An Assessment of the Reliability of CanFax Reported Negotiated Fed Cattle Transactions and Market Prices

Submitted to:
CanFax Research Services
Canadian Cattlemen's Association

Submitted by:

Ted C. Schroeder, Ph.D.

Eric J. Belasco, Ph.D.

March 1, 2016

Table of Contents

SECTION I. EXECUTIVE SUMMARY

Purpose

This report summarizes analyses completed to assess the reliability of CanFax negotiated fed cattle market price reports. With thinning negotiated fed cattle trade and fewer transactions being available to compile such reports over time, understanding the reliability and how it is changing over time is critical to assessing the value of price reports.

Approach

We analyzed all transactions comprising CanFax negotiated fed cattle price reports over the 2004-2015 period to determine reliability over time. We also compared formula trade price reports available since mid-2014 with negotiated trade of the same time period. Specifically, we assessed the number of transactions represented in rail and live prices over time, variability in reported prices, and seasonality in these measures. The efficacy of using formula trade to inform or cross-check negotiated prices was also evaluated. Finally, the number of transactions CanFax needs to collect to have confidence in reported prices was determined.

Key Findings

- The number of fed cattle transactions CanFax has collected on negotiated trade has dropped precipitously from nearly 3,500 annually in 2004 to just 337 in 2015.

- In 2015, the number of transactions included in the CanFax negotiated price report increased for the first time in over the past decade relative to the prior year by 2.4%, suggesting either increased resources in price collection by CanFax or possible stabilization in numbers of negotiated trades occurring. However, 337 total transactions in 2015 is on average less than 7 transactions per week and less during some weeks because of seasonality.

- Seasonality in the number of negotiated transactions in CanFax reports is apparent as over the past six years (2010-2015) about 9-11% of transactions occur in each March, April, May, June, and August, whereas, less than 7% occur in November-December.

- Live sales represent about 55% and rail sales 45% of negotiated transactions from 2004-2015. This split has changed over time as rail sales represented 41% of all transactions from 2004-2009 and 63% of all transactions from 2010-2015.

- Variation in weekly CanFax reported prices, conditional on price levels, has not increased over time with thinning reports. In fact, conditional variability has been notably smaller since 2010 than prior. This indicates that within the reported price

series themselves, on a weekly basis, they are not more volatile providing some comfort that unexplained noise in reported prices is not increasing in recent years.

- The ratio of live to rail prices varies week to week, but for the most part has ranged from 58.9% to 60.5% over time. There has been an upward trend in the ratio since 2008-09 when it was a bit over 59% to being greater than 60% in 2014-15. This indicates reported live prices have increased relative to rail prices.

- CanFax reported fed cattle rail transaction prices have generally been highly correlated with US benchmark dressed prices of both the Nebraska Direct market as well as the Five-Region market. Simple correlations of weekly prices exceed 0.98 over 2010-2015. The correlation in the natural logarithm of weekly price differences, which removes common longer run trends and is commonly used in empirical commodity price studies, is 0.36 during the past six years. Correlations have in fact increased over the 2010-2015 time period suggesting weekly average CanFax reported transaction prices are more closely aligned with the US benchmark prices over recent years.

- Formula trade prices have been collected and reported by CanFax since August 2014. Formula trades have mostly been rail (90%) as opposed to live basis. Formula trades are on average committed to the packer 16 days in advance of slaughter, but a large range (2 to 37 days) is present between commitment and slaughter on formula transactions.

- A Comparison of formula trade to negotiated transactions reveals formula rail prices lag negotiated prices by about two weeks. That is, rail prices for formula cattle delivered this week are most closely associated with negotiated prices reported two weeks ago.

- Formula rail prices this week are on average $4.91/cwt higher than negotiated rail prices reported two weeks earlier. Formula rail prices can be used as an approximation for checking negotiated prices two weeks earlier, but formula trade will only be a rough proxy as the two prices often diverge by $6/cwt and at times by $10/cwt either up or down (after the average $4.91/cwt adjustment). We see modest value in using formula trade prices to inform or check negotiated prices.

- An assessment was made to estimate how many transactions CanFax would need to collect and report for various levels of confidence in reported sampled prices being reliable estimates of the population of market prices. To be 95% confident prices reported are within $0.50/cwt of the negotiated fed cattle market price each week, CanFax would need at least 17 transactions included in their weekly report. If they had only 4 transactions in the report (randomly selected from the population), the

95% confidence interval would expand to $1.00/cwt for both live and rail transactions.

- Given seasonality and the number of transactions collected by CanFax during 2014-2015, it appears that reasonably reliable weekly and monthly price reporting was achieved in most months with a variance of $0.90-$1.00/cwt, which places a wide range around price estimates.

Recommendations

- CanFax is doing a good job reporting fed cattle transaction prices in a thinning market and this is a service that provides important market information to stakeholders. Over time, CanFax reported negotiated fed cattle prices have a strong correlation with US fed cattle markets and the strength of this correlation has increased in recent years. However, the numbers of transactions represented in CanFax reporting have declined markedly and are at critical threshold levels for price reporting reliability. As such, we recommend increasing efforts to collect more transactions on negotiated trade each week – striving for at least doubling the numbers of transactions collected per week in 2016 is recommended.

- We recommend on-going surveillance of regularly assessing the relationship between CanFax reported prices and US benchmarks. Continued efforts should also include obtaining access to packer data samples to regularly assess price reporting accuracy. Given the importance of price reporting information, assessing price reporting reliability should be a regular and on-going activity.

- Including price reports from Saskatchewan fed cattle trade does add some to price reporting overall as these prices are consistent over time with Alberta prices. However, Saskatchewan transactions are so few that they are not adding much value and time might be better spent trying to capture more Alberta transaction prices.

- Formula trade is sufficiently different from negotiated trade that each does not provide a precise barometer for the other. Over time, the two prices generally follow similar major trends, but formula prices often diverge in economically important ways from negotiated prices.

SECTION II. INTRODUCTION AND OVERVIEW

Introduction

The overriding purpose of this study was to determine the reliability of fed cattle negotiated transaction prices collected and reported by CanFax. As cash negotiated fed cattle markets have thinned over time, with fewer transactions taking place, the reliability of reported prices in this thin market is a concern. In a thin market, a few transactions that may not be representative of overall market conditions can significantly influence reported prices. Furthermore, as markets thin, market data on recent prices become less available reducing the information content of price reports for those who are negotiating transactions. Increased variability in discovered prices occurs as market information becomes increasingly scarce.

To directly test reliability of CanFax reported fed cattle transaction prices ideally we would compare these sampled prices with the population of transaction prices from beef packer purchase records. Having the population of prices would provide a direct test of the reliability of sampled prices. Unfortunately, beef packer transaction data were not available for this study. These data were requested from packers, but access was not provided to the research team. However, even with proprietary packer cattle negotiated purchase records, if the cash negotiated transactions are unduly thin, packer data may also not provide definitive tests on reliability of CanFax reported prices beyond simply determining whether the reported prices track the population. That is, likely Canada's overall negotiated fed cattle market is sufficiently thin that problems associated with thin markets are also prevalent in packer transaction data.

Assessing the reliability of reported prices also can rely upon available benchmark price series that are known to be reliable. However, in the case of Canadian fed cattle transaction prices, no perfect benchmark exists. Arguably, US fed cattle market prices can be used as a benchmark. However, the US market prices are imperfect benchmarks for Canadian fed cattle prices for several reasons including differences is localized supply and demand across these spatially disparate markets; meandering exchange rates and transportation costs; and the fact that the US negotiated cash fed cattle market is also thinning itself raising questions of its own reliability.

As a result of the above constraints, we rely on a combination of empirical methods and data to assess the characteristics of CanFax reported prices themselves over time together with comparing these price series with imperfect benchmarks of fed cattle prices reported in the US. Valuable inferences can still be gleaned from this analysis, but these important limitations are apparent and must be kept in mind as findings are reviewed and implications are synthesized.

Overview

This study focuses on characterizing the reliability of using transaction price data from Alberta and Saskatchewan to provide price discovery information for buyers and sellers of fed cattle in Canada. To examine the issues associated with price discovery, data were collected from CanFax on cash transactions between 2004-2015. The negotiated transaction data are summarized in table 2.1.

Table 2.1. Frequency Counts for Major Indicators by Location, 2004-2015.

Location	Gender		Type		Buyer		Total
	Heifer	Steer	Live	Rail	CDN	US	Transactions
Alberta	6,260	10,276	8,732	7,804	15,426	1,110	16,536
	37.9%	62.1%	52.8%	47.2%	93.3%	6.7%	88.9%
Saskatchewan	781	1,279	1,443	617	1,898	162	2,060
	37.9%	62.1%	70.0%	30.0%	92.1%	7.9%	11.1%
Total	6,967	11,436	10,145	8,258	17,136	1,267	18,596
	37.5%	61.5%	54.6%	44.4%	92.1%	6.8%	

Approximately 89% of the transactions are from the Alberta market region, 55% are based on live pricing, 92% are transactions that include a Canadian buyer, and 62% are steers. Alberta transactions are more evenly split between live and rail transactions, while both locations have nearly equal proportions of steer/heifer and US/CDN buyer splits. The split between live and rail has changed over time as the percent of transactions from rail pricing since 2010 increased to 62% (up from 43% for 2004-2009) of the total transactions in Alberta and 68% (up from 21% for 2004-2009) of the total transactions in Saskatchewan.

One concern within Canadian transaction data is the extent to which a smaller number of transactions may change the variance around the CanFax reported price series. As shown below in figure 2.1, the numbers of transactions represented in negotiated trade reports in both Alberta and Saskatchewan are falling at similar rates, albeit with Alberta starting from a substantially higher base. Maintaining price discovery information on an on-going basis is concerning given the consistent drop in cash transactions at both locations. The figures contained within figure 2.1 are shown in table 2.2 and also reported as a percentage of total transactions. In 2015, 325 transactions were reported in Alberta and 12 transactions were reported in Saskatchewan. However, it is notable that in 2015 transactions increased in Alberta by 2.4%. This was the first increase in transactions in Alberta and may indicate a potential bottoming-out of decreases in transactions or possibly greater resources used to identify and report such trade by CanFax.

Figure 2.1. Annual Transaction Count by Location, 2004-2015.

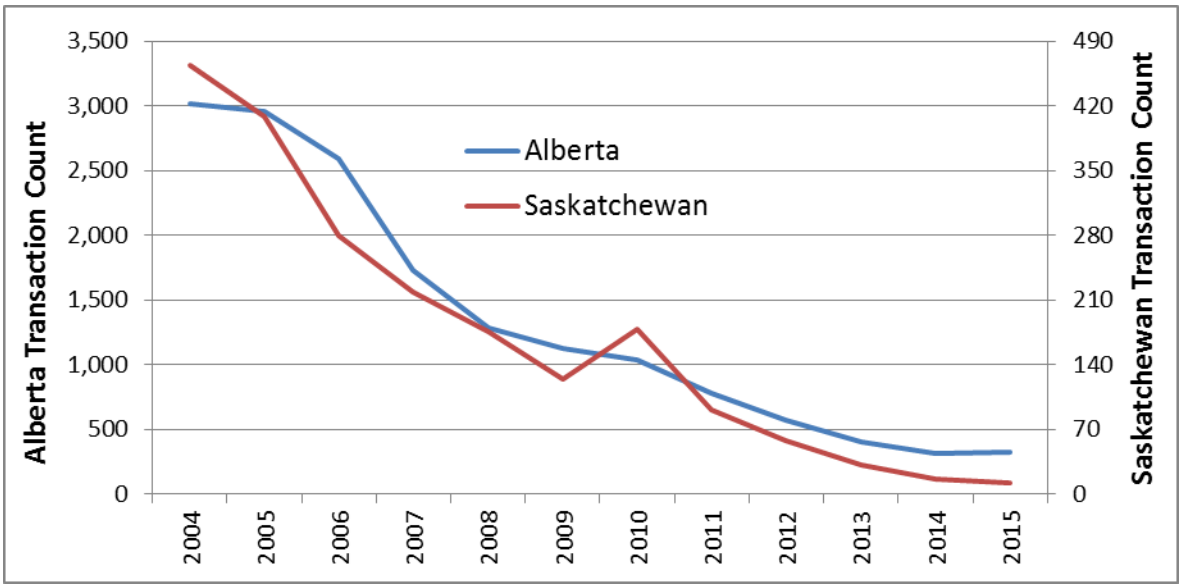


Table 2.2. Annual Transaction Figures, Year-over-Year (YoY) Growth Rates, and % of Total Transactions by Location, 2005-2015.

	Alberta			Saskatchewan			Total		
Year	Transactions	% YoY Change	% of Total	Transactions	% YoY Change	% of Total	Transactions	% YoY Change	% of Total
2004	3,022		18.7%	464		22.5%	3,486		19.1%
2005	2,958	-2.1%	18.3%	408	-12.1%	19.8%	3,366	-3.4%	18.5%
2006	2,594	-12.3%	16.1%	280	-31.4%	13.6%	2,874	-14.6%	15.8%
2007	1,729	-33.3%	10.7%	219	-21.8%	10.6%	1,948	-32.2%	10.7%
2008	1,291	-25.3%	8.0%	176	-19.6%	8.5%	1,467	-24.7%	8.1%
2009	1,132	-12.3%	7.0%	125	-29.0%	6.1%	1,257	-14.3%	6.9%
2010	1,036	-8.5%	6.4%	179	43.2%	8.7%	1,215	-3.3%	6.7%
2011	781	-24.6%	4.8%	91	-49.2%	4.4%	872	-28.2%	4.8%
2012	570	-27.0%	3.5%	58	-36.3%	2.8%	628	-28.0%	3.4%
2013	409	-28.2%	2.5%	32	-44.8%	1.6%	441	-29.8%	2.4%
2014	313	-23.5%	1.9%	16	-50.0%	0.8%	329	-25.4%	1.8%
2015	325	3.8%	2.0%	12	-25.0%	0.6%	337	2.4%	1.8%

Seasonal factors also persist in both Canadian locations as shown below in figure 2.2. Seasonal patterns may further complicate the ability to provide price discovery in thinning markets when months of low numbers of transactions persist. However, the largest value associated with price discovery information is likely during months where the most transactions are occurring. As shown in figure 2.2., both Canadian markets are characterized with the most transactions occurring in the late spring through early fall months. The Alberta season tends to be more evenly split across months, with a high

around early summer and a decrease in transactions as fall progresses. The seasonal features in Saskatchewan are a bit more striking with most transactions occurring between May through October and a peak in June. This pattern is consistent with a smaller market with transactions less likely to occur 'off-season.' The numbers supporting figure 2.2 can be found in table 2.3.

Figure 2.2. Percent of Total Transactions by Location and Month, 2004-2015.

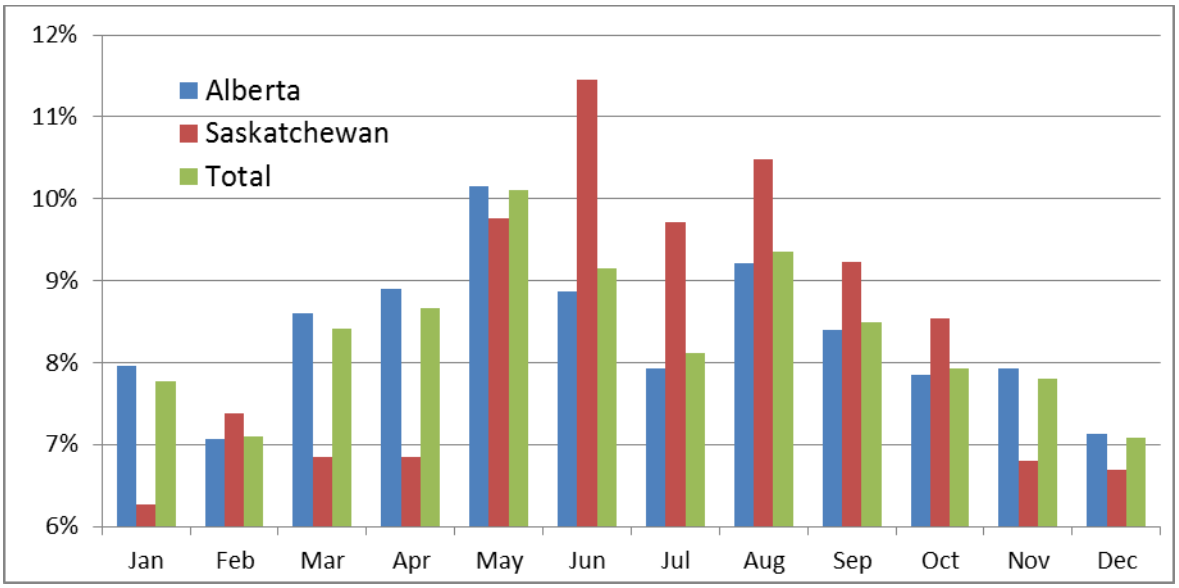


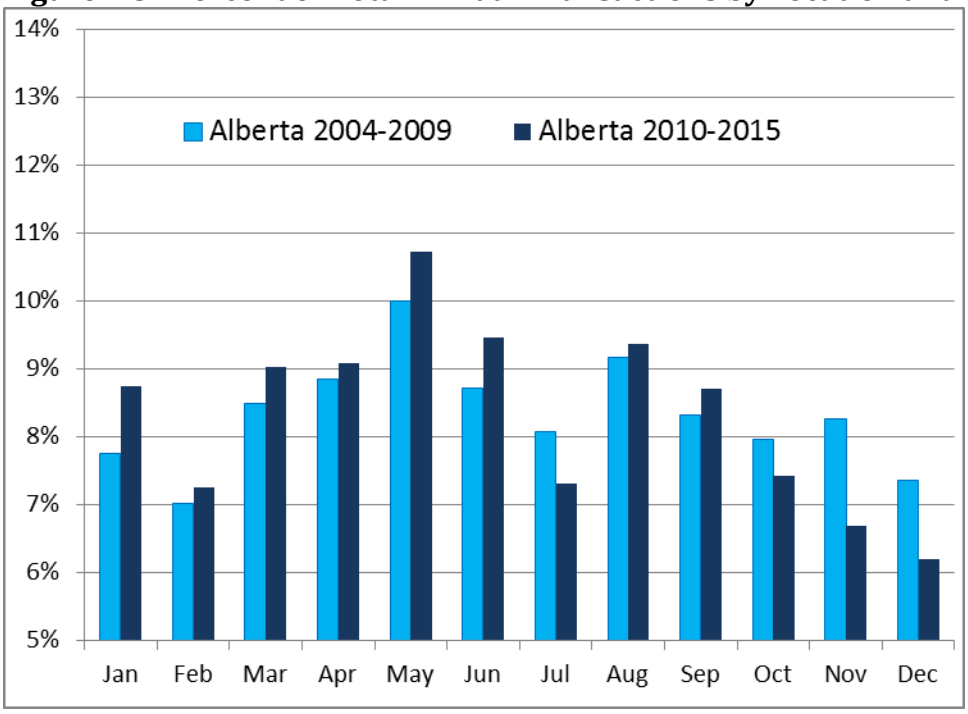
Table 2.3. Number of Total Transactions and Percent of Total Transactions by Location and Month, 2004-2015.

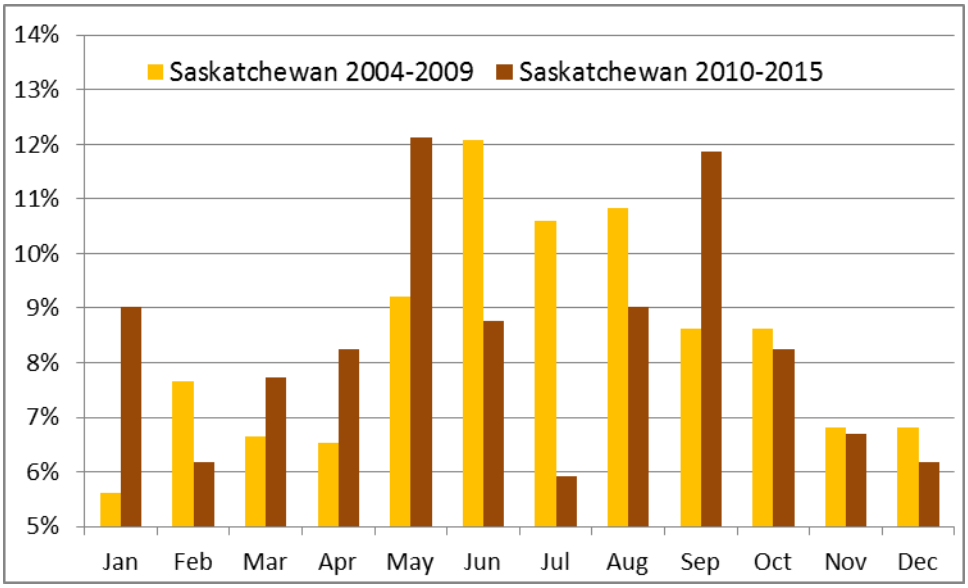
	Alberta		Saskatchewan		Total	
Month	Transactions	% of Total	Transactions	% of Total	Transactions	% of Total
Jan	1,316	8.0%	129	6.3%	1,445	7.8%
Feb	1,169	7.1%	152	7.4%	1,321	7.1%
Mar	1,423	8.6%	141	6.8%	1,564	8.4%
Apr	1,471	8.9%	141	6.8%	1,612	8.7%
May	1,678	10.1%	201	9.8%	1,879	10.1%
Jun	1,467	8.9%	236	11.5%	1,703	9.2%
Jul	1,310	7.9%	200	9.7%	1,510	8.1%
Aug	1,524	9.2%	216	10.5%	1,740	9.4%
Sep	1,390	8.4%	190	9.2%	1,580	8.5%
Oct	1,298	7.8%	176	8.5%	1,474	7.9%
Nov	1,312	7.9%	140	6.8%	1,452	7.8%
Dec	1,178	7.1%	138	6.7%	1,316	7.1%

As shown in figure 2.3, seasonal changes in Alberta transactions have changed slightly toward the latter half of the study period as the amount of transactions have tended to

move earlier with a higher proportion of transactions in the first half of the year (Jan – June) with a lower proportion of transactions occurring in fall months (Oct, Nov, Dec). The bulk of transactions remain in May with 10.7% of all transactions occurring in that month.

Figure 2.3. Percent of Total Annual Transactions by Location and Month, 2004-2015.





Given the relatively low volumes in Saskatchewan, particularly after 2009, it is difficult to tell whether seasonal features have systematically changed. The figure above does indicate a movement from a peak in June to a peak in May.

SECTION III. TEMPORAL AND SPATIAL PRICE ASSESSMENT

Objective:
Determine whether variability across transaction prices collected by CanFax have changed over time using both unconditional (prices alone) and conditional (prices conditioned on factors associated with the individual transactions) modeling approaches to test for patterns and trends. Increased variation across transactions can be evidence of an increasingly thinning market, though is not by itself definitive.

Main Findings:

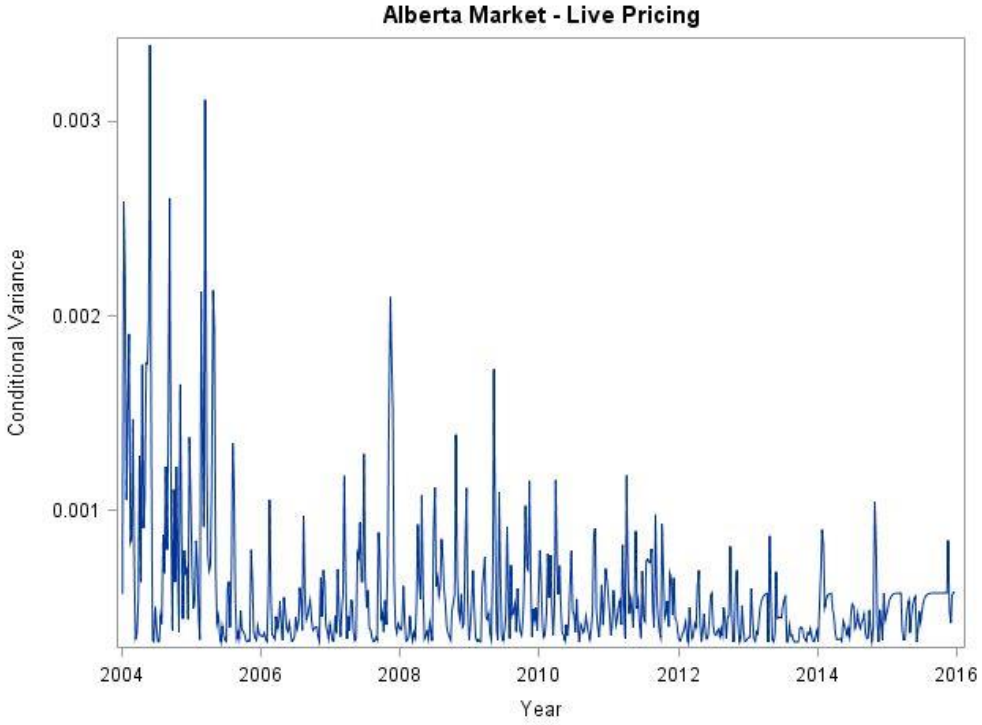
- Transaction price variance varies systematically across time, as is consistent with other price series.
- Conditional variance has been relatively steady in CanFax reported fed cattle markets over the past five years with the exception of the last half of 2015, which is consistent with higher than normal volatility in US cattle markets.
- The ratio between live to rail pricing averaged 59.7% and a standard deviation of 0.78, implying that approximately 68% of the weekly ratios are within one standard deviation of the mean, or the range between 58.9 and 60.5%.
- The ratio between live to rail pricing varied by year with a low between 2008-2011.
- The ratio between live to rail prices tends to move consistently across gender.

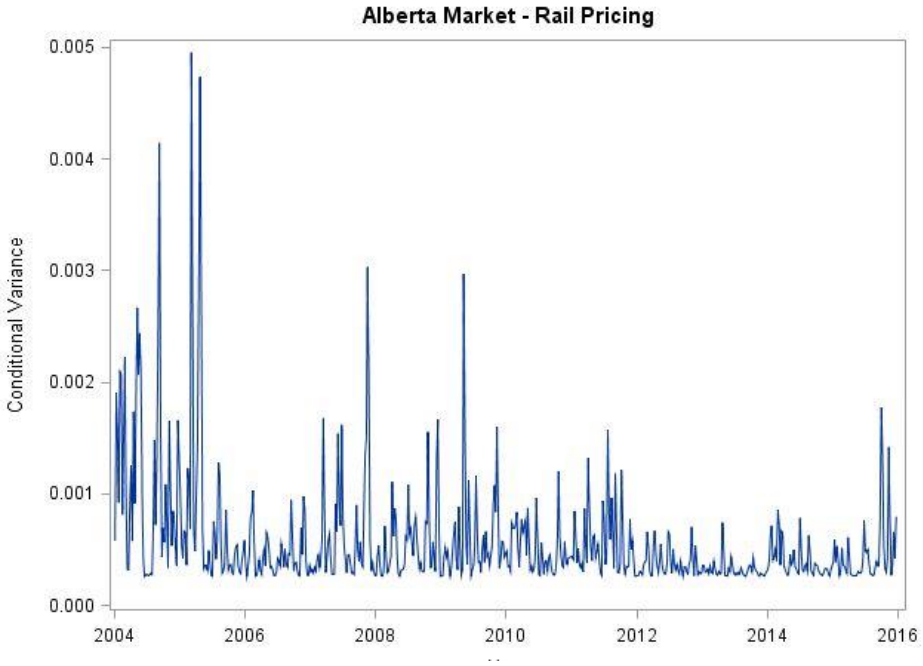
To complete this objective, cattle transaction data were collected from CanFax from 2004-2015. Data were aggregated by week and separated by location (Alberta and Saskatchewan), gender (steer and heifer), and transaction type (rail and live weight basis). Transactions from cattle exported to the US (i.e., coded with a US buyer) were deleted from the sample, as they are likely to be systematically different from domestic transactions.

To identify the existence of changes to variance over time, we estimated a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model. The main assumption within a GARCH model is that variance is not constant over time and relies on recent deviations. In most cases, the model is able to identify instances when periods of large deviations tend to imply future large deviations. GARCH models are commonly used with commodity price series as there tends to be periods of high and low volatility, which are accounted for with the use of a GARCH model. Statistically significant parameter results confirm Alberta cattle prices conform this to model. Once characterized, this model allows for the calculation of expected or conditional variance, which is functionally related to the magnitude of prior deviations.

Figure 3.1 plots the conditional variance for live and rail price in Alberta and allows for the identification of changes to variance over time. One concern in markets that are thinning is that variance may increase with fewer observations. Prices in this series have been transformed using logarithms to avoid the issue that arises when nominal prices increase and typically results in larger absolute variance. Here we are focused on variation as a proportion of the price, so that increases in variance can be interpreted as a change in the relative magnitude of price movements. If variance is increasing, it is critical to identify the form of variance so that confidence intervals can be accurately placed within sample estimates. However, those plots do not appear to indicate an increased variance within the latter part of the series. Large spikes in conditional variance are present during 2004-2005, but appear to be more stable since 2010. There is a noticeable spike in the variance within the last part of 2015, which are illustrated in rail pricing. This 2015 spike in variance is consistent with the spike that has occurred in US markets over the last few months of 2015 as both live and feeder cattle prices have fallen quickly and leveled off over the last few months, albeit with increased volatility.

Figure 3.1. Estimated Conditional Variance from GARCH (2) model for Live and Rail Pricing in Alberta market.





Another important relationship within cattle markets is the relationship between rail and live pricing methods. Figure 3.2 plots the relationship between weekly live and rail prices in Alberta. These prices clearly move together. The ratio between the two pricing methods is shown in figure 3.3. The price ratio is relatively stable with a mean of 59.7% and a standard deviation of 0.78, implying that approximately 68% of the weekly ratios are within one standard deviation of the mean, or range between 58.9% and 60.5%.

Figure 3.2 illustrates that annual average ratio between reported live and rail prices in order to determine the larger movements in the ratio. The ratio is also split by gender. First, distinctions by gender do not seem to generally play a role in the difference in the ratio. Steer and heifer ratios move together across years. There are a few exceptions to this, which include 2009 and 2014-2015. Given the relatively small number of observations for heifer transactions during 2014-2015, these estimates are likely provided with a larger confidence interval, which would indicate less precision. Second, there does appear to be a pattern of decreased ratio during 2004 and from 2008-2011. All other years appear to be relatively high.

Figure 3.2. Weekly Transaction Prices Separated by Live and Rail Pricing Methods in Alberta.

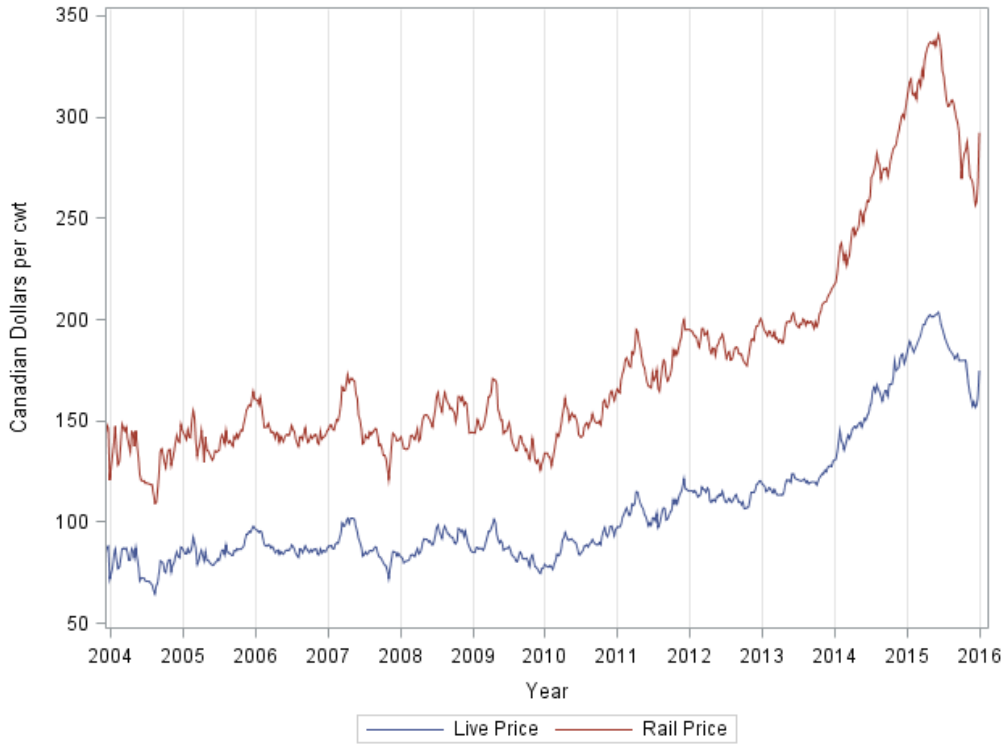


Figure 3.3. Ratio between Weekly Live and Rail Transaction Prices in Alberta.

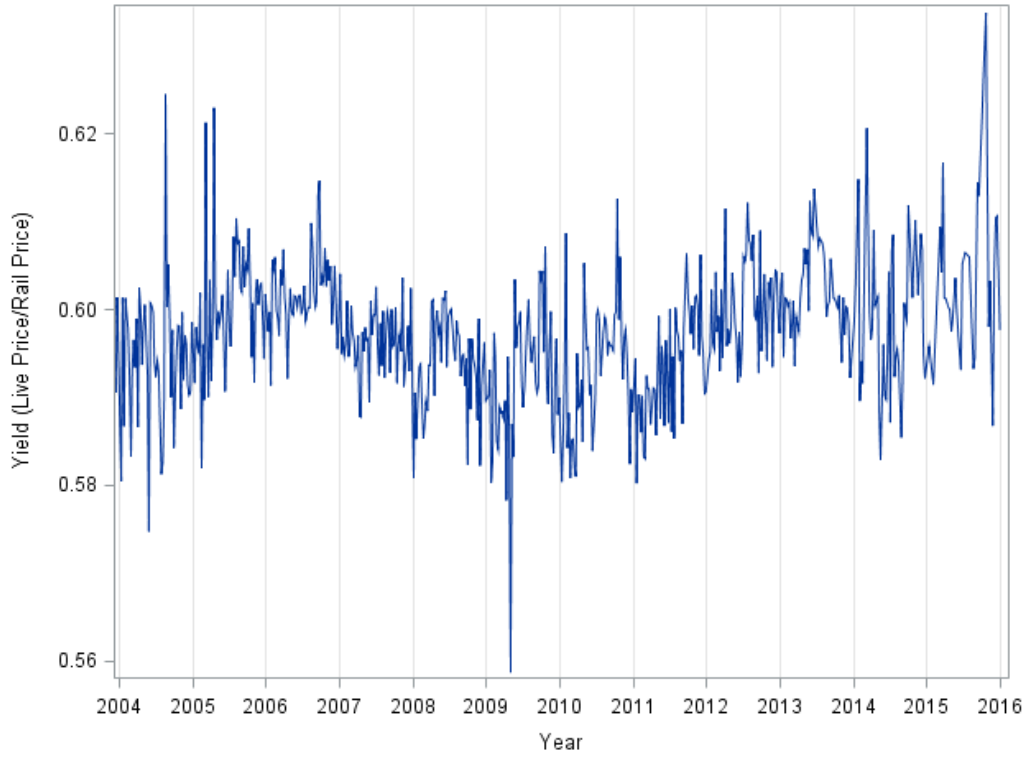
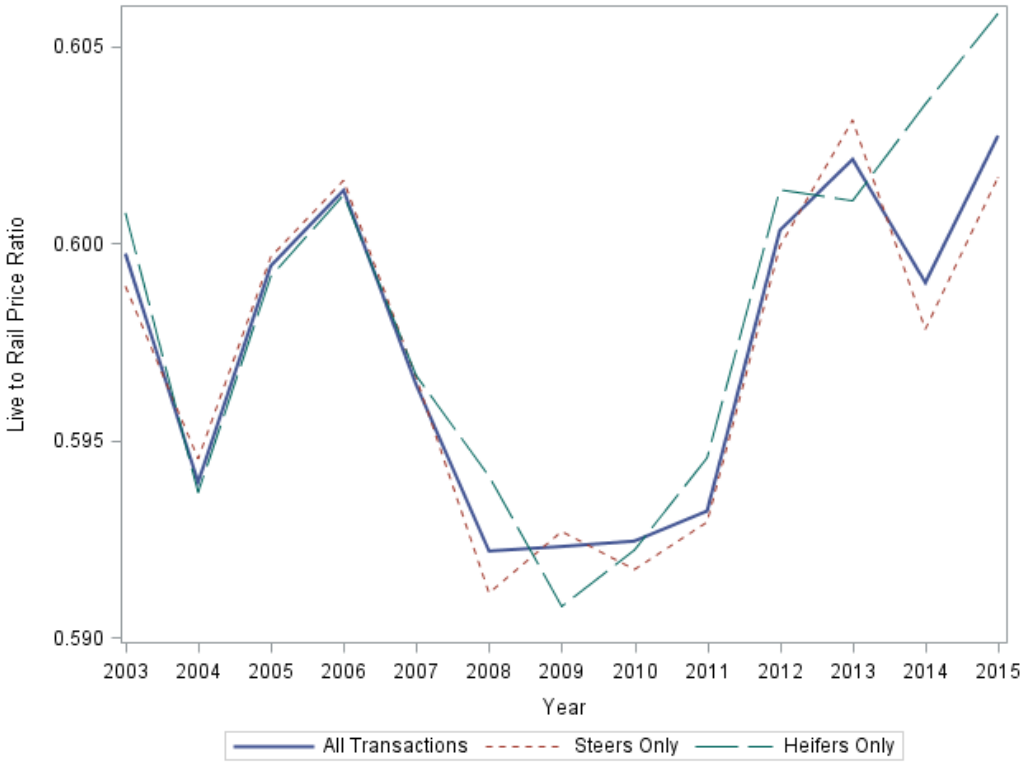


Figure 3.4. Average Weekly Live to Rail Price Ratio by Year and Gender.



SECTION IV. COMPARISON OF CANADIAN PRICES TO BENCHMARK PRICE SERIES

Objective:
Determine how the Alberta fed cattle weighted-average prices reported by CanFax compare to benchmark price series in the United States over time such as the Nebraska direct negotiated prices or similar benchmark. Specifically, this segment examines how basis level and variability are changing over time. Increased variability is evidence of either markets that are less geographically connected over time and/or of a thinly traded or unrepresentative CanFax reported price. Understanding how and when the relationship between these prices is changing is important for providing a measure of reliability in CanFax reported prices.

Main Findings:

- The correlation between Alberta fed cattle weighted-average prices and US benchmark price series has been relatively constant throughout the study period.
- The last two years have resulted in some of the highest degrees of correlation between Alberta and US benchmark series.
- The correlation between US benchmark series and Alberta shows a high degree of variability across years, which can be related to exchange rate variability, among other variables.
- Periods of high exchange rate volatility are correlated with periods of low correlation between Alberta and US benchmark series.
- Overall price volatility has fallen by more than 20% in both US and Alberta markets during 2010-2015, relative to 2004-2009.

This objective was accomplished with the use of cattle transaction data provided by CanFax and US transactions data provided by the Livestock Marketing Information Center that included weekly weighted average transactions for Nebraska and the Five-Market Region, which includes Texas/Oklahoma, Kansas, Colorado, Nebraska, and Iowa/Minnesota. Comparisons were made between Alberta rail transactions and the US dressed transactions. Comparisons were able to be made between these particular series due to the consistent magnitude of observations. US weekly transaction data were converted to Canadian Dollars through the use of weekly exchange rate information downloaded from Quandl.com.

The main objective of this section is to characterize the relationship between Canadian and benchmark US transaction data. We report two measures of correlation that include the standard unadjusted correlation and the transformed correlation. As is standard practice with price data over time, we use the logged difference of each weekly transaction price in order to eliminate time trends or non-stationary components that are typically found in

price series. If these elements of the series are not accounted for, results will be biased and artificially report a higher correlation than the true correlation. To illustrate, we use the following variable definition:

$$d_t = \log(P_t) - \log(P_{t-1})$$

where t corresponds to a given week, t-1 corresponds to the week prior, and so on. Evaluating the correlations of this variable allows us to see how movements in one market correlate with movements in another market during the same week.

As shown below in table 4.1, correlations between Alberta weekly prices and prices in US benchmark series during the same week has the highest degree of correlation. To illustrate, the correlation between weekly movements in price between Alberta and Nebraska was 0.336 for the entire time span of 2004-2015. The first half of that time frame had a correlation of 0.322, while the second half had a correlation of 0.360. It is notable that this falls off dramatically when we consider a one week delay between Alberta (time=t) and US markets (time=t-1). The purpose for checking for this one week lag is to see whether price movements in the US markets have an impact one week later in the Alberta market. This does not appear to be the case. Price swings within the US markets are shown to have similar movements to the Alberta market.

Table 4.1. Correlations and Standard Deviations between U.S. Benchmark Series and Alberta (t).

	Simple Correlation		Logged First Differenced Correlation		Standard Deviation (Logged First Differenced Variables)		
	NE	5 State	NE	5 State	NE	5 State	Alberta
All (2004-2015)	0.960	0.960	0.336	0.338	0.025	0.024	0.023
1st Half (2004-2009)	0.138	0.133	0.322	0.323	0.027	0.027	0.027
2nd Half (2010-2015)	0.985	0.985	0.360	0.364	0.021	0.021	0.018

Simple correlations are also reported to measure overall movements between markets. Clearly, the run up in prices that began in 2010 were observed in both US and Canadian markets. The high degree of correlation in the simple correlation measures demonstrates this relationship. Longer run trends that penetrate both markets are included in the simple correlation measure, while the logged first difference measure focuses on the week-to-week variability in prices and how quickly these movements are transmitted between markets. Given the upward movements in price in both markets, the correlation between the two markets between 2010-2015 was 0.985, which is nearly a perfect correlation. However, this simply reveals that when prices were above the 2010-2015 average in

Canada, the same was true in the US, which is not very informative. For this reason, we rely on the logged first differenced correlation figures to determine how price changes across the two locations week-to-week without inflating these correlations because of common long run trends. This transformation is typically used in price series and often used when computing hedge ratios to evaluate the linkages between price series.

One further question includes whether price variance has changed over time. In all three series, the standard deviations shrink during the second half of the price series. This may be partially explained by the large impact of BSE in 2003, however, it does seem that these data do not support the hypothesis that variance has increased over time. Further, the variance in the Alberta price series are in line with that of the US markets. During the second half of our study period, 2010-2015, the variance of Alberta is smaller than that of the US market. This measure of variance can be interpreted as a percentage deviation in the price, which accounts for the growth in nominal prices over the study period.

In order to more closely evaluate the relationship between Alberta prices and that of Nebraska and the Five-Region Market, we computed the correlation in the logged deviation for each year. Results are reported in table 4.2. Once 2004-2005 are excluded, the correlations are higher than 0.30 in all years, except 2010 and 2013. The four years with the lowest correlation include 2004, 2005, 2010, and 2013. Since 2013, the correlation between the Alberta and US markets has remained above 0.40, which is consistent with the average in other 'normal' years.

Table 4.2. Correlation between Alberta and U.S. Benchmark Series, by Year, 2004-2015.

Year	Nebraska	Five-State Mkt
2004	0.126	0.128
2005	0.119	0.147
2006	0.635	0.657
2007	0.625	0.622
2008	0.383	0.362
2009	0.417	0.404
2010	0.251	0.249
2011	0.351	0.354
2012	0.353	0.355
2013	0.218	0.213
2014	0.455	0.463
2015	0.411	0.425

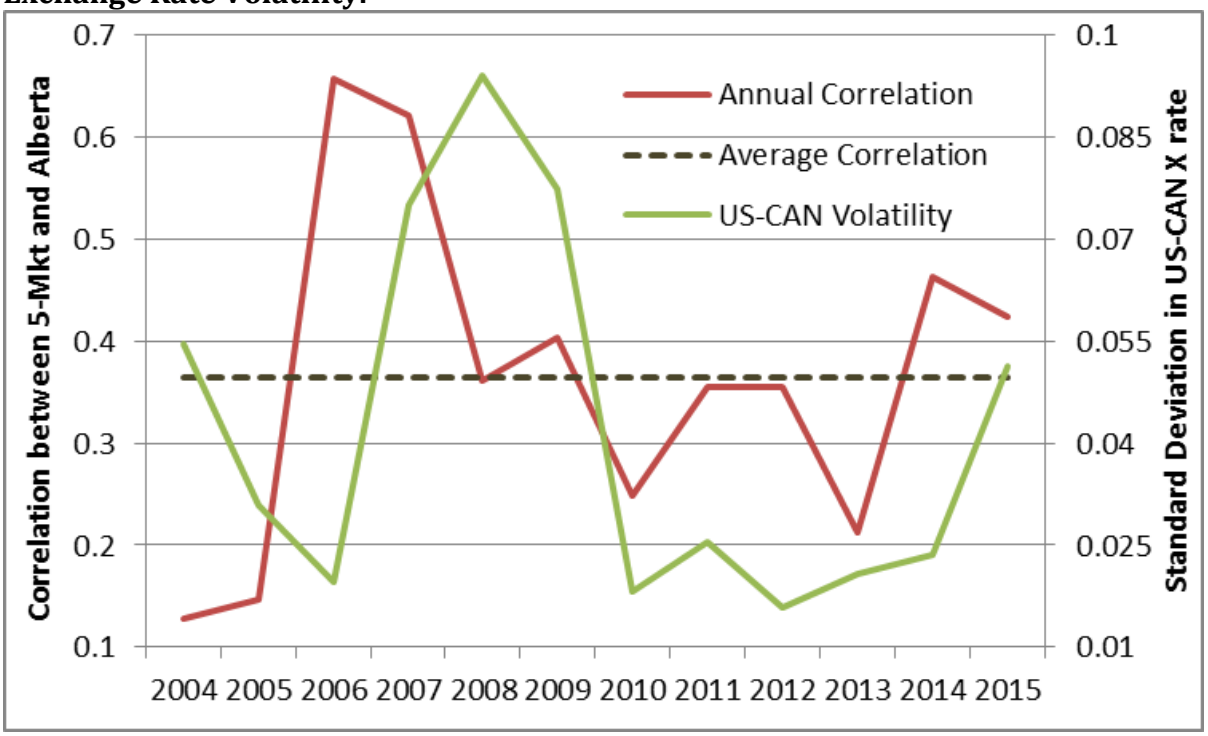
This correlation, particularly over the last couple of years, indicates a strong linkage between Alberta and the US market. At a minimum, it is safe to say that these markets have not become less integrated over the last few years.

These figures are plotted below in figure 4.1. The average correlation between markets during the years of 2004-2015 was 0.365. It is notable that the annual correlation, measured as the correlation in the weekly deviations throughout the year, fell below the average rate between 2010-2014, then rose above that rate during 2015.

Variation in the correlation between these markets arise for a multitude of reasons. First, exchange rate variation may lead to differences between US and Canadian markets as changes in the exchange rate move through the sector. Figure 4.1 also includes the volatility in the US-Can exchange rate, measured as the standard deviation in the weekly rates, averaged for each year. For example, in 2008, the volatility in the US-CAN exchange rate peaked, while bottoming out between 2010-2014. It is notable that the actual level of the exchange rate does not seem to matter as much as the variance, since the variance brings with it differences in expectations with regard to the exchange rates. Thus, figure 4.1 suggests exchange rate volatility is positively correlated with the correlation between prices in the US and Canada.

Second, differences in weight and quality characteristics may vary over time. This variation is likely to be magnified in the case of a thinning market, where weight and quality variation is likely to grow across a smaller number of transactions. Third, regional demand factors may cause changes in the correlation as excess supply or demand, at the regional level, may lead to decreased correlation between national US prices and Alberta.

Figure 4.1. Plot of Correlation between Alberta and US Five-Market Average and Exchange Rate Volatility.



SECTION V. COMPARISON OF CASH AND FORMULA PRICES

Objective:

The objective of this segment of the study is to determine to how similar formula marketed fed cattle price data collected by CanFax are to negotiated fed cattle prices reported by CanFax. The purpose of this analysis is to assess whether formula prices can be used to confirm, monitor, and inform negotiated fed cattle price reports. If for example, formula trade prices are economically similar to, and highly correlated with negotiated cash fed cattle prices, formula trade could potentially be combined with negotiated prices to increase the volume of cattle and number of trades represented in regular CanFax price reporting. Alternatively, formula prices could be used to check or verify whether thinly reported negotiated prices are consistent with formula prices if the two price series track each other.

Main Findings:

- Formula prices and negotiated transaction prices reported by CanFax are highly correlated with each other on a weekly basis. However, there is a lag in that negotiated prices this week are associated most strongly with formula prices paid for cattle slaughtered in two to three weeks into the future.
- Formula commitments typically occur from two to three weeks prior to delivery to the packer.
- Formula prices this week can be used to compare with negotiated prices reported two weeks ago, but formula prices are higher during the sample period by about $4.91/cwt than negotiated prices two weeks prior. Further, the variability in the relationship between formula and lagged negotiated prices is large enough that formula price only provides a rough approximation that will frequently differ by more than $6/cwt and at times by more than $10/cwt rail after the $4.91/cwt adjustment relative to negotiated rail prices.

Procedures and Data Adjustments

To complete this objective, negotiated and formula fed cattle transaction prices collected by CanFax spanning the period from August 11, 2014 through December 31, 2015 were compared. The time period analyzed was limited by when CanFax began formula transaction price collection.

Several data adjustments were made in completing this analysis including:

- Transaction price reports for both formula and negotiated sales were converted to volume-weighted weekly averages combining both steer and heifer sales together for analysis. Individual transactions included in price reports are somewhat sporadically reported across various days making weekly averages the most frequent viable series to evaluate. Even using weekly averages, there are occasional

weeks in the data series where either no negotiated or formula trades were reported as documented below.

- Only rail sales are included in this assessment since the vast majority of formula trade is rail as documented below. Further, the transaction data collected by CanFax on formula and negotiated trade does not have sufficient information to convert live trade prices to reliable rail prices, so the live trades are not used in this segment of the analysis.

- Only cattle sold to Canadian packers are included in this segment since exported cattle have unique logistical characteristics and as such prices that differ from domestic sales. Furthermore, the number of export formula deliveries is limited in the data set.

Results

Specific formula and negotiated transactions that were analyzed in this segment of the report are summarized in table 5.1. A total of 71 weeks encompassed the August 11, 2014 – December 31, 2015 time period. Four of those weeks did not have a negotiated rail transaction and 17 did not have a formula rail transaction price reported.

Overall, 453 transactions were represented in the negotiated trade and 172 in formula trade markets. After dropping export and live trades, 339 negotiated transactions and 159 formula transactions were utilized in the analysis. About two-thirds of negotiated trade is rail whereas more than 90% of formula trade is rail. Few transactions are export sales, though a larger percentage of formula trade (18%) is export compared to negotiated trade (8%). Steers represent roughly 2/3 of transactions for each negotiated and formula trade.

Table 5.1 Summary of Transactions Included in Comparison of Formula and Negotiated Trade, August 11, 2014 - December 31, 2015.

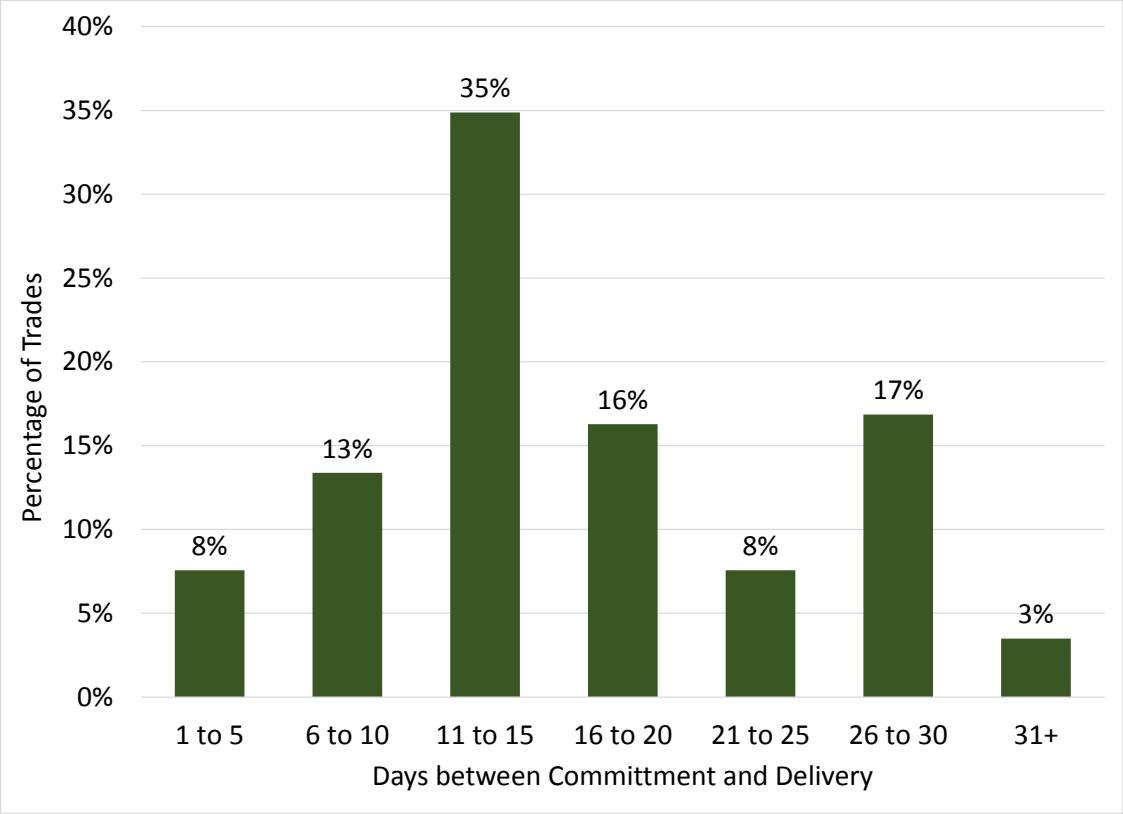
	Transaction Type						Weeks with
	Total	Live	Rail	Export	Steers	Heifers	no Transactions
Negotiated Trade	453	114	339	34	289	164	4
Formula Trade	172	13	159	31	116	56	17

Note: Total number of weeks = 71

On average, formula trades are committed 16 calendar days prior to being delivered with a range from 2 to 37 days. About one-half of formula trade cattle are committed for delivery

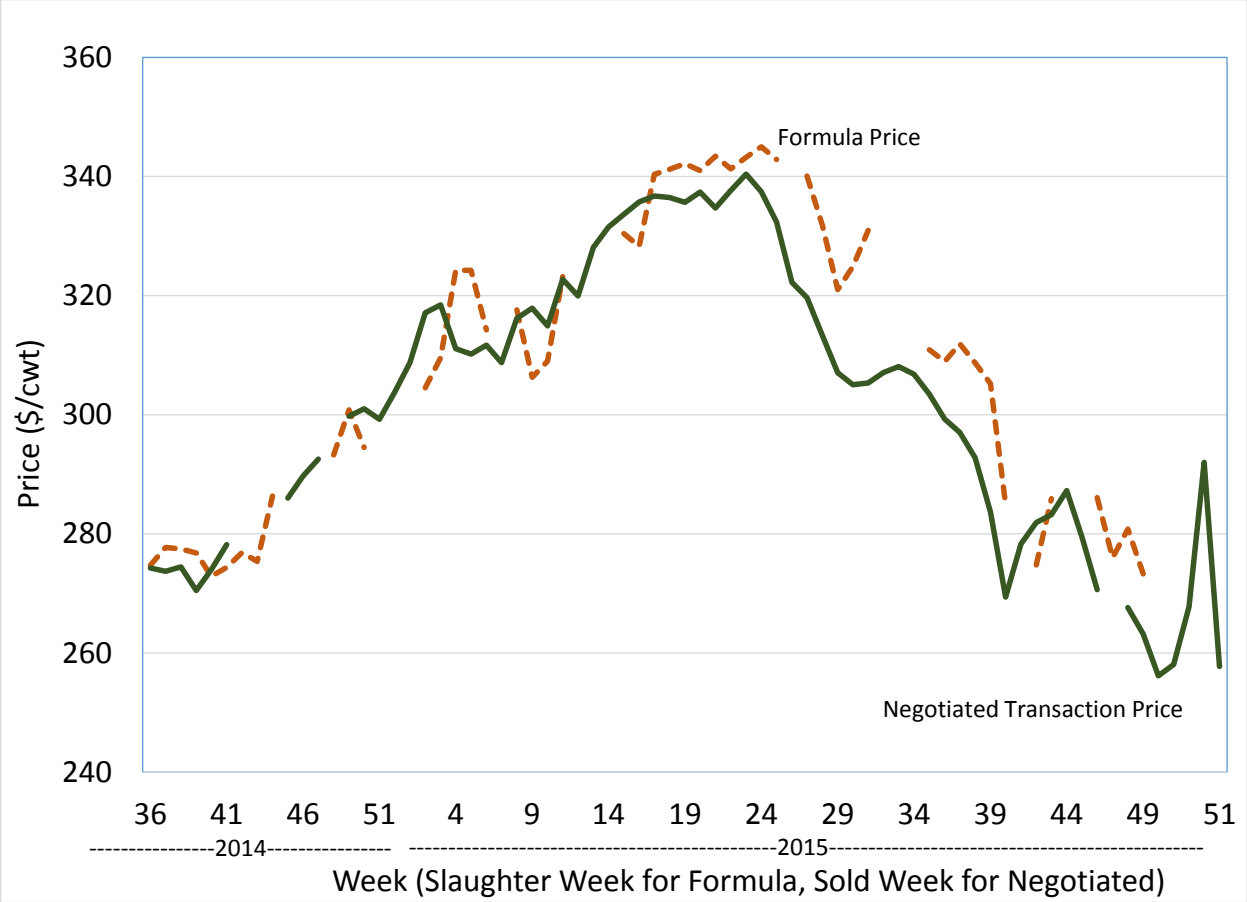
between 11 and 20 days prior to the slaughter week. Figure 5.1 illustrates the distribution of number of days between when the cattle were committed and when they were slaughtered.

