Fed cattle basis risk under grid pricing.

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Abstract

Hedging risk in fed cattle markets has become increasingly important as producers face elevated price volatility and market uncertainty. This challenge is particularly pronounced for producers marketing cattle using grid pricing systems, which reward or penalize producers based on carcass attributes such as yield grade, quality grade, and carcass weight. Grid pricing has expanded rapidly over the last decade to represent about 70% of fed cattle marketings. Despite its prominence, little is known about how basis risk changes when cattle are priced using grids instead of traditional live or dressed pricing.

With more variable factors impacting realized net price, we expect basis risk increases when cattle are sold on a grid. While grid pricing offers opportunities to capture premiums for higher-quality cattle, it also exposes producers to downside risk due to discounts applied to cattle that do not meet desired specifications. Managing this dual exposure to both price and quality-related premium/discount risks requires quantifying the price risk managed through traditional live or dressed price hedging. It also involves understanding the risk that remains due to varying cattle quality and associated grid component value variation. Results will inform producers using grid pricing of unhedgeable risk using traditional price risk management tools of futures and Livestock Risk Protection. Depending on the magnitude of elevated price risk, additional price risk management instruments might be warranted to manage price risk more effectively. For example, developing a Choice-Select spread or other price risk management market may be valuable.

The objectives of this thesis are to quantify how fed cattle hedging risk has changed and to identify the main determinants of hedging risk for grid-priced fed cattle. A key measure is basis risk, the difference between the realized and predicted basis under various fed cattle valuation systems, and the uncertainty of cattle quality. Unique to this study is the adjustment of

the predicted basis based on how cattle are priced and the expected quality distributions of cattle of varying quality and premiums/discounts, providing an essential contribution to better understanding contemporary fed cattle basis risk.

Hedging risk changes as uncertainty on cattle quality and premiums and discounts are introduced:

1. We start by quantifying traditional weekly basis risk for cash-negotiated cattle over 20 years (2005-2024). This provides a baseline to illustrate historical trends and the evolution of basis risk.
2. Next, risk is quantified on a weekly basis for constant cattle quality (used broadly here to include quality grades, yield grades, carcass weights, etc.), letting premiums and discounts vary over time. Constant carcass quality distributions are averages based on more than 10,000 pens of packing plant grid carcass data obtained from commercial feedyