feeder Steer Weight Classes by Price.

Market Location	Mean[1] Rank	Weight Class	N	Mean $/cwt	Mean[2] Group
	1	#4-500	53	110.41	A
Winnipeg	2	#5-600	53	107.76	B
LSD=1.72	3	#6-700	53	100.87	C
MSD=2.59	4	#7-800	53	97.32	D
	5	#8-900	53	94.70	E
	6	#9-1,000	53	89.11	F
	1	#4-500	53	112.81	A
Brandon	2	#5-600	53	108.47	B
LSD=1.91	3	#6-700	53	102.67	C
MSD=2.87	4	#7-800	53	97.29	D
	5	#8-900	53	92.69	E
	6	#9-1,000	53	88.29	F
	1	#4-500	53	110.95	A
Grunthal	2	#5-600	53	107.28	B
LSD=1.66	3	#6-700	53	100.82	C
MSD=2.40	4	#7-800	53	94.40	D
	5	#8-900	53	89.98	E
	1	#4-500	53	112.22	A
Ste. Rose	2	#5-600	53	109.84	A
LSD=2.08	3	#6-700	53	103.98	B
MSD=3.14	4	#7-800	53	97.45	C
	5	#8-900	53	92.87	D
	6	#9-1,000	53	88.13	E

Note: Grunthal data was not available for the #9-1,000 category.

[1] Mean rankings are based on mean price levels.

[2] Mean groupings are based on the MSD values. Only means that differed by more than the MSD values could be ranked into separate groups represented by the different letter. Weight classes with two letters could not be differentiated from the category above or below.

Table G.6 Summary of Mean and Mean Group Rankings of Manitoba Markets Across #4-500 to #900-1,000 Feeder Heifer Weight Classes by Price.

Market Location	Mean[1] Rank	Weight Class	N	Mean $/cwt	Mean[2] Group
	1	#4-500	53	102.01	A
	2	#5-600	53	99.43	B
Winnipeg	3	#6-700	53	94.04	C
LSD=1.70	4	#7-800	53	91.82	CD
MSD=2.55	5	#8-900	53	89.44	D
	6	#9-1,000	53	84.97	E
	1	#4-500	53	104.50	A
	2	#5-600	53	100.51	B
Brandon	3	#6-700	53	95.86	C
LSD=1.96	4	#7-800	53	91.86	D
MSD=2.94	5	#8-900	53	87.77	E
	6	#9-1,000	53	84.02	F
	1	#4-500	53	101.11	A
Grunthal	2	#5-600	53	98.15	B
LSD=1.75	3	#6-700	53	93.75	C
MSD=2.51	4	#7-800	53	89.37	D
	5	#8-900	53	84.81	E
	1	#4-500	53	102.22	A
	2	#5-600	53	99.39	B
Ste. Rose	3	#6-700	53	95.40	C
LSD=1.87	4	#7-800	53	91.51	D
MSD=2.82	5	#8-900	53	88.56	E
	6	#9-1,000	53	84.08	F

Note: Grunthal data was not available for the #9-1,000 category.
[1] Mean rankings are based on mean price levels.
[2] Mean groupings are based on the MSD values. Only means that differed by more than the MSD values could be ranked into separate groups represented by the different letter. Weight classes with two letters could not be differentiated from the category above or below.

Table G.7 Summary of Mean and Mean Group Rankings of Winnipeg and Brandon Markets across #4-500 to #900-1,000 Feeder Steer Weight Classes by Price.

Market Location	Mean[1] Rank	Weight Class	N	Mean $/cwt	Mean[2] Group
	1	#4-500	53	110.41	A
	2	#4-600	53	109.12	AB
	3	#5-600	53	107.76	B
	4	#5-700	53	104.74	C
Winnipeg	5	#6-700	53	100.87	D
LSD=1.55	6	#6-800	53	99.51	DE
MSD=2.64	7	#7-800	53	97.32	EF
	8	#7-900	53	95.74	F
	9	#8-900	53	94.70	FG
	10	#8-1,000	53	92.26	G
	11	#9-1,000	53	89.11	H
	1	#4-500	53	112.81	A
	2	#4-600	53	110.77	AB
	3	#5-600	53	108.47	B
	4	#5-700	53	105.57	C
Brandon	5	#6-700	53	102.67	D
LSD=1.69	6	#6-800	53	100.01	DE
MSD=2.87	7	#7-800	53	97.29	EF
	8	#7-900	53	95.05	FG
	9	#8-900	53	92.69	GH
	10	#8-1,000	53	90.59	HI
	11	#9-1,000	53	88.29	I

Note: [1] Mean rankings are based on mean price levels.
[2] Mean groupings are based on the MSD values. Only means that differed by more than the MSD values could be ranked into separate groups represented by the different letter. Weight classes with two letters could not be differentiated from the category above or below.

Table G.8 Summary of Mean and Mean Group Rankings of Winnipeg and Brandon Markets across #4-500 to #900-1,000 Feeder Heifer Weight Classes by Price.

Market Location	Mean[1] Rank	Weight Class	N	Mean $/cwt	Mean[2] Group
Winnipeg LSD=1.58 MSD=2.68	1	#4-500	53	102.01	A
	2	#4-600	53	100.74	A
	3	#5-600	53	99.43	AB
	4	#5-700	53	96.91	B
	5	#6-700	53	94.04	C
	6	#7-800	53	91.82	CD
	7	#6-800	53	91.73	CD
	8	#7-900	53	90.93	D
	9	#8-900	53	89.44	DE
	10	#8-1,000	53	87.65	EF
	11	#9-1,000	53	84.97	F
Brandon LSD=1.74 MSD=2.96	1	#4-500	53	104.50	A
	2	#4-600	53	102.59	AB
	3	#5-600	53	100.51	BC
	4	#5-700	53	98.18	CD
	5	#6-700	53	95.86	DE
	6	#6-800	53	93.78	EF
	7	#7-800	53	91.86	FG
	8	#7-900	53	89.90	GH
	9	#8-900	53	87.77	HI
	10	#8-1,000	53	86.21	IJ
	11	#9-1,000	53	84.02	J

Note: [1] Mean rankings are based on mean price levels.
[2] Mean groupings are based on the MSD values. Only means that differed by more than the MSD values could be ranked into separate groups represented by the different letter. Weight classes with two letters could not be differentiated from the category above or below.