Figure 5.1. Frequency Distribution of Number of Days between Formula Trade Commitments and Deliveries, August 11, 2014 – December 31, 2015.



A graph of the weekly weighted average formula and negotiated prices is presented in figure 5.2. Formula prices and negotiated weekly average prices follow similar patterns over time as would be expected. However, as is evident in the graph, the formula price during the slaughter week tends to most closely track the negotiated price of 2-3 weeks earlier.

Figure 5.2. Weekly Weighted-Average Formula Rail Price and Negotiated Transaction Rail Price, August 11, 2014 – December 31, 2015.



To determine the strength of the relationship between formula and negotiated prices we regressed the weekly weighted average formula price against the negotiated prices (contemporaneously and with various lags on the negotiated prices to account for the lag structure apparent in figure 5.2). In particular we regressed the weekly weighted average formula price as a function of the contemporaneous, 1-week, 2-week, 3-week, and 4-week lagged weekly weighted average negotiated prices as follows:

$$\text{Formula Price}_t = \beta_0 + \beta_1 \text{Negotiated Price}_{t-k} + e_t \quad \text{for } k=0, 1, 2, 3, \text{ or } 4.$$

Results from this model provide information of the nature and strength of the relationship over time among the two price series. If the two prices move together, we would expect the value of β_1 to be close to 1. The R-square of the regression provides a measure of the correlation among the prices over time. Comparison of the R-squared across the models provides an assessment of the strongest lag length relationship among the series.

Estimates from these simple regressions are summarized in table 5.2. Several things can be gleaned from the regression analysis reported in table 5.2, but most noteworthy is that for formula trade cattle reported in CanFax price reports, the formula price the slaughter week is most closely associated with the negotiated trade price two weeks earlier. That is, the R-Squared (a measure of the correlation of the two price series) is largest at 0.95 when the slaughter week formula price is regressed against the two-week earlier negotiated price. Also, the root mean squared error of the two-week lag model is lowest of those tested at $5.43/cwt. The next best model is the slaughter week formula trade as a function of the three-week lagged negotiated price. This finding suggests formula trade at the slaughter week is most closely aligned with negotiated transaction prices reported two or three-weeks earlier.

For checking robustness, the regression models were also estimated using natural logarithms of the prices and weekly first differences of the logarithmic adjusted prices and results of the two-week lag being the strongest were identical to the linear specification. The simple difference between the formula price series and the two-week lagged negotiated transaction price series had no discernable trend over time suggesting the linear models reported were appropriate.

Table 5.2 Regression Results of Weekly Weighted Average Formula Rail Price (Steers and Heifers Combined) Against Weekly Lagged Weighted Average Alberta Transaction Weighted Average Rail Prices, August 11, 2014 – December 31, 2015.

Independent Variable	Obs.	Intercept	Slope	RMSE	R-Squared
Contemporaneous CanFax Weekly Weighted Average	43	19.8 (18.52)	0.95 (0.06)	9.25	0.86
One-Week Lag CanFax Weekly Weighted Average	43	4.47 (14.67)	1.00 (0.05)	7.19	0.92
Two-Week Lag CanFax Weekly Weighted Average	43	1.79 (10.98))	1.01 (0.04)	5.43	0.95
Three-Week Lag CanFax Weekly Weighted Average	43	-7.18 (13.22)	1.04 (0.04)	6.31	0.94
Four-Week Lag CanFax Weekly Weighted Average	43	-15.63 (16.61)	1.06 (0.05)	7.60	0.90

Note: Standard errors in parentheses.

To further explore the relationship between the formula prices and the two-week lagged negotiated prices, we also estimated using a restricted regression model:

$$\text{Formula Price}_t = \beta_0 + 1.0\ \text{Negotiated Price}_{t-2} + e_t$$

In the restricted model, we forced the slope coefficient to be 1 and re-estimated the model to determine how much performance of the model changed with this restriction. Furthermore, imposing this restriction, allows one to make an easier adjustment to the formula trade to compare it with negotiated prices. The results of the restricted and unrestricted regression estimates are provided in table 5.3. The models both have similar goodness of fit, indicting the restricted model, which is easier to use, will perform as well as the unrestricted model. In particular, the weighted average formula trade price for cattle slaughtered this week can be adjusted by subtracting $4.91/cwt from the price to compare to the weekly weighted average negotiated price from two weeks earlier as follows:

$$\text{Formula Price}_t - 4.91 = \text{Negotiated Price}_{t-2} + \text{random error}$$

The magnitude of the random errors from using the above equation to compare with the actual negotiated prices are summarized in table 5.4 and the actual data points are graphed in figure 5.3. The purpose of the table and graph are to illustrate how similar the formula price minus $4.91 has been to the two-week prior negotiated cash price. About one-fourth of the time, this price would be more than $6/cwt different (higher or lower) than the actual negotiated cash price. More than half of the time (54%) the difference in these two series would be within 1% of the weighted average negotiated price. What this all means is that while adjusted formula prices could be used to check representativeness of reported negotiated prices, the relationship would not be precise and would work mostly as a barometer to assess whether further investigation were merited rather than serving as a week-to-week precise cross check. There will be weeks where the two series diverge by economically important amounts and even though highly correlated over time, the formula trade during the slaughter week only provides modest guidance of where we might have expected the negotiated trade prices to have been at two weeks earlier.

Table 5.3. Comparing Regression Results of Weekly Weighted Average Formula Rail Price (Steers and Heifers Combined) Against Two-Week Lagged Transaction Weighted Average Rail Prices (Restricted and Unrestricted Models), August 11, 2014 - December 31, 2015.

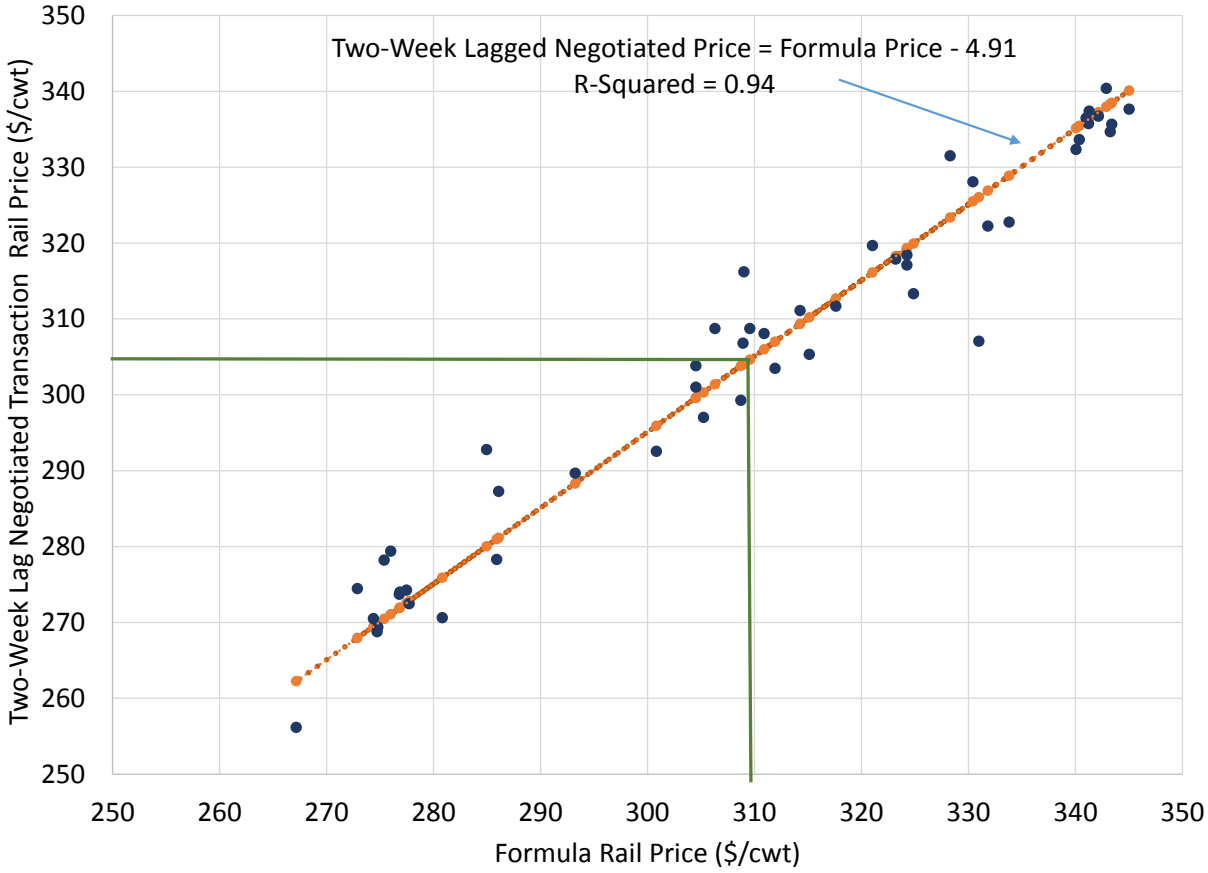
Model	Observations	Intercept	Slope	RMSE	R-Squared
Unrestricted Model	43	-1.79	1.01	5.43	0.95
		(10.98)	(0.04)		
Model Restricting Slope = 1.0	43	4.91	1.00	5.38	0.95
		(0.82)			

Note: Standard errors in parentheses.

