DETERMINANTS OF RISK PREMIUMS ON FORWARD CONTRACTS FOR KANSAS WHEAT

by

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Abstract

Forward contracts are one of the main tools used by producers to manage price risk because forward contracts shift the risk from producers to the grain elevator offering the contract. The elevators protect themselves from this risk by hedging, leaving them susceptible to basis risk, which they offset by adding a risk premium to the forward contracts they offer producers. This risk premium is affected by increased volatility and by differences in elevator-specific characteristics at elevator locations across Kansas.

This study replicates the results in Taylor, Tonsor, and Dhuyvetter (2013) and adds a set of elevator-specific characteristics to measure their effect on risk premiums. A random effects generalized least squares model is estimated due to the data gathered being panel data. The contribution of this study is to further examine the drivers of risk premiums in forward contracts for Kansas wheat.

The results indicate that all of the elevator-specific characteristics in the data set have a statistically significant impact on the value of risk premiums on forward contracts for Kansas wheat. The results also confirm the findings in Mallory, Etienne, and Irwin (2012) and Taylor, Tonsor, and Dhuyvetter (2013) that increased volatility post 2007 caused increases in risk premiums. The risk premiums after the structural break in 2007 increased by $0.069695/bushel, as the average risk premium prior to 2008 was $0.158682/bushel, while the average risk premium after 2007 was $0.228378/bushel.

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I would finally like to thank my parents. All of your motivation and support throughout this process, as well as through life, has provided me the ability to accomplish my goals and pursue all the endeavors I chose to go after.

Chapter 1 - Introduction

The objective of this thesis is to examine the cost that grain producers may incur by using forward contracting to market their wheat and manage risk. In a historical context, forward contracting has been the tool of choice for price risk management by producers, as it has many desirable characteristics when compared to hedging futures contracts (Mallory, Etienne and Irwin 2012). With a forward contract the producer is not exposed to basis risk; and has no need to open a margin account or manage cash flow to meet margin calls.[1] These characteristics lead producers to use forward contracting to control risk; however this risk shifting mechanism does not come without a cost of its own. This cost, which is essentially a basis bid that is lower than the expected basis at harvest or delivery, can be looked at as a risk premium that grain buyers offering forward contracts build into their forward contract bids to help offset the risk they are assuming from the producer (Hieronymus 1977). Oftentimes the elevators will hedge forward contracted grain using the futures markets, which exposes them to the risks of detrimental basis moves and margin calls. This transfer of risk from the producer to the elevator drives the elevator to charge a risk premium. The risk premium is only one portion of the full cost of forward contracting, which is believed to be made up of not only the risk premium but potential basis forecasting error elements as well (Taylor, Dhuyvetter and Kastens 2003; Taylor, Tonsor and Dhuyvetter 2013; Mallory, Etienne and Irwin 2012).

One of the main reasons that knowing the costs of these risk management tools is so valuable to producers is the fact that volatility of prices and basis has increased in recent years, which is likely to increase the costs of using forward contracts. A visual inspection of Figures 1.1 through 1.4, which display the average harvest time basis for Kansas elevators in Andale, Goodland, Garden City and Topeka, reveals that, prior to 2007 basis followed a seasonal pattern and was relatively stable. The mean harvest time basis across the four locations during this period was -\$0.2272 per bushel with a standard deviation of \$0.0662 per bushel. After 2007, however, basis becomes relatively more volatile, with an average basis of -\$0.4110 per bushel and a standard deviation of \$0.3086 per bushel. The harvest time basis also appears to lose some

[1] Quantity requirements for forward contracting vary by elevator, while they are set at 5,000 bushel increments for forward contracts.

of the seasonality displayed beforehand. If this change is permanent then it can have distinct implications for risk premiums and basis forecasting. The implications are that if this change in volatility persists, there will be increased risk for both producers and grain elevators from unfavorable changes in basis and price, as well as decreased accuracy of basis forecasts by elevators, which could then affect the risk premiums they set for forward contracts with producers.

Two studies that have looked at basis and the cost of forward contracting before and after 2007, Mallory, Etienne, and Irwin (2012) and Taylor, Tonsor, and Dhuyvetter (2013), both found strong evidence of a structural break in basis and the cost of forward contracting in 2007. The structural break occurred for commodity prices and volatility as well. This structural change indicates that the increase in volatility may be permanent which presents a number of challenges for all parties that participate in those markets. These challenges include, but are not limited to, larger and more sudden changes in prices of cash grains and futures contracts, more uncertainty in the accuracy of basis forecasts, and more uncertainty in the size of risk premiums which will likely be higher than prior to 2007.

1.1 Thesis Objectives

The objective of this thesis will be to replicate the results found in the study by Taylor, Tonsor and Dhuyvetter (2013). After this replication, grain elevator characteristics for the locations used in the data set will be added in an attempt to separate the impact elevator-specific characteristics may have on the risk premium charged for forward contracting. The inclusion of elevator specific characteristics expands the research by Taylor, Tonsor and Dhuyvetter (2013), as these variables were unavailable and were controlled for by estimating a component error structure. By reducing the effects of spatial differences in the error term by adding elevator-specific characteristics to the regression, it is possible to determine the direction and magnitude by which those effects shift risk premiums. The overall focus of this thesis will be how the added elevator characteristics affect the cost of forward contracting.

1.2 Thesis Outline

The remaining layout of this thesis will consist of four chapters detailing different sections of this study. Chapter 2 will review past literature on the topic of forward contracting and risk premiums. This review outlines a methodological foundation for the work in this study as well as providing results with which to compare the findings of this study. Chapter 3 will provide an overview of the data used in this thesis as well as discussing each portion individually. Additionally Chapter 3 will present both the conceptual model underlying the study and the econometric model and methods. Chapter 4 will tabulate and discuss the results of the econometric work and discuss the extent to which the results match the predictions of variable direction and magnitude. Finally, Chapter 5 will draw conclusions from the results and study as a whole and will also state the limitations of the study along with avenues for future research.

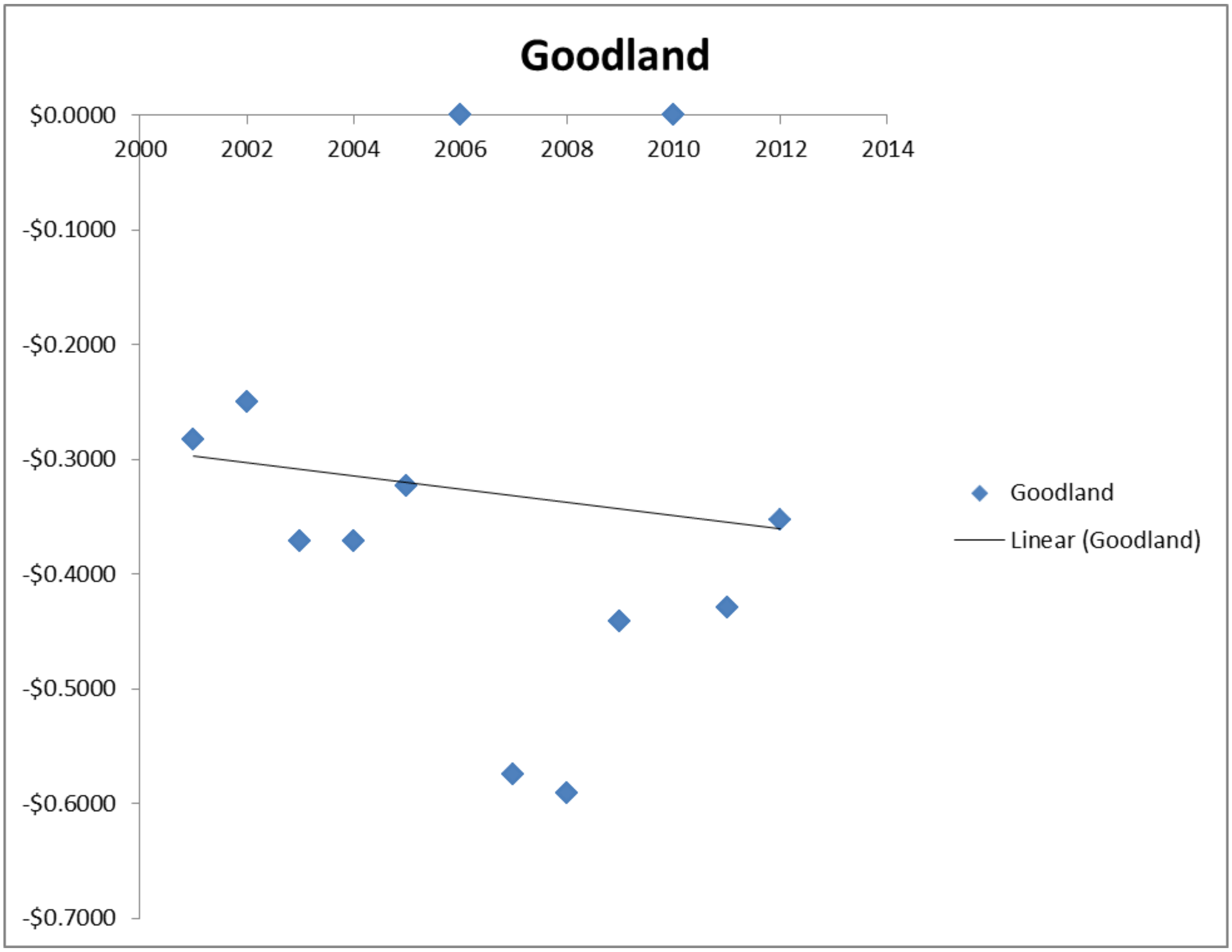

Figure 1.1- Goodland Harvest Basis (2000-2012)

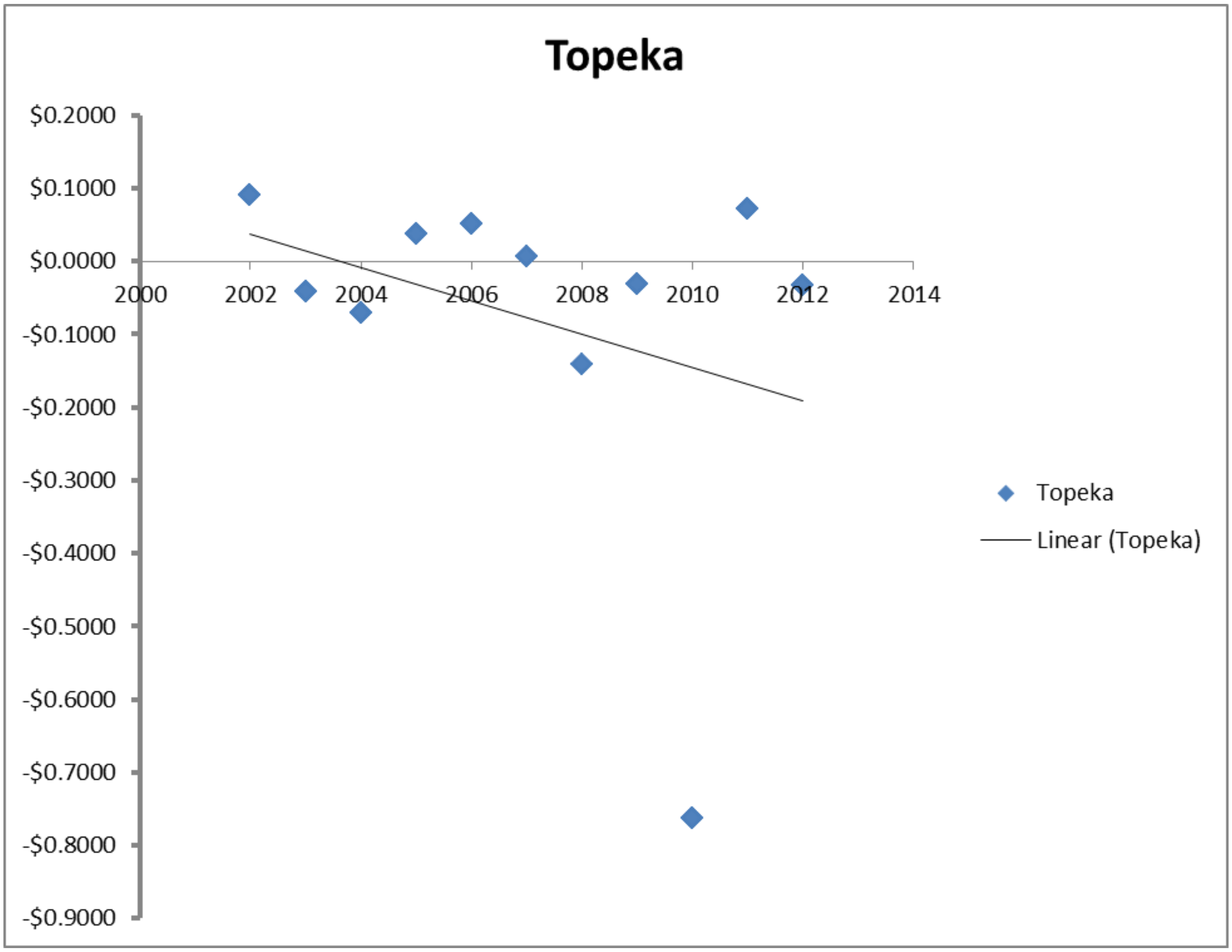

Figure 1.2- Topeka Harvest Basis (2000-2012)

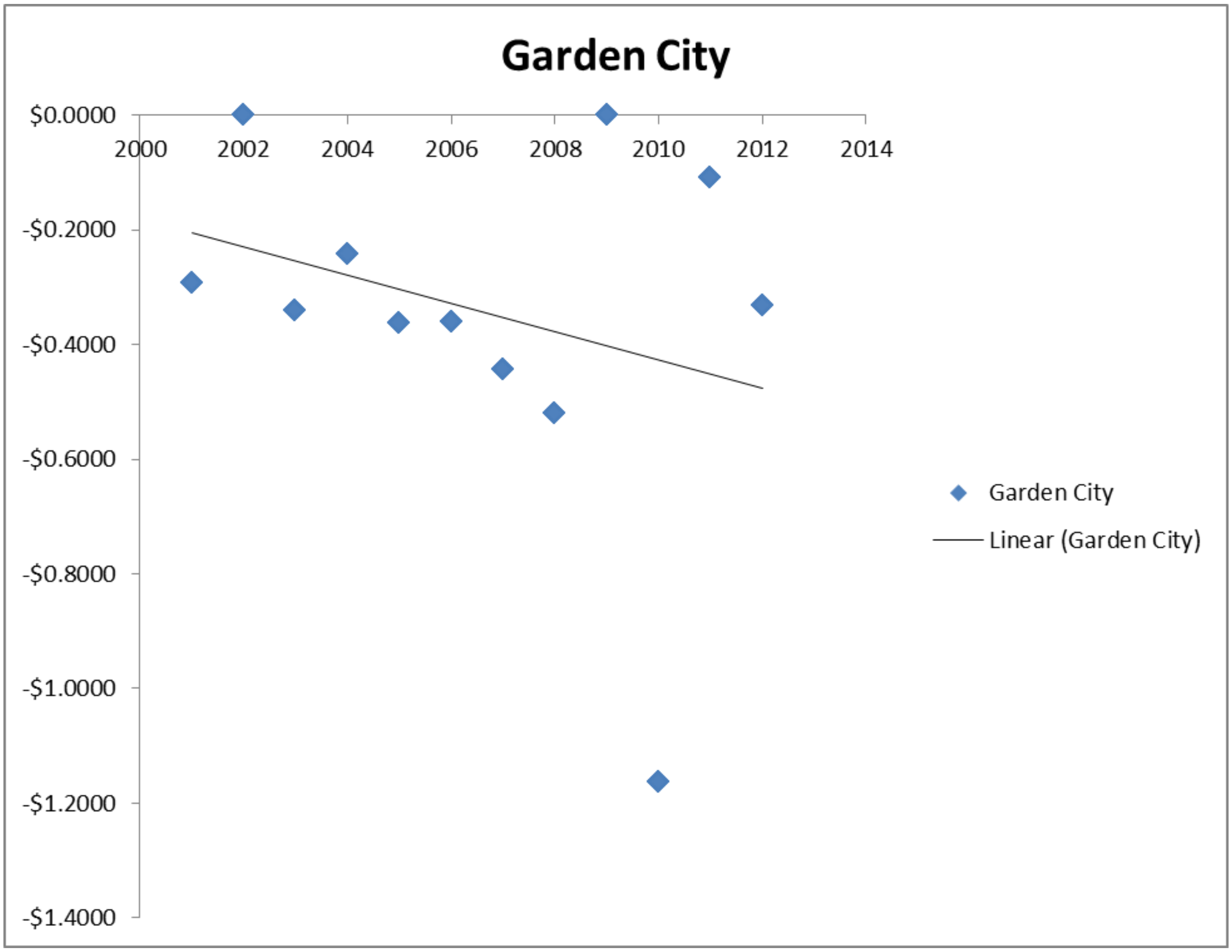

Figure1.3- Garden City Harvest Basis (2000-2012)

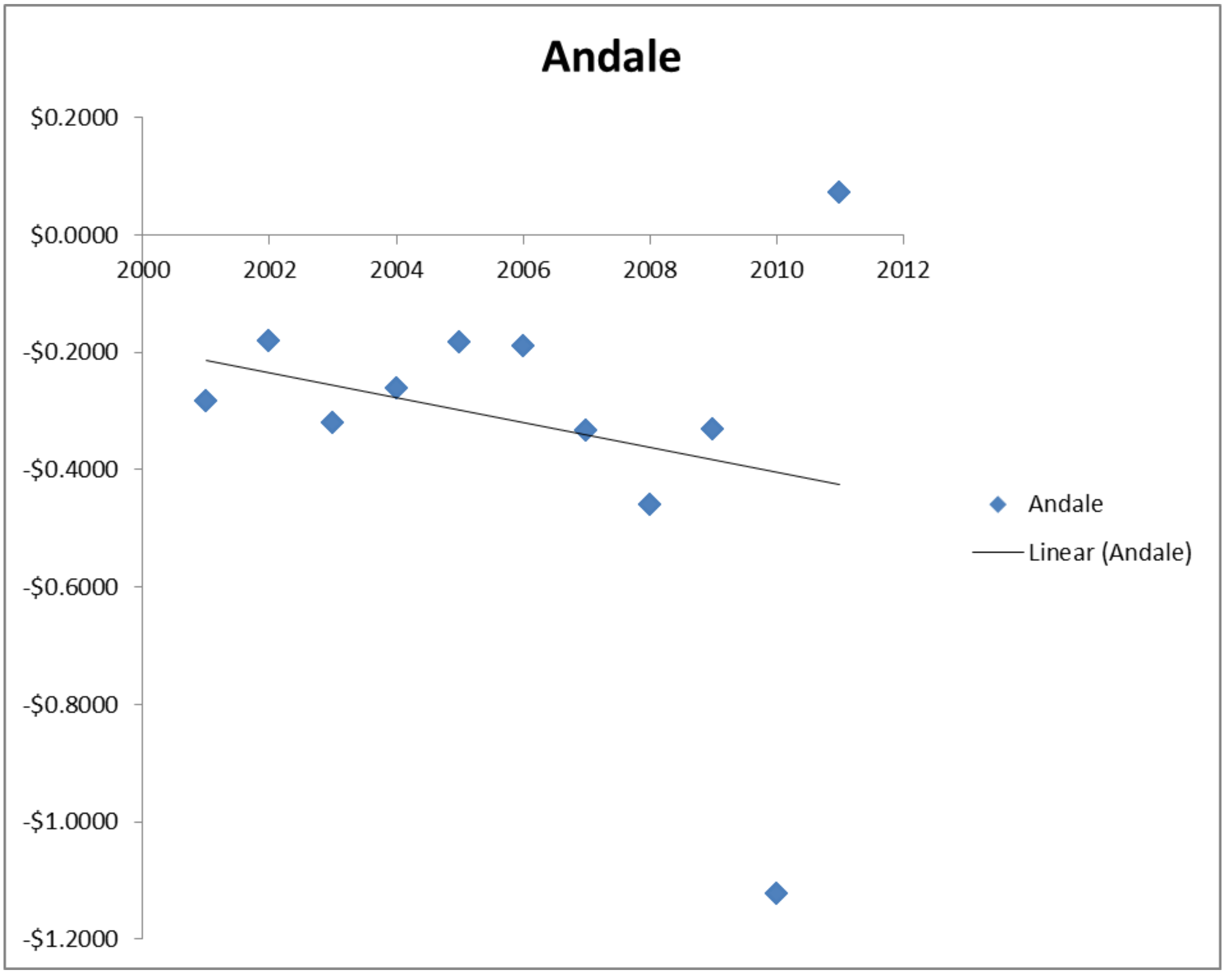

Figure 1.4- Andale Harvest Basis (2000-2012)

Chapter 2 - Literature Review

The literature on the cost of forward contracting is fairly extensive. However, with the exception of Mallory, Etienne and Irwin (2012) and Taylor, Tonsor and Dhuyvetter (2013), the studies were conducted prior to 2007, when agricultural markets saw increased volatility. This lack of research on forward contracting under today's market conditions motivates an update of the work.

A study conducted by Brorsen, Coombs and Anderson (1993) examined Gulf forward basis bids for hard red winter wheat with the intent to determine, on average, what producers pay for forward contracting. The study also aimed to compare the forward contracting cost with that of hedging in the futures market. The data used in the study were unpublished Gulf wheat forward basis bids for 1975-1991, with 1979 being excluded, as no bids were available that year. The bids were collected daily from January 2 through June 30. The authors defined delivery time as the number of calendar days from when the bid was quoted to the last day in June. Overall the data set consisted of sixteen years of cross-sectional, time-series data. For the empirical work, the authors used both a parametric model as well as a non-parametric method. The general form of the equation estimated sets the forward bids as a function of the time to delivery and the year. The parametric equation they estimated is as follows:

$$(1)\ FBB_{it}=\alpha_0+\Sigma\alpha_i D_i+\alpha_{16}DEL_i+\varepsilon_{it}$$

where FBB_{it} is defined as the forward basis bid in year i with t days to delivery, D_i is a binary variable for each year of the sixteen years in the sample (1975-1991); DEL_i is the number of days to delivery, and ε is a normally distributed error term.

The non-parametric method used was to calculate the means of the forward basis bids for each day across the year and then calculate 7-day moving averages to estimate the effect of time to delivery. The authors argue that this non-parametric estimation yields an unbiased and consistent estimate for weekly average forward basis bid; however the result for an estimate on a given day is neither consistent nor unbiased. The study states that "[t]he advantage of non-parametric regression is that an explicit functional form is not imposed" (Brorsen, Coombs and Anderson, 1993). The non-parametric results show that bids offered further away from delivery will be lower than those offered closer to the date of delivery. The basis increases rapidly as harvest approaches, suggesting that a producer would receive, on average, a lower price by forward contracting as opposed to selling outright in the cash market in the last half of the year.

The parametric results are similar to the non-parametric analysis, confirming that as delivery approaches the basis bid decreases. The parametric data also shows that over time the Gulf forward basis has increased. The cost of forward contracts using the parametric approach is found to be half of that using the non-parametric method and the authors attribute this difference to the fact that the parametric equation imposes a linear form, causing this cost to be underestimated.

Another study of forward contracting costs was conducted by Townsend and Brorsen (2000) who examined the cost of forward contracting hard red winter wheat. The authors state that the cost of forward contracting can be viewed as the expected difference in the cash price at harvest and the forward contract price. They go on to argue that, if this is truly the case then contracting is costly when basis between the forward contract price and the futures contract price at delivery increases as time to delivery decreases

The data used in this study were gathered from a grain elevator in Catoosa, Oklahoma and are Arkansas River terminal elevator bids for hard red winter wheat. The bids were gathered for the period 1986 through 1998 and were available for every day of the year that the elevator offered a forward contract bid, up to the last day delivery was accepted. Futures prices were also gathered for the Kansas City Board of Trade (KCBOT) July hard red winter wheat contract. The authors estimate a regression of the Arkansas River terminal bids as a function of the Gulf bids that were collected in Brorsen, Coombs, and Anderson (1993), the July KCBOT wheat futures prices, crop year dummy variables and the number of days left to delivery.

The method employed in this study includes two techniques: a parametric model and a non-parametric model. The non-parametric method is a seven day moving average of the forward bids, similar to the method used by Brorsen, Coombs, and Anderson (1993). The moving average was calculated within each year and across years.

The parametric method involved estimation of a first differences model, which was obtained through a series of derived equations. The equations state the cost of forward contracting, as well the fact that futures are modeled as a martingale, which culminates in the following equation (Townsend and Brorsen 2000):

$$(2)\ \beta(t-1)-\beta(t) = \alpha_1+E_{t-1}[\beta(0)]-E_t[\beta(0)]$$

where $\beta(t\text{-}1)\text{-}\beta(t)$ is the difference between the Arkansas River forward basis bid at delivery and at $t\text{-}1$ days to delivery. On the right hand side of equation (2), the term $E_{t-1}[\beta(0)]$ has an expected value of $E_t[\beta(0)]$, which means that the whole term $E_{t-1}[\beta(0)]\text{-}E_t[\beta(0)]$ has zero mean and can be viewed as an error term. This leaves the right hand side of the equation as only α_1, suggesting that the process of forward contracting has a unit root.

The results of the non-parametric estimation suggest that the cost of forward contracting trends upward as days to delivery decrease, and that under the assumption of unbiased futures prices, forward contracting near planting would result in a lower price than a producer selling cash grain at harvest. The authors conclude that the costs associated with forward contracting are higher than those of hedging with futures.

Another study dealing with the question of hedging cost versus forward contracting cost of wheat was conducted by Taylor, Dhuyvetter and Kastens (2003). The purpose of the study was to examine two risk management tools available to producers (hedging via futures and forward contracting), and determine the cost differences between them. The authors use forward contract bids collected from 48 Kansas elevator locations on a weekly basis. The bids start in week 10 of the calendar year and end in week 21. Week 27 was selected as the harvest week for basis calculation purposes. The other price that was collected was the July KCBOT hard red winter wheat contract price. The expected basis was calculated as the new crop bid minus the July futures contract price and the actual basis was calculated as the cash price at harvest minus the July futures contract price. The authors state that the difference between expected basis and the actual basis can be viewed as the cost of forward contracting, which is also referred to as the risk premium. The results of the study show that the average cost of forward contracting across locations was $0.09/bushel. The authors also found that forward contracting costs declined as harvest approached and attributed this finding to the basis risk declining as harvest approaches. This study also shows that this cost would be less if the commission cost of hedging is included.

The authors also discuss some issues with the study and its results. These issues are that predictions of basis at harvest, either historical or that predicted by the new crop bid calculations, have not been very accurate over time. It has also been shown by this study that elevator predictions of harvest time basis have not necessarily been any more accurate than historic averages. The data also show that the risk premium may not always be a positive value, as some years show a negative value, which would mean that producers actually received money for forward contracting as opposed to paying a fee. On average however, the cost of forward contracting is still a positive value.

A study undertaken by Mallory, Etienne and Irwin (2012) aimed at quantifying the cost of forward contracting for corn and soybeans in Illinois. The study also examined the possibility of a structural break occurring after 2007.

The data set consisted of daily pre-harvest forward contract bids from 1977-2010 and uses calendar year weeks 20-29 for corn and 6-29 for soybeans. The forward basis bids were from seven different regions across Illinois and represent one bid per region per week. For the futures price component, the Chicago Board of Trade (CBOT) December contract was used for corn and the November contract for soybeans. The resulting data set is a panel of 238 location-year pairs.

The conceptual model that the authors specify follows Townsend and Brorsen (2000) and specifies the cost of forward contracting as the difference in the spot price at delivery and the current forward price. The forward basis is defined as the difference between the forward bid and the futures price, and a cash basis at maturity is defined as well. The authors then solve for an equation that is the expectation of the difference in forward basis at time *t* before harvest minus basis at harvest and the futures price at time *t* before harvest minus futures price at maturity. Since the futures price is modeled as a martingale the second term drops out to garner an equation that is the difference between the expected basis prior to harvest and actual basis at harvest.

The other major goal of the article was to determine if a structural break had occurred before and after 2007. The authors used Welches two sample t-test with unequal variances, which were statistically significant. This significance led the authors to present the results for each subsample (1977-2006, 2007-2010) as well as pooled across years. The study found the cost of forward contracting for corn to be $0.95/bushel and statistically significant and the cost appears to be stationary through the marketing year.

The results for soybeans show the lagged coefficient on cost of forward contracting is again $0.95/bushel and statistically significant. The authors again hesitate to conclude that they found an actual downward trend. Again the results in percentage terms for soybeans are much like the results in levels

The authors conclude that there has indeed been a structural break in the cost of forward contracting for corn and soybeans in Illinois as the costs post 2006 are much higher than those before 2006. The authors also conclude that the post 2006 world has more weekly variability, which could play a role in making forward contracting more costly than hedging. This uncertainty leads to forward contracts no longer being the outright cheapest way to manage risk, so producers must be very careful and diligent in their decision making process over what tool will be most effective in helping them manage their risk exposure element.

The last article reviewed here is the most recent article on this topic and was performed by Taylor, Tonsor and Dhuyvetter (2013). The study's objective was to determine if the cost of forward contracting faced by grain producers has been affected by an increase in volatility of wheat basis in Kansas.

The data used in this study were forward bids collected from 18 locations across the state, cash price at harvest, prices for the KCBOT July wheat futures contract, and implied volatilities for the KCBOT July wheat contract. The model used in the study was derived from a series of equations that culminates in an equation that defines the cost of forward contracting to be a function of the difference in the elevators expected basis and the implicit basis they set in the forward contract plus an additive risk premium.

The empirical model that the authors use is a fixed effects model that aims at estimating the risk premium that elevators build into their forward contract bids. The equation is as follows

$$(4)\ \mathrm{r}_{\mathrm{i,j,t}} = \beta_1 + \beta_2 BV_{i,j-1} + \beta_3 R_{i,j-1} + \beta_4 IV_{j,t} + \beta_5 SB + \Sigma^{\mathrm{T}}_{\mathrm{t=1}} \beta_t W_t + \mu_i + \varepsilon_{i,j,t}$$

where $\boldsymbol{\beta}$ is a vector of coefficients to be estimated, $BV_{i,j-1}$ is a measure of the implicit volatility of the previous year's forward contracts, $R_{i,j-1}$ is a variable for the returns on previous year's forward contracts, $IV_{j,t}$ is the implied volatility of the July wheat futures contract, SB is a binary structural break variable, and W_t are a set of binary variables representing each week of the crop year in which forward contracts were offered.

The results of the study find that the risk premium varies across elevator locations in a systematic manner, and that increases in volatility of basis and futures prices have increased the cost of forward contacting for producers. The results also suggest that returns to forward contracting in previous years affect the risk premium and that a structural break in the cost of forward contracting occurred after 2007, likely due to the increase of volatility of basis.

This thesis will contribute to the existing literature on forward contracting and risk premiums by examining the effects of elevator specific variables on risk premiums. The need for more current studies is clear as only two (Mallory, Etienne, and Irwin 2012; Taylor, Tonsor, and Dhuyvetter 2012) examine these topics after the basis and price volatility shift in 2007. The existing literature is comprised of differing evidence on how risk premiums and the cost of forward contracting move as harvest approaches, which means that more examination of how forward contracting costs change over time is necessary. However some overarching statements can be made about the findings in the existing literature. The first is that the costs of forward contracting decline as harvest approaches and the second is that the cost of forward contracting has increased in recent years. The other area where this thesis will contribute to the literature is in the consideration of elevator-specific characteristics variables and their impacts on forward contract risk premiums.

Chapter 3 - Data and Methodology

3.1 Data Overview

The data set compiled for this thesis consists of wheat forward contract bids, futures prices, and cash prices at harvest time, as well as implied volatility for the July KCBOT wheat contract and several elevator-specific characteristics, which will be outlined later in this chapter. To give a better visual representation of the data contained in this study, three figures are presented. All three figures present data for the Andale, Kansas location, which was selected due to its consistent availability of the information summarized in the figures. Figure 3.1 shows the forward price over the time, Figure 3.2 shows the implied, or expected, basis over time, and Figure 3.3 shows the changes in the risk premium measure over time. This chapter will separately discuss the price data, elevator characteristic data, and location choices.

3.1.1 Price Data

The forward and cash prices were collected from DTN on a weekly basis from locations throughout Kansas (DTN.com). The forward bids are gathered every Wednesday, or Thursday if the Wednesday bid was unavailable or was a holiday. The data contained some unreported values, which were subsequently filled in form an alternative data source (Bloomberg).[2]

The futures prices are from the Kansas City Board of Trade (KCBOT) July hard red winter wheat contract[3]. The futures contract used for the implicit basis at time *t* of forward contracting is the July contract prices for time *t*, while the futures for the basis at harvest is the average price of the July contract during the fourth week of June. The cash price at harvest was also gathered and is the price that each elevator location offered on the Wednesday of the fourth week of June. The implied volatilities are an average of puts and calls for the July contract at time *t*.

This dataset also contains three variables that were calculated from the values discussed above: an expected basis, an actual basis, and a calculated risk premium. The expected basis at

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[2] The missing values were week 16 in 2001, weeks 10-16 in 2007, weeks 20-22 in 2008, weeks 15-22 in 2009, week 5 in 2010, week 15 in 2011 and week 18 in 2012.

[3] These contracts were moved to the CME Group in April 2012 but for this study the KCBOT prices are used.

time *t* before harvest is taken as the difference in the forward bid price and the July futures price, *basis_fc(t) = bid_fc(t) – July_fc(t).* The actual basis, or realized basis at harvest, is taken as the difference in the harvest cash price and the June week 4 July futures contract price, *basis_h(0) = cash_h(0) – July_h(0).* Finally the forward contract risk premium variable is taken as the difference in the actual basis and the expected basis variables, *prem_fc = basis_h(0) – basis_fc(t).*

3.1.2 Elevator Characteristics

The elevator characteristics used in this study were gathered from the Kansas Grain and Feed Association directory books for each year of the dataset (2001-2012). Each elevator submits information specific to their facility regarding capacity, rail access, feed mill operation, and licensing. A set of six characteristics were identified and summary statistics, along with a brief description of each characteristic, are shown in Table 3-1. These characteristics were chosen because they are relevant to the research question.

Most of these variables are binary with the exception of vertical storage capacity and flat storage capacity. *Capacity* measures the changes in vertical storage over time while *flat_cap* marks the changes in the horizontal storage, also called flat storage capacity.

For the binary variables a 1 represents yes and 0 represents no; these responses correspond to whether or not the elevator has the characteristic in question. The first two binary variables are *state_gwh* and *fed_gwh*, which represent state licensed grain warehouse and federal licensed grain warehouse, respectively. In this data set the two are mutually exclusive, meaning that no elevator is both state and federally licensed. *State_gwh* equals one if the elevator is a state licensed grain warehouse, and zero otherwise. Likewise, *fed_gwh* equals one if the elevator is a federally licensed grain warehouse, and equal to zero otherwise.

The variable *feed_mill* indicates if that the elevator has a feed mill on site in addition to its grain storage facilities. The variable equals one if the elevator has an on-site feed mill, and zero if it does not have this amenity on the same premises.

The next variable, *rail*, identifies if an elevator is located next to a railroad. It should be noted that elevators have two options when transporting grain: rail and truck. *Rail* equals one if the location has access to a rail head, and zero otherwise.

The last variable, *terminal*, examines whether or not the elevator location is a terminal elevator. A terminal elevator takes in grain from country elevators or producers, inspects grain for quality and quantity, stores it and has the ability to transfer the grain to foreign or domestic buyers via rail, truck or ship. *Terminal* equals one if the location is a terminal location, and equals zero otherwise.

3.1.3 Location Data

The 18 locations, shown in figure 3.4, that were chosen for this study were chosen based upon two major criteria: diversity of their physical location across the state and their consistency of available forward contract bids (Taylor, Tonsor, and Dhuyvetter 2013). Geographic diversity of the locations considered in the study is important in order to achieve a representative sample of forward contracting and risk premiums throughout the state.

Figure 3.1 - Forward Price Over Time

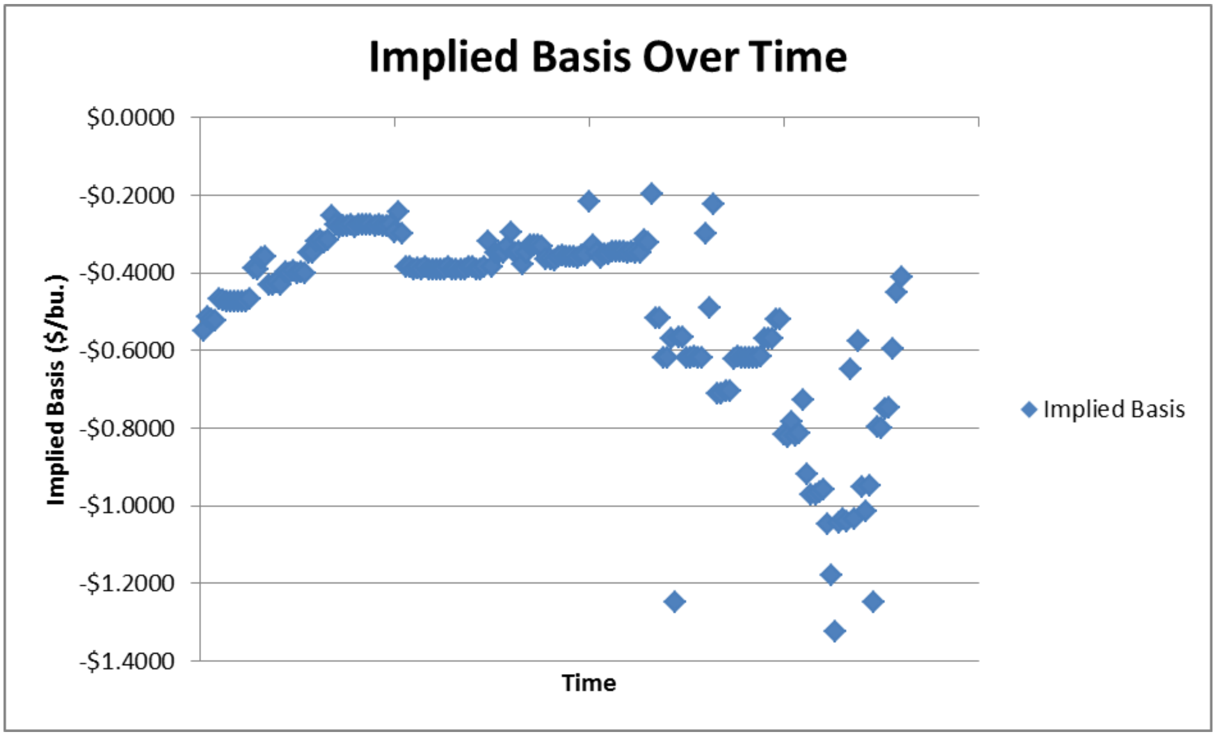

Figure 3.2 - Implied Basis Over Time

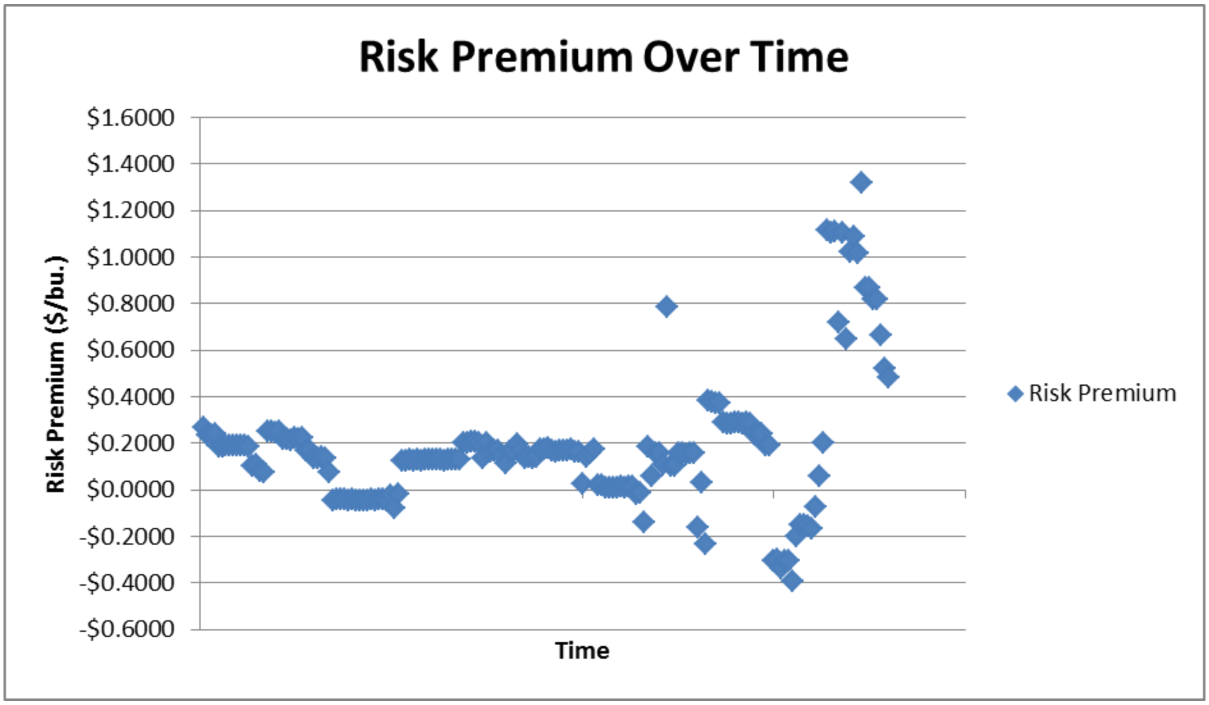

Figure 3.3 - Risk Premium Over Time

Table 3-1, Elevator Characteristics Summary

Elevator Characteristics	Variable Names	Description	Mean	Std	Min	Max
Total Capacity	*tot_cap*	Total vertical and horizontal storage capacity	1428.364	772.5357	258	4214
Total Capacity Squared	*tot_cap2*	Squared total vertical and horizontal storage capacity	2636762	2694389	66564	1.78E+07
Fed Lic. Grain Warehouse	*fed_gwh*	Indicates if elevator is federally licensed	0.4592255	0.4984482	0	1
Feed Mill	*feed_mill*	Indicates if elevator has feed mill on site	0.2915718	0.4545897	0	1
Rail	*rail*	Indicates if elevator has access to rail transport on site	0.6952164	0.4604206	0	1
Terminal	*Terminal*	Indicates if elevator location is a terminal elevator	0.4223235	0.4940421	0	1

Table 3-2, Cross Tabulation Table

	when fed_gwh = 0	when fed_gwh = 1	when feed_mill = 0	when feed_mill = 1	when rail = 0	when rail = 1
Average Capacity	1298.082	1581.781	1304.176	1730.102	998.7025	1616.727
Proportion of Rail Access	54.08	45.92	70.84	29.16		
Proportion of Fed. Licensees			70.84	29.16		

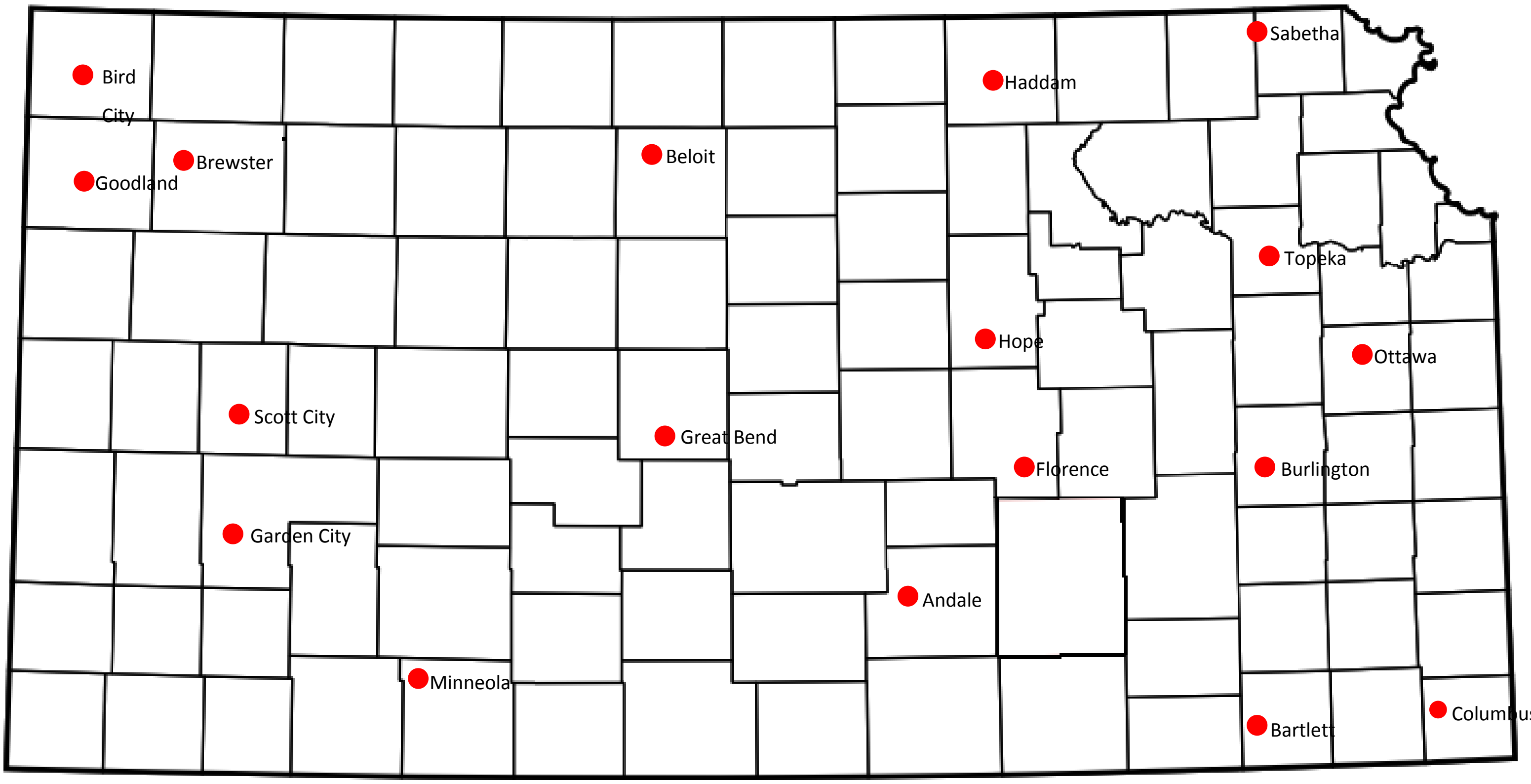

Figure 3.4. Kansas Elevator Locations

3.2 Conceptual Model

This section describes the theory underlying the econometric model that is estimated. Also discussed is the economic intuition for the use of elevator characteristics in the empirical model.

3.2.1 Conceptual Model

Following Taylor, Tonsor and Dhuyvetter (2013), the cost incurred by farmers who use forward contracts, $Cfc_{i,j}(t)$, is defined as follows:

$$(5)\ Cfc_{i,j} = Cp_{i.j}(0) - Fc_{i.j}(t)$$

where $Cp_{i,j}(0)$ is the cash price at harvest for wheat in crop year j, offered by elevator i. $Fc_{i,j}(t)$ is the forward contract bid offered by elevator i for wheat in crop year j at time t to harvest. As has been in other studies, the forward contract bids that elevators offer have a risk premium built into them, so equation (5) can be rewritten as:

$$(5.1)\ Cfc_{i,j} = Cp_{i.j}(0) - (Fc_{i.j}(r_{i,j}))(t)$$

where all element definitions remain the same as in equation (4) with the risk premium on the forward contract bid offered by elevator i in crop year j defined as $r_{i,j}$. With the specification of equation (5.1), and since it is not possible to actually observe the risk premium, a calculated value for the forward contracting cost after harvest is used. This observation of the actual harvest time basis can be compared to the expected, or implicit, basis at the time of the forward contract bid.

Also following Taylor, Tonsor, and Dhuyvetter (2013), the terms in equation (5) can be rewritten and shown broken down into their component parts. The terms in equation (5.1) can be rewritten as follows:

$$(6)\ Cp_{i,j}(0) = B_{i,j}(0) + Kp_j(0)$$

$$(7)\ (Fc_{i,j}(r_{i,j}))(t) = B_{i,j}(r_{i,j})(t) + Kp_j(t)$$

where $B_{i,j}(0)$ is the harvest time basis in crop year j for elevator i; $Kp_j(0)$ is the KCBOT July hard red winter wheat contract price at the time of harvest for elevator i in crop year t; $B_{i,j}(r_{i,j})(t)$ is the basis at the time of the forward contract, which can also be viewed as the implicit basis within the forward contract, by elevator i in crop year j at time t before harvest; and $Kp_j(t)$ is the KCBOT hard red winter wheat July contract value in crop year j at time t before harvest.

Now that the components of equation (5.1) have been defined they can be substituted back into (5.1):

$$(8)\ Cfc_{i,j} = B_{i,j}(0) + Kp_j(0) – B_{i,j}(r_{i,j})(t) – Kp_j(t)$$

With equation (8) defined as above, the need now arises to apply expectations operators to show that some elements in the equation are values that producers expect to be a certain way at harvest. The expectations operators, whose expectations are conditional on information that is set at time *t* before harvest in crop year *j*, will be applied to the first two right-hand side terms in equation (8), $B_{i,j}(0)$ and $Kp_j(0)$. The expectations operators are applied to the harvest time basis term because at the time the forward contract is offered the elevator uses an expectation of what the harvest time basis will be to estimate basis and inform their decision of where to set the forward contract price. This this value is a representation of what participants in the industry believe price will be at contract maturity, harvest time in the case of this study. Applying the expectations operators' yields:

$$(8.1)\ Cfc_{i,j} = E_j(t)[B_{i,j}(0)] + E_j(t)[Kp_j(0)] – B_{i,j}(r_{i,j})(t) – Kp_j(t)$$

where expectations are again conditional on information at time *t*, in crop year *j*. The futures prices used are modeled as martingale prices, which means that the expectation of harvest time price at *t* before harvest is equal to the actual harvest time price. This explanation is best shown mathematically such that, $E_j(t)[Kp_j(0)] = Kp_j(t)$. Clearly the second and last right-hand side terms will now drop out of the equation. Therefore equation (8.1) can be rewritten as:

$$(8.2)\ Cfc_{i,j} = E_j(t)[B_{i,j}(0)] – B_{i,j}(r_{i,j})(t)$$

In looking at the last term in equation (8.2), $B_{i,j}(r_{i,j})(t)$, it is clear that the implied basis, or basis at the time of forward contracting, and the risk premium are both a part of this term and as in Taylor, Tonsor and Dhuyvetter (2013) it is assumed that the risk premium is an additive component on the forward contract price bid. Therefore equation (8.2) becomes

$$(9)\ Cfc_{i,j} = E_j(t)[B_{i,j}(0)] – B_{i,j}(t) – r_{i,j}(t)$$

where $E_j(t)[B_{i,j}(0)]$ is the elevators expected value of the basis at harvest, set at time *t* before harvest, which is also the basis they use in setting the forward contact bid price. $B_{i,j}(t)$ is the actual realized basis at harvest and $r_{i,j}(t)$ is the risk premium on the forward contract when it is set at time *t* before harvest. The first two terms make up one part of the cost of forward contracting because if the elevator is accurate in forecasting the harvest time basis the difference in these two terms will be zero and the only cost of forward contracting will be the risk premium portion. If, however, the elevators do not correctly predict the harvest time basis the difference in the first two terms will either be positive or negative and the cost of forward contracting will not only be the risk premium but also the difference in expected and actual basis. If this difference is positive, the expected basis is larger than the actual basis, the elevator will lose money as they have effectively paid the producer to engage in a forward contract. If the difference is the opposite, a negative value, meaning the expected basis was less than the actual basis, the elevator will make more money than it had intended and the producer will have paid even more for the opportunity to forward contract wheat. The risk premium as defined here can also be thought of as the elevators cost of doing business with forward contracts. The elevator uses the risk premium to offset the risk it incurs by taking on the producers risk, as well as using it to offset some of the costs of hedging, such as maintaining a margin account. The error in basis forecasting, or lack thereof, could be systematic, which could provide insight as to how error in forecasting affects the cost of forward contracting. If a systematic trend in forecasting error could be observed it may be able to be linked to possible similar trends in risk premiums, which could then indicate more definitively how each portion affects the cost of forward contracting. At this time in this study, however, even though the data set contains both the implied basis and the actual at harvest basis, the risk premium component is not observed explicitly so it is impossible to determine to what extent each item affects the cost of forward contracting measure.

3.2.2 Elevator Characteristics

The first independent variable in the model is ave_iv_t and it measures the average implied volatility of the wheat futures contract at time t before harvest. This variable only has a time component because each elevator location in the sample faces the same volatility on the July KCBOT wheat futures contract. The reason this variable is included in the model is to measure the implied volatility of puts and calls for the July wheat futures contract, which reflects the volatility of the wheat futures contract used for hedging by both producers and elevators. High volatility makes predicting the harvest time price, and the direction of price moves, much more difficult. This uncertainty about the stability of futures prices would more than likely drive producers to use alternate methods of risk management and elevators to protect themselves from unfavorable futures moves in other ways as well. One of the ways in which an elevator could help to insulate itself from this volatility would be to build in a larger risk premium to their offered forward contract bid price, a contract which they would then hedge. The expected sign on the ave_iv_t variable is positive, meaning that when the volatility increase the risk premium will increase correspondingly.

The next variable is $std\_fcb1_{i,t,j-1}$ which measures the standard deviation of the previous year's forward contract bid prices, and gives an observation of how elevators changed their bids. This observation is put into a contemporaneous model because it is not possible to observe the changes in forward bids until after harvest. This variable has both time and location components because it varies over time and across the elevator locations. The importance of having this variable in the model is that it measures the variance of the forward contact bids, which could indicate several things. The first is, the variance of forward bids may indicate weak stability in either wheat cash prices or futures prices. The connection to cash prices is that the forward bids the elevators offer are based on the elevators expected price at harvest and the cash price at the time before harvest when the forward bid is offered. Excessive volatility in cash price would lead to forward bids showing large variation as well. The connection with futures prices is that if futures are highly volatile elevators may find it harder to protect themselves by using them and will reflect this uncertainty in their basis bids. This lack of stability would naturally bring about uncertainty on the part of the elevators, which would make them keen to protect themselves from damaging price moves by using higher risk premiums.

The explanatory variable $return1_{i,t,j-1}$ measures the returns on the previous year's forward contracts for the elevator locations, whether they be positive, negative or zero. The variable has both time and space components as it can vary over time at each elevator and across the elevator locations. The importance of having this variable in the model is that the returns to forward contracts the elevators experience can influence their aversion to risk, or the amount of risk an elevator is willing to expose itself to, which in turn influences the amount of risk protection the elevator will use. The returns the elevators make, and the risk protection they use, are affected by the increase in volatility, uncertainty and their ability to accurately predict the basis at harvest. The accuracy of these predictions is an issue because the elevator attempts to predict the basis at harvest via the forward bid price and the futures contract price and if they do not correctly predict this basis they may set their forward bids at the wrong level. This causes problems for the elevator at harvest because if they set a forward bid price that is higher than the expected and realized price, the basis becomes positive, which means the elevator loses money on the forward contracts and the producers make money on the contract. It is possible the risk premiums are affected by the amount of risk protection an elevator desires. If the returns to last year's forward contracts were positive for the elevators, they may be able to offer a more competitive forward bid by lowering the risk premium. The opposite side of this positive scenario would be if the previous year's forward contracting returns were negative, the elevator may increase its risk premium in order to protect itself from more risk and make back some of the profit they lost in the previous year. The predicted sign for the $return1_{it}$ variable is negative.

The two variables, $week_t$ and $week\_sq_t$ are included to account for a potential non-linear effect of time remaining to harvest on the forward contract risk premium. If there is a quadratic effect form time remaining to harvest, the derivative with respect to $week_t$ shows both the direction and rate at which the risk premiums decrease or increase as harvest time approaches. The expected sign on the week trend variable is negative because as harvest approaches the uncertainty about the season's crop decreases (Brorsen, Coombs, and Anderson 1993; Taylor, Dhuyvetter, and Kastens 2003). Thus the elevators would have less need to cushion their downside risk, and be able to offer forward bids with lower risk premiums.

The next two variables in the model are tot_cap_{it} and tot_cap2_{it} which are the total capacity and total capacity squared. The total capacity variables are created by taking the sum of the flat capacity and vertical capacity for each location. These capacity measures can vary over time giving these variables both time and location components. The importance of having these variables in the model is that they allow for a potential non-linear effect of elevator capacity on risk premiums that are built into forward contract bids. The tot_cap_{it} variable gives the direction in which risk premiums move as total capacity of the elevator locations changes and the tot_cap2_{it} variable measures the rate at which capacity affects the risk premium. The full effect of the two variables is calculated by taking the derivatives of each and summing them together. This allows for a view of the direction of change in risk premiums via the coefficient on the total capacity variable and the nature of this change, whether it is at an increasing rate or a decreasing rate.

The expected sign on the total capacity variable is negative because as the grain storage capacity of the elevator increases the cost of forward contracting and the risk premium component should decrease. Conversely as capacity decreases it should increase the cost and risk premium. This is because as the elevators ability to store grain increases so too does its ability to absorb the impacts of potential and realized contract defaults by producers who do not have the grain to fulfill their contract obligations. This ability to absorb these defaults lessens the need for the elevator to insulate itself using high risk premium values. The decrease of this overall cost to forward contracting makes this a more appealing option to producers, in turn bringing more grain and business to the elevator.

The next variable, fed_gwh_i, is the first of several binary variables indicating if an elevator has certain characteristics. The variable fed_gwh_i indicates whether or not the elevator is a federally licensed grain warehouse. The opposite of this is for the elevator to be a state licensed grain warehouse, and the two are mutually exclusive in this data set, which means that all of our elevator locations are either federally licensed or state licensed. This elevator characteristic only varies over the location component in the model as time does not affect it for the time period of this study. The fed_gwh_i variable is included because all grain warehouses must be licensed at either the state or federal level. With that being the said, any impact the type of licensing would have on the risk premium would be due to some difference between the requirements of the two license types.

A state licensed grain warehouse may act as a true grain warehouse in that it can purchase or hold grain pursuant to state code but may not hold federally loaned grain without a federal Uniform Grain and Rice Storage Agreement (UGRSA) (Kansas Department of Agriculture, 2011; Illinois Department of Agriculture; SD Public Utilities Commission, Warehouse Division; USDA: FSA Uniform Grain and Rice Agreement, 2013). A federally licensed grain warehouse on the other hand has all of the benefits of a state licensed warehouse but it can also use and store grain that is loaned by the federal government, again pursuant to federal code or the Uniform Grain and Rice Agreement (SD Public Utilities Division, Warehouse Division; USDA: FSA Uniform Grain and Rice Agreement 2013). The benefit of having the ability to use and store government grain is one item sets the two licensing categories apart, as this ability allows the elevator to get a loan of federal grain if they are short of grain that they need for shipping or milling.

The other two aspects that make the licensing types different are inspection frequency and net worth requirements. State licensed warehouses are mandated to be inspected yearly, while federally licensed warehouses are to be inspected every three years (Casper 2013). In terms of net worth, state elevators must have a net worth of $0.25 for every bushel of capacity, with a minimum of $25,000 or $50,000 for elevators seeking a UGRSA. A UGRSA may be obtained through the USDA for no charge and allows the facility to store federally loaned grain (SD Public Utilities Division, Warehouse Division). Federally licensed elevators must have a net worth of $0.25/bushel for every bushel of capacity with a minimum of $200,000 (Casper 2013; SD Public Utilities Division, Warehouse Division; USDA: FSA Uniform Grain and Rice Storage Agreement 2013). The higher net worth requirement for federal licenses might make the elevator more financially stable and affect their pricing strategies for forward contracts. It may be that this financial stability carries over into more competitive bids or causes the elevator to be more conservative and charge a higher risk premium. Therefore, the expected sign on this variable is ambiguous.

The next binary variable is $feed\_mill_i$. This variable indicates whether or not the elevator has a feed mill on site. The reason this variable is included in the model is to account for the potential impact an on-site feed mill may have in diversifying the elevators business. The sign on this variable is expected to be negative, which means that it will decrease the cost of forward contracting and risk premiums. The reason is that with a feed mill on site the elevator eliminates the cost of transporting grain to a feed mill and it has the ability to mill the grain into feed stuffs, which are higher value products, for sale to animal feeders across the state. Both of these benefits reduce risk for the elevator, which could lead to lower risk premiums.

The variable $rail_i$, indicates whether or not the elevator location has access to rail transport. This variable varies across the elevator locations, but not across time in the sample. The importance of this variable is that access to rail diversifies transportation options for grain elevators and allows them to ship their grain by rail or transport it by truck to its final destination. This variable is expected to have a negative impact on the risk premiums of forward contracts.

The last variable in the regression is $terminal_i$, which indicates whether or not the elevator is a terminal elevator. This variable varies only across the elevator locations, not across time. This variable is included because terminal elevators are often large capacity operations that take grain from all over and then store it to be transported by rail, truck, barge or other means to destinations both foreign and domestic. An elevator being a terminal location could have impacts on its risk premium level because their large capacity would drive their risk premium down due to the fact that more capacity creates a risk cushion. This could also affect risk premiums due to the other factors discussed with the *tot_cap_{it}* variable.

3.3 Econometric Models

Two models are estimated in order to determine the variables that drive changes in risk premiums of forward contracts. Table 3.3 shows summary statistics of the variables used in both models. The first model that was estimated is as follows:

$$(10)\ r_{i,j}(t) = \alpha + \beta_1\ ave\_iv_t + \beta_2\ std\_fcb1_{i,t,j-1} + \beta_3\ return1_{i,t.j-1} + \beta_4\ week_t + \beta_5\ week\_sq_t + \beta_6\ tot\_cap_{it} + \beta_7\ tot\_cap2_{it} + \beta_8\ fed\_gwh_i + \beta_9\ feed\_mill_i + \beta_{10}\ rail_i + \beta_{11}\ terminal_i + \varepsilon_{it}$$

where α is a constant; *ave_iv_t* is the average implied volatility for the July wheat futures contract at time *t* to harvest; *$std\_fcb1_{i,t,j-1}$* is the standard deviation of the forward contract bids for elevator *i* at time *t* to harvest; *$return1_{i,t,j-1}$* is a backward looking variable for the elevator *i's* return on the previous year's forward contracts, at time *t* before harvest; *$week_t$* is a weekly trend variable and *$week\_sq_t$* is the squared counterpart used in conjunction with the week trend in order to capture the possibility of a quadratic effect of time on risk premiums. The following variables are the selected elevator characteristics from the locations across Kansas, with *tot_cap_{it}* being a variable for total capacity of elevator *i* at time *t* to harvest and *tot_cap2_{it}* being the squared version of the total capacity variable that shows the full effect of capacity; *fed_gwh_i* is a binary variable indicating if the elevator is a federal grain warehouse or a state licensed grain warehouse; *$feed\_mill_i$* is a binary variable that indicates if the elevator location has a feed mill on site or not; *$rail_i$* is a binary variable that indicates whether or not the elevator has access to rail transport; *$terminal_i$* is a binary variable that indicates where or not the elevator is a terminal elevator. ε_{it} is an iid error term.

The second model that was estimated is similar to the first but is estimated under a different specification with a different error structure, and is as follows

$$(11)\ r_{i,j}(t) = \alpha + \beta_1\ ave\_iv_t + \beta_2\ std\_fcb1_{it} + \beta_3\ return1_{it} + \beta_4\ week_t + \beta_5\ week\_sq_t + \beta_6\ tot\_cap_{it} + \beta_7\ tot\_cap2_{it} + \beta_8\ fed\_gwh_i + \beta_9\ feed\_mill_i + \beta_{10}\ rail_i + \beta_{11}\ terminal_i + \mu_i + \varepsilon_{it}$$

where $\mu_i + \varepsilon_{it}$ is an error structure with μ_i being an elevator-specific error term, and as such it does not change over time but only over the elevator locations, and ε_{it} is an error term that is independent and identically distributed (iid).

Equation (10) is estimated using ordinary least squares (OLS) regression, while equation (11) is estimated using random effects generalized least squares (GLS) regression. The benefits to the random effects GLS model are that it allows one to view how risk premiums are affected by both time and location components, which also makes full use of the panel aspect of the data in this study. For panel data models, random effects GLS is preferred to OLS because OLS is inefficient due to the location-specific term having correlated errors for the same location. This error correlation produces OLS results that are inefficient with incorrect standard errors. However random effects GLS utilizes the location and time attributes of the panel data and a component error structure to produce efficient results (Cameron and Trivedi, 2005; McManus, 2011; "Panel Data Econometrics").

Table 3-3, Regression Variables Summary

Elevator Characteristics	Variable Names	Description	Mean	Std	Min	Max
Forward Contract Risk Premium	*prem_fc*	Risk premium on forward contracts for Kansas wheat	0.1884235	0.2849615	-0.505	1.421
Average Implied Volatility	*ave_iv*	Average implied volatilities for July wheat futures contract	31.16047	7.749675	18.11	54.845
Standard Deviation of Forward Contract Bids	*std_fcb1*	Standard deviation of the previous year's forward contract bids	0.0647938	0.072335	0.001118	0.6313614
Return on Forward Contracts	*return1*	Return on previous year's forward contracts	0.1490522	0.2392879	-0.3033333	0.9425714
Week	*week*	Week of the crop year	14.44233	5.835947	1	25
Week Squared	*week_sq*	Week of the crop year squared	242.6248	169.9286	1	625
Total Capacity	*tot_cap*	Total vertical and horizontal storage capacity	1428.364	772.5357	258	4214
Total Capacity Squared	*tot_cap2*	Squared total vertical and horizontal storage capacity	2636762	2694389	66564	1.78E+07
Fed Lic. Grain Warehouse	*fed_gwh*	Indicates if elevator is federally licensed	0.4592255	0.4984482	0	1
Feed Mill	*feed_mill*	Indicates if elevator has feed mill on site	0.2915718	0.4545897	0	1
Rail	*rail*	Indicates if elevator has access to rail transport on site	0.6952164	0.4604206	0	1

Chapter 4 - Results

In this chapter results for both models, the OLS and random effects GLS, are presented. Results for the regressions without the elevator characteristics are supplied in Appendix A. The OLS results are shown in table A-1 while the RE GLS results are shown in table A-2. Comparing the results for the estimations with and without the elevator characteristics gives an idea of how adding the characteristics affects the fit of the model. An inspection of the respective R-squared, and Adjusted R-Squared, measures indicates that both the OLS and RE GLS models show gains from adding the elevator characteristics. The results of the OLS regression are shown in table 4-1, while the results for the random effects GLS regression are shown in table 4-2. The coefficient estimates from the two models are very similar, and the fit of the model as measured by the R-squared values are also similar. The lack of difference between the two models is likely a result of the panel information being picked up by the elevator-specific characteristics that were added to the model specification. This may have caused the random effects GLS estimation technique to not differ noticeably from the OLS estimation. The coefficient results for the more robust of the two models, the random effects GLS model (R-squared 0.4801), will be discussed here.

Two of the variables in the model described in equation (10), $terminal_i$ and tot_cap_{it}, are correlated at a 0.6855 level. This high level of correlation can cause the coefficient estimates to be biased. The high level of correlation between the two variables also nullifies an assumption of the OLS and random effects GLS estimation methods. Both methods require all linear regressors to be independent of one another in order to be best linear unbiased estimators (BLUE). The high level of correlation requires one of the variables from the regression to be dropped. The variable that will be dropped is the $terminal_i$ variable. The reason this variable was chosen to be dropped from the model is that only a small portion of the eighteen locations used in this study are terminal elevators.

The sign of the coefficient for the variable ave_iv_t is positive, which matches the expected sign for the variable. This variable is statistically significant at the one percent level ($p<0.01$) with a p-value of 0.000 and suggests that as the volatility on the July wheat futures contract increases by \$0.01/bushel the risk premium an elevator charges does as well, by \$0.004/bushel.

The variable std_fcb1_{it} has a positive coefficient that is statistically significant (p-value 0.000), which indicates that as the variation of the previous year's forward bid prices increases so does the risk premium on bid prices in the current year. This can be viewed as a reflection of the uncertainty in predicting the harvest time basis by elevators. Due to this year to year uncertainty elevators appear to attempt to protect themselves by using a higher risk premium which clearly increases the cost of forward contracting for wheat producers.

The next variable, $return1_{it}$ is statistically significant and has a negative sign on its coefficient, which matches the expectation of a negative relationship. The coefficient estimate for this variable indicates that as the elevators return on last year's forward contracts increases, the risk premium on the forward bids offered in the following year will decrease. The opposite scenario would be if the returns on last year's forward contracts are negative, the risk premium on the next year's bids will increase. This is likely due to the elevator looking to recoup some of its losses from the previous year by charging a higher risk premium the following year. For every \$0.01/bushel increase in returns on previous years forward contracting, the risk premium decreases by \$0.52/bushel.

The next two coefficients in the model are $week_t$ and $week\_sq_t$ and are used in conjunction in order to examine the direction and rate of change in risk premiums as harvest approaches. The sign of the coefficient for $week_t$ is positive and statistically significant at the one percent level (p-value 0.000) and the sign for $week\_sq_t$ is negative and significant at the same level (p-value 0.000). These two coefficients indicate that as harvest approaches the risk premiums increase at a decreasing rate. Figure 4.1 shows this effect graphically.

This finding goes against the expected effect of risk premiums decreasing as harvest approaches. However an examination of figure 4.1 shows that the effect of time causes the risk premium to increase in the weeks farthest out from harvest. This impact occurs at a decreasing rate until week 15 of the calendar year, where it then switches and becomes negative.

An explanation for this coefficient finding could lie in the findings of several previous studies, as the results on time to harvest and its effects on forward contracting differ slightly across them. The two most recent studies have used a similar time frame as this study and are therefore the best to compare to the finding here. Taylor, Tonsor and Dhuyvetter (2013) find that their time tend variable is consistent with previous research in that it shows that the cost of forward contracting decreases as time to harvest decreases. However when viewed in pre- and post-2007 structural break periods, the evidence is less robust, as the pre break period has a time trend that is significant, and the post break period has one that is not. They conclude that this lack of a significant trend after 2007 could be due to the variability in basis driving risk premiums more so than time or local information gathered over time. Mallory, Etienne and Irwin (2012) found that the time trend they used showed no significant evidence of a downward slope over the full time period or in either of the two structural break periods. This evidence points to the fact that time may be an ambiguous indicator of risk premium movements, especially through only limited lengths of time.

The variable tot_cap_{it} is negative and statistically significant at the one percent level (p-value 0.000) and the variable tot_cap2_{it} is positive and statistically significant at the one percent level (p-value 0.000). This indicates that as total storage capacity of an elevator increases, the risk premiums will decrease at an increasing rate. This result matches the predicted sign and even gives a look at the expected rate of the decrease, which is the derivative of the coefficient estimate on the tot_cap2_{it} variable. Figure 4.2 shows this total effect graphically. The effect decreases at an increasing rate for capacities up to 1,642,600 bushels, where it then switches and becomes positive. This effect shows that the tot_cap_{it} variable conforms to prediction that as elevator size increases the risk premium decreases, but only up to a certain point. This could be due to several different factors, including, but not limited to, market power, forecasting ability, capacity utilization, and production expectations.

Market power could influence an elevators risk premium through the ability of the elevator to set its' own price instead of offering a price that is equal to fair market value. This kind of power is usually seen in larger firms, which could correlate to why the effect of the total capacity variable is as seen in Figure 4.2. If the larger firms in this study have market power they could use that power to set their forward contract price artificially high, via a larger risk premium, which would explain the effect the tot_cap_{it} has on the risk premium measure.

The forecasting ability of elevators is another factor that could impact how capacity affects risk premiums on forward contracts. If the elevator is poor at forecasting harvest time price or basis levels they may set their forward bid price such that they under or over utilize their grain storage capacity. This could cause the elevator to change its forward bid basis or risk premium in the next year, giving the impression that capacity was what caused the change as opposed to forecasting basis.

As was mention above, utilization of elevator capacity, as well as the elevators need for grain, could have an impact on forward contracting. The utilization of an elevators capacity in two ways, depending if their capacity is being under or over utilized. If an elevator is at full capacity they may increase their risk premium, thereby decreasing the forward contract bid and decreasing the likelihood of producers bringing in grain due to the lower price they would receive. On the other hand if an elevator wants to attract more grain, they may lower their risk premium in order to give a more favorable price to producers, who would then be more likely to bring grain to the elevator.

An elevators need for grain could also impact the effect of the tot_cap_{it} variable, especially for smaller elevators. A smaller elevator may need to be more aggressive to get grain, whereas a larger elevator may not need to use this tactic. The aggressiveness of the small elevator would come in the form of decreased risk premiums, which would make the forward bid price more attractive to producers who are looking to contract their grain.

Production expectations are another item that could explain the effect that total capacity was found to have on risk premiums in this study. If production is expected to be full then an elevator may offer weaker basis bids due to the fact that more crop production will drive prices down. On the other hand, if production is expected to be low, an elevator may offer strong basis bids in order to attract grain to the elevator.

The variable fed_gwh_i is positive and statistically significant at the one percent level (p-value 0.000), which goes against the expected sign for this variable. The sign on this variable indicates that if an elevator is licensed federally as opposed to being licensed by the state of Kansas they will increase the risk premium built into the forward contract. The reasons for the finding could be due to the difference in state licenses and federal licenses. For Kansas grain warehouses the two major differences in the license type are inspection frequency and net worth requirements. State licensed warehouses are required to be inspected yearly, while federally licensed warehouses are only required to go through inspection every three years. The lower federal inspection frequency may be attractive to elevators that lack efficient management and are thus lax when it comes to keeping up with regulations and guidelines. The way that net worth requirements differ between the license types could explain the difference between the expected and actual sign on this variable as well. For state licensed grain warehouse the operation must have and be able to maintain a $25,000 net worth or 50% of the value of the stored grain (South Dakota Public Utilities Commission Warehouse Division). The federal side of things is a bit different with federally licensed grain warehouses needing to have and maintain a net worth of $200,000 or $0.25/bushel on every bushel for their total capacity (USDA FSA, 2011). The net worth differences could mean that most federally licensed warehouses are larger than some of their state licensed counter parts, which can be seen in table 3-2. This plays into the risk premium measure through capacity, as was stated earlier.

The variable $feed\_mill_i$ is positive and statistically significant at the one percent level (p-value 0.000), meaning that if the elevator location has a feed mill on site their risk premium on forward contracts will increase by $0.095/bushel. This coefficient does not match the predicted sign as $feed\_mill_i$ was expected to have a negative impact on the risk premium measure. Some reasons for this disparity could be the grain mix an elevator desires to keep in storage, the location of the elevator or the fact that feedlots often have feed mills of their own.

If the elevator wishes to keep more corn or other commodities in storage rather than wheat they could possibly increase the risk premium on their wheat contract offers in order to limit the volume of wheat producers will contract with the elevator.

The location of the elevator could also come into play with the commodity mix that the elevator wishes to have in their bins. If the elevator is located in the area of the state that is highly saturated with feedlots they may well desire to keep more corn on hand for sale to cattle feedlots. The elevators in the sample are fairly evenly distributed throughout the state however so the effects of feedlot concentration or grain growing regions may not be the biggest factor in giving this variable a positive sign.

Following on the location of elevators, another reason this variable could have come out differently than expected is that many feedlots have their own feed mills on site and thus may not need to purchase pre-milled grain. If an elevator made an investment for a feed mill that it ended up not utilizing or utilizing at an inefficient capacity it could stand to reason that they would try and gain back some of the losses from that investment by increasing the risk premium on its forward contracts.

The last variable in the regression, $rail_i$, has a negative coefficient that is statistically significant at the one percent level (p-value 0.000). This suggests that if the elevator has on-site rail access, they tend to decrease their risk premiums on forward contracts by $0.063/bushel. The sign on the estimated variable matches the prediction of a negative relationship between $rail_i$

and the risk premium measure due to lower transportation costs being passed on to producers through lower risk premiums.

4.2 Further Variable Examination

Two variables were added to the models represented in equation (10) and equation (11) to investigate their impacts on forward contract risk premiums. The variable aiv_fut_t replaces the original implied volatility measure and sb_t is a binary structural break variable. The results for the OLS regression with these added variables are shown in table 4-3 and the results for the RE GLS regression with the added variables are shown in table 4-4.

The aiv_fut_t variable is an interaction variable between the average implied volatility and futures price. This variable only has the time component as all elevators face the same volatility in prices. It is included in an attempt to capture price level variability as well as to examine if the basis level is correlated with the price level. The expected sign on this variable is positive because as the variability in price increases, the risk premium should increase as well. This is due to the fact that, much like with implied volatility, as variability increases, so too does uncertainty and elevators will try to minimize the negative impacts of this uncertainty with higher risk premiums.

The results show that aiv_fut_t is positive and statistically significant at the one percent level (p-value 0.000), which matches the expected sign for this variable. The coefficient on this variable indicates that as price level variability increases by $0.01 elevators will increase their risk premium by $0.0003/bushel.

The variable sb_t is a binary variable indicating a structural break in wheat prices before and after 2007. This variable only varies across the time component because every elevator would face the effects of the structural break in wheat basis volatility A 1 for this variable indicates the year was after 2007, whereas a 0 indicates the year was 2007 or earlier. The expected sign on this variable is positive because increased variability due to the structural break in prices and volatility will cause elevators to increase risk premiums in order to reduce their risk from wild and unfavorable swings in price.

The results show that sb_t is positive and statistically significant at the one percent level (p-value 0.000), which matches the expected sign for this variable. The coefficient on the structural beak variable indicates that after 2007, forward contract risk premiums increased by $0.07/bushel.

With the effects of all the above variables taken into account it can be seen that the average risk premium on Kansas wheat forward contracts increases by $0.069695/bushel. The average risk premium before the structural break in 2007 was $0.158682/bushel, while the average risk premium after the structural break period is $0.228378/bushel.

Table 4-1, OLS Regression

prem_fc	Coef.	Std. Err.	t	P>t	[95%	Conf. Interval]
ave_iv	0.0037097	0.0007296	5.08	0.000	0.0022789	0.0051405
std_fcb1	2.495766	0.0752438	33.17	0.000	2.348199	2.643333
return1	-0.5134688	0.0227962	-22.52	0.000	-0.5581764	-0.4687612
week	0.0176548	0.004302	4.1	0.000	0.0092179	0.0260917
week_sq	-0.0005753	0.0001468	-3.92	0.000	-0.0008632	-0.0002873
tot_cap	-0.0002595	0.0000242	-10.74	0.000	-0.0003068	-0.0002121
tot_cap2	7.93E-09	6.34E-09	12.52	0.000	6.69E-08	9.17E-08
fed_gwh	0.0455284	0.0117808	3.86	0.000	0.0224241	0.0686327
feed_mill	0.0979601	0.0124555	7.86	0.000	0.0735326	0.1223875
rail	-0.0569833	0.0136108	-4.19	0.000	-0.0836766	-0.0302901
_cons	0.0288209	0.0382058	0.75	0.451	-0.0461077	0.1037494
R-squared	0.471	Adj. R-squared	0.4683		RMSE	0.22118

Table 4-2, RE GLS Regression

prem_fc	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
ave_iv	0.0036886	0.0007266	5.08	0.000	0.0022645	0.0051128
std_fcb1	2.503866	0.0749164	33.42	0.000	2.357033	2.6507
return1	-0.5232276	0.0226542	-23.1	0.000	-0.5676291	-0.4788261
week	0.0176666	0.0042618	4.15	0.000	0.0093135	0.0260196
week_sq	-0.0005729	0.0001454	-3.94	0.000	-0.0008579	-0.0002879
tot_cap	-0.0002609	0.0000288	-9.06	0.000	-0.0003174	-0.0002045
tot_cap2	8.29E-08	7.18E-09	11.55	0.000	6.88E-08	9.69E-08
fed_gwh	0.0524502	0.0150221	3.49	0.000	0.0230074	0.0818929
feed_mill	0.0945428	0.0164717	5.74	0.000	0.0622588	0.1268268
rail	-0.061519	0.0174893	-3.52	0.000	-0.0957973	-0.0272407
_cons	0.0232484	0.0395325	0.59	0.556	-0.0542339	0.1007306
R-squared	0.4801					

Table 4-3, OLS Regression With Additional Variables

prem_fc	Coef.	Std. Err.	t	P>t	[95%	Conf. Interval]
aiv_fut	0.002882	0.0000632	4.56	0.000	0.0001643	0.0004121
std_fcb1	2.201972	0.0798068	27.59	0.000	2.045456	2.358488
return1	-0.5019916	0.0245589	-20.44	0.000	-0.5501561	-0.453827
week	0.0191326	0.004112	4.65	0.000	0.0110682	0.0271969
week_sq	-0.0006116	0.0001405	-4.35	0.000	-0.0008872	-0.0003361
tot_cap	-0.0002343	0.0000236	-9.94	0.000	-0.0002805	-0.000188
tot_cap2	7.00E-08	6.21E-09	11.28	0.000	5.78E-08	8.22E-08
fed_gwh	0.0461103	0.0114227	4.04	0.000	0.0237083	0.0685123
feed_mill	0.0973581	0.0121119	8.04	0.000	0.0736045	0.1211118
rail	-0.0470584	0.0132491	-3.55	0.000	-0.0730422	-0.0210746
sb	0.0680925	0.0176414	3.86	0.000	0.0334945	0.1026906
_cons	0.0438693	0.0329651	1.33	0.183	-0.0207812	0.1085198
R-squared	0.5011	Adj. R-squared	0.4983		RMSE	0.21484

Table 4-4, RE GLS Regression With Additional Variables

prem_fc	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
aiv_fut	0.0002849	0.0000626	4.55	0.000	0.0001621	0.0004077
std_fcb1	2.206335	0.0794864	27.76	0.000	2.05045	2.362126
return1	-0.5123667	0.0244026	-21.00	0.000	-0.560195	-0.4645384
week	0.0190506	0.0040708	4.68	0.000	0.0110721	0.0270292
week_sq	-0.0006066	0.0001391	-4.36	0.000	-0.0008792	-0.000334
tot_cap	-0.0002405	0.0000278	-8.64	0.000	-0.000295	-0.000186
tot_cap2	7.41E-08	6.97E-09	10.63	0.000	6.05E-08	8.78E-08
fed_gwh	0.0519982	0.0144164	3.61	0.000	0.0237426	0.0802538
feed_mill	0.096354	0.015823	6.09	0.000	0.0653416	0.1273664
rail	-0.0479294	0.0168378	-2.85	0.000	-0.0809309	-0.014928
sb	0.0696954	0.017535	3.97	0.000	0.0353274	0.1040634
_cons	0.040845	0.0344243	1.19	0.235	-0.0266253	0.1083153
R-squared	0.5108					

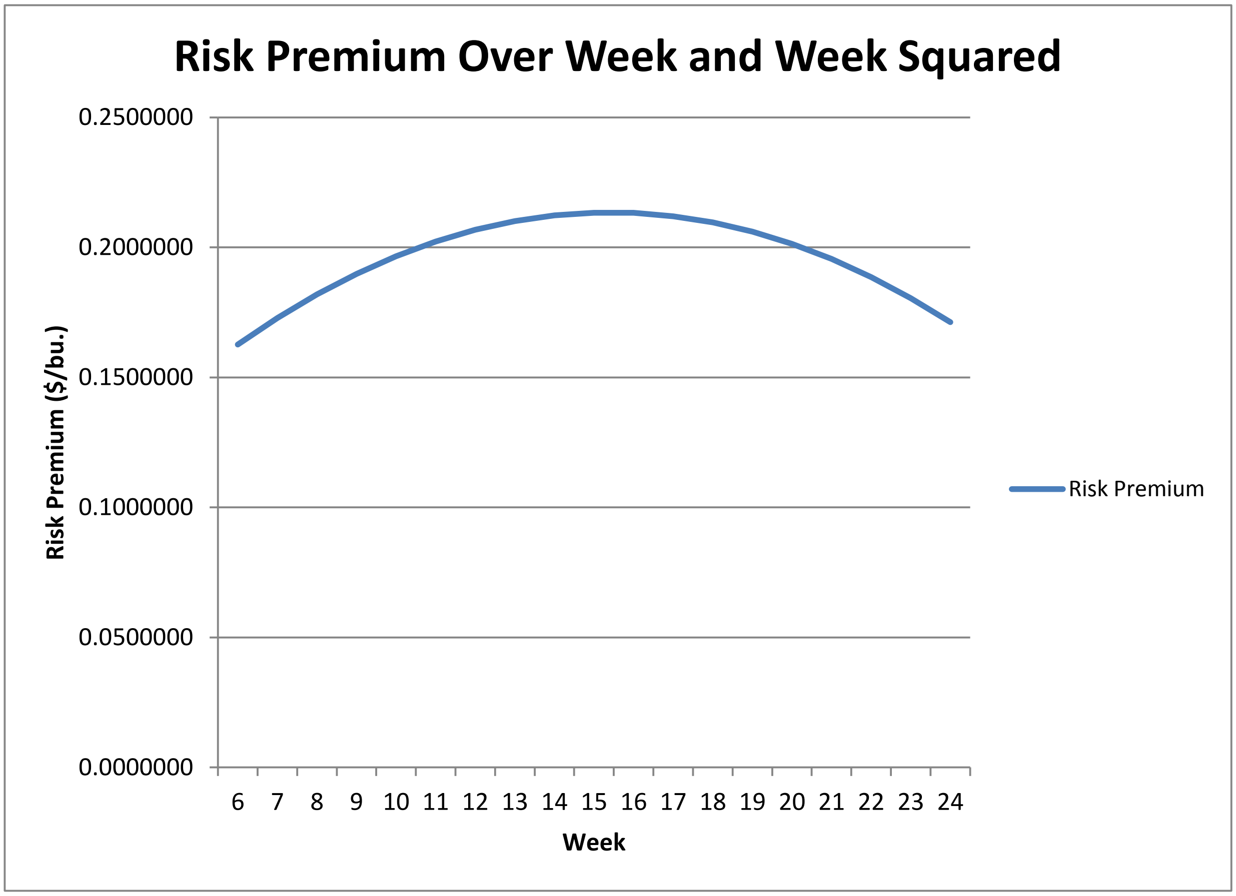

Figure 4.1- Risk Premium Across Week and Week Squared

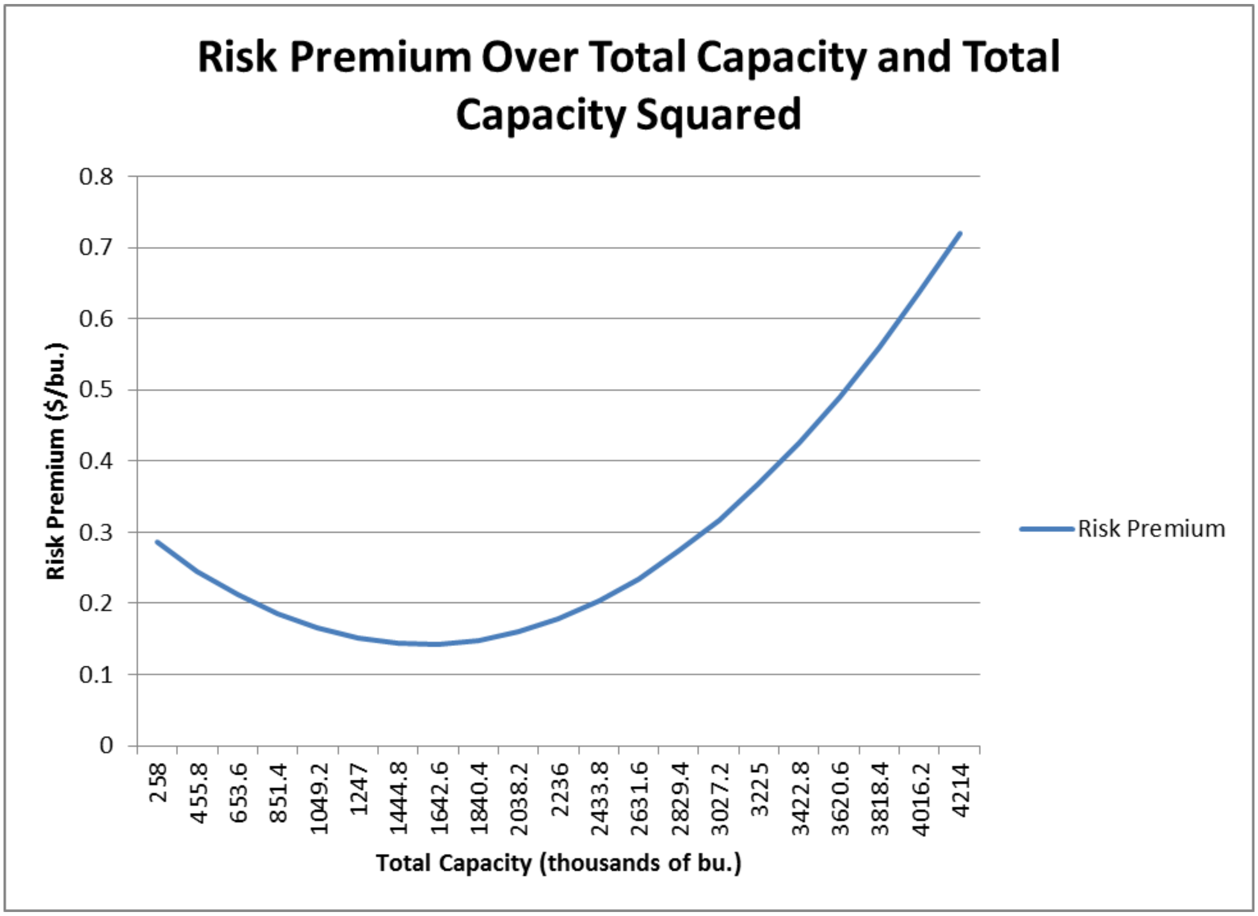

Figure 4.2- Risk Premium Across Total Capacity and Total Capacity Squared

Chapter 5 - Conclusion

Most of the elevator-specific characteristics that were examined in this thesis were found to have a statistically significant impact on risk premiums of forward contracts. The impact of different elevator characteristics could be of assistance to producers in their decision of which risk management strategy to use and their decision of which elevator to take their grain to, if they have a choice in available elevator locations. These impacts could also assist elevators in their decisions to change some of their elevator characteristics, based on how they affect forward contacting. If an elevator desires to use forward contracts to a greater or lesser extent, it may be affected by the characteristics of the elevator. The conclusions of Taylor, Tonsor, and Dhuyvetter (2013), that increased volatility in expected and actual basis has increased the forward contacting cost to producers, were supported by the results of the study.

Some limitations of this study include determining all the unobservable factors that the elevator characteristics measured in the model, the fact that the forward contract bids are offers, not accepted bids, and the choice of estimation method. The question of the elevator characteristics representing something other than what they define arises because some of them came out with signs that were not expected and were statistically significant. This could mean that the elevator characteristics are reflecting some of the unobserved impacts on risk premiums such as management traits, business structure and practices, and finances. These traits are often not easily measured explicitly so it may be that they are being captured by the elevator characteristics.

The forward contract bids being offered bids by the elevator rather than actual accepted contracting prices limits this study because it does not allow for insight on producers ideas of price. If accepted bids were available they could show if there were a cutoff price that producers are willing to accept for forward contracts. They could also be used, along with grain production numbers, to examine trends in the forward prices, such as if forward bid prices are low and not being accepted, if could mean that the elevator is not in need of grain.

The issue of model estimation methods refers to the justification of choosing the random effects GLS regression over the OLS regression. If an improvement of the efficiency of the coefficient estimates was achieved for the data used in this study by employing random effects GLS, the regression would have yielded smaller standard errors than the OLS regression. This is the case for many of the variables in the regression, but not all of them. Also, the improvement in the efficiency was very small, even for the variables with improved efficiency of the standard errors. An explanation for this is that the panel effects of the data were captured explicitly through the elevator characteristics so the additional benefits of random effects GLS are minimal.

Future research on this topic may include further investigation of the unobservable aspects of the data on elevator-specific characteristics, especially how some of the characteristics are related or measure similar aspects of the elevator industry. Examining different econometric specifications could yield significant results if a specification was found that fit the data more closely or that showed a different side of the data and results found in this thesis. Other research could look at using more locations or other grains, such as corn and soybeans, to see if the results of this study hold for them as well. Another avenue to examine would be how producer demand for forward contracts affects the risk premiums on the contracts, as this study focuses on the supply side through elevators. Demand could influence how aggressive elevators are in setting risk premiums, how consistent elevators are in offering forward bids, and the volatility of forward bids, among other things. Demand for forward contracts could be influenced by the other risk management options that producers can use, such as crop insurance, government programs, and regional/seasonality trends.

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Appendix A - OLS and RE GLS Coefficient Estimates Without Elevator Characteristics

Table A-1, OLS Estimated Coefficients Without Elevator Characteristics

prem_fc	Coef.	Std. Err.	t	P>t	[95%	Conf. Interval]
ave_iv	0.0053618	0.0007078	7.85	0.000	0.0039737	0.0067499
std_fcb1	2.438744	0.0750858	32.48	0.000	2.291494	2.585994
return1	-0.4401758	0.0224633	-19.6	0.000	-0.4842284	-0.3961232
week	0.0128371	0.0043058	2.98	0.003	0.004393	0.0212812
week_sq	-0.0004	0.000147	-2.72	0.007	-0.0006882	-0.0001118
_cons	-0.1585976	0.0335707	-4.72	0.000	-0.2244329	0.0927623
R-squared	0.4136	Adj. R-squared	0.4122		RMSE	0.22997

Table A-2, RE GLS Estimated Coefficients Without Elevator Characteristics

prem_fc	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
ave_iv	0.0053618	0.0007078	7.85	0.000	0.0039745	0.0067491
std_fcb1	2.438744	0.0750858	32.48	0.000	2.291579	2.58591
return1	-0.4401758	0.0224633	-19.6	0.000	-0.4842031	-0.3961485
week	0.0128371	0.0043058	2.98	0.003	0.0043979	0.0212763
week_sq	-0.0004	0.000147	-2.72	0.006	-0.0006880	-0.0001119
_cons	-0.1585976	0.0335707	-4.72	0.000	-0.2243950	-0.0928001
R-squared	0.4385					