Table 5.4. Percentage of Weeks Predicted Weighted Average Negotiated Rail Price Differed Relative to Actual Price, August 11, 2014 – December 31, 2015.

Price Difference Actual - Predicted	Percent of Weeks	Percentage Difference (Actual-Predicted)/Actual	Percent of Weeks
-$6/cwt or more	16%	-3% or more	4%
-$2/cwt to -$6/cwt	16%	-1% to -3%	18%
-$2/cwt to $2/cwt	34%	-1% to 1%	54%
$2/cwt to $6/cwt	26%	1% to3%	22%
$6/cwt or more	8%	3% or more	2%

Figure 5.3. Scatter Plot of Weekly Weighted Average Formula Price, Slaughter Week vs. Two-Week Lagged Weighted Average Negotiated Transaction Price, August 11, 2014-December 31, 2015.



SECTION VI. STATISTICAL POWER OF AVAILABLE PRICE SERIES

Objective:
Assess to the extent data allows, how much confidence CanFax reported prices provide relative to reported prices being within selected tolerance levels of reliability. This segment will use standard statistical methods to provide measures of confidence in reported prices relative to the variation in price over time and the number of transactions needed to increase confidence in precision of reported prices. Results from this phase will allow for insights regarding the minimum volume necessary for weekly or monthly cash reports to be accurate.

Main Findings:

- The variance in reporting weekly and monthly prices were used to identify an amount of observations needed to provide price discovery in order to balance feasibility and statistical validity, using common power test statistics.
- Results indicate that if sampling consistent with 2014 and 2015 were to persist in the future, prices reported can be confidently stated within a dollar of the true price value, but no smaller level of acceptable variance would match with that level of transactions.
- In order to provide weekly and monthly data that would confidently present results that are consistently within 0.50 dollars of the true value the number of weekly and monthly transactions needed would be 17 and 96, respectively.
- Given seasonality and the number of transactions received in 2014-2015, it appears that weekly and monthly price reporting would be achieved in most months with an acceptable variance of 0.90-1.00, which places a wide range around price estimates.

Typically this type of an analysis would include some population parameters that can be compared to the sample parameters, in order to understand how well the sample collected reflects the population parameters. For example, if a sample of data were collected within a region, an aggregated benchmark would be used for the same region in order to identify the population parameters. However, due to the lack of packer data or regional aggregates, the population parameters are unknown in this application. However, in place of population parameters, we can make some general assumptions that the price series characteristics in Alberta and Saskatchewan would reflect some of the larger U.S. markets, given a larger sample. If this assumption is made, then we are able to make some inference regarding the number of observations necessary to provide weekly or monthly price series that reports figures within a particular confidence level.

A simple way to determine the minimum number of observations needed to provide an estimate within a specified confidence level of being within a certain distance from the true value can be written as follows:

$$n = \left[\frac{Z_c \sigma}{E}\right]^2$$

In this example, n is the minimum number of observations needed, σ is the population variance, E is the acceptable amount of variance, and $Z_c = 1.96$ if we are interested in a 95% confidence interval. This implies that 95% of the time the true price will be no statistically different from the estimated price. From 2006-2015, the standard deviation in weekly reported transactions can be estimated in order to provide an estimate for σ. For both rail and live price series, this figure is estimated to be 1.056. One additional input is that of the acceptable amount of variance (E). If for example, we were to assume an acceptable amount of variance would be 0.50 Canadian Dollars in the weekly price series, then we obtain the following:

$$n = \left[\frac{1.96 * 1.056}{0.50}\right]^2 = 17.13$$

where 17 observations would be needed in order for the true price to be contained within the estimated confidence interval 95% of the time. Generally, a 95% confidence is found to be acceptable, given that only 5 times out of 100 will the estimated price be statistically different from the true value. Different acceptable variance levels are shown below in table 6.1.

Table 6.1. Minimum Number of Transactions Needed to Compute Price Estimates within Acceptable Variance Levels with 95 Percent Confidence

	Minimum observations needed (n)	
Acceptable Variance (E)	Weekly	Monthly
0.10	428.4	2,401.0
0.20	107.1	600.3
0.30	47.6	266.8
0.40	26.8	150.1
0.50	17.1	96.0
0.60	11.9	66.7
0.70	8.7	49.0
0.80	6.7	37.5
0.90	5.3	29.6
1.00	4.3	24.0

Note: Assumes $\sigma = 1.056$ for weekly transactions and $\sigma = 2.500$ for monthly transactions. These figures are based on CanFax data from 2006-2015.

A range of acceptable variance figures are provided as it is typical to balance what is considered to be 'acceptable' with that which is 'realistic', in terms of data collection. For example, in 2015, 325 transactions were collected. This averages to about 27 transactions per month or 6 transactions per week. If this number of transactions were to continue, and

the transactions are random across the population, the reported price data would be confidently estimated within 1.0 Canadian Dollar of the true value.

Monthly figures are also included in order to provide an alternative process whereby data are collected on a monthly basis. Monthly data were shown to have a much higher standard deviation ($\sigma = 2.500$) than that which was collected within the week. The main reason this happens is that the market is more likely to make large movements over a month, rather than a week. For example, if prices are trending upward, much of that movement will be observed within the month and not much during the week. This also means the overall range in prices received during the month are likely to be larger that within a single week. Generally, more data would imply a smaller standard deviation, though not necessarily the case with most price series and the way prices tend to be nonstationary.

If we use 2014-2015 to estimate the future of future transactions reported through CanFax, then we can expect around 330 transactions per year. Using this information and the seasonality implied in table 2.2 (page 7), we can infer than many months would contain an insufficient number of observations to attain an acceptable variance of 0.50. Given the results from table 6.2, an acceptable variance of 0.80 would imply a weekly transaction count of 6.7, which would be achieved in only 7 of 12 months. For an acceptable variance of 0.90, 5.3 transactions per week are needed and would be achieved in all 12 months. Thus, given the assumed number of transactions per year, 0.90 is the realistic amount of precision that could be achieved under a weekly series. A monthly series with an acceptable variance of 1.00 would require 24.0 transactions per month and would likely be achieved in 10 out of 12 months.

Table 6.2. Implied Seasonality of transactions Based on Historical Seasonality and 330 Transactions Per Year.

Month	Percent of Total Transactions within Given Month (from table 2.3)	Implied Monthly Transactions	Implied Weekly Transactions
Jan	7.8	25.7	6.4
Feb	7.1	23.4	5.9
Mar	8.4	27.7	6.9
Apr	8.7	28.7	7.2
May	10.1	33.3	8.3
Jun	9.2	30.4	7.6
Jul	8.1	26.7	6.7
Aug	9.4	31.0	7.8
Sep	8.5	28.1	7.0
Oct	7.9	26.1	6.5
Nov	7.8	25.7	6.4
Dec	7.1	23.4	5.9

Note: Weekly transactions are computed by dividing monthly transactions by 4.

SECTION VII. SHORT BIOS

Ted C. Schroeder, Ph.D.
Ted is a University Distinguished Professor of Agricultural Economics at Kansas State University. He has a B.S. from the University of Nebraska and Ph.D. from Iowa State University. He has been on the Agricultural Economics faculty at Kansas State University since 1986.

Ted teaches and conducts research in agricultural marketing and risk management. He is founding director of the North American Institute for Beef Economic Research and the Center for Risk Management Education and Research. Ted has done extensive research in livestock market risk management, meat demand, meat and livestock marketing, and price discovery and has more than 100 published journal articles and numerous other publications. Schroeder has worked as a consultant on numerous meat and livestock value-added projects, and he has been the principal investigator on a large number of external grants.

Eric J. Belasco, Ph.D.
Eric J. Belasco is an associate professor in the Department of Agricultural Economics and Economics at Montana State University. He was previously an assistant professor at Texas Tech University in the Department of Agricultural and Applied Economics. He earned a B.S. degree in Economics from Saint Mary's College of California in 2001, and his M.S. and Ph.D. degrees in Economics from North Carolina State University in 2005 and 2007, respectively.

For his dissertation research, which focused on modeling risk in livestock production systems, Belasco was the recipient of the 2007 Kenneth R. Keller Award for Excellence in Doctoral Dissertation Research and the 2008 Nancy Pollock Graduate School Dissertation Award for the College of Agricultural and Life Sciences. Since then, Belasco has published 28 peer-reviewed articles that evaluate risk management within the context of livestock marketing, crop insurance performance, moral hazard, financial risk management, insurance markets, and cancer prevention. These articles appear in top agricultural economics and economics journals, including *American Journal of Agricultural Economics* (2009), *Journal of Agricultural Science* (2012), *Journal of Agricultural and Resource Economics* (2008, 2010, 2013, 2015), *Agricultural and Resource Economics Review* (2012, 2013), *Agricultural Finance Review* (2010, 2015), *Journal of Agricultural and Applied Economics* (2009), and *Managerial Finance* (2012). Additionally, Belasco has managed over $700,000 in grants that focus on individual decisions related to uncertain outcomes within areas of risk management education, risk management in organic and specialty crop production systems, high tunnel production, as well as developing commercially viable bio-based products.

Belasco has also served as a reviewer for various USDA grant programs, including the Specialty Crop Research Initiative and AFRI Economics, Markets, and Trade, as well as continually serves as a reviewer for top agricultural economics journals, and is currently on the Board of Directors for the Western Agricultural Economics Association. Belasco also serves as an underwriting expert for the Risk Management Agency and has consulted on various projects related to livestock marketing and risk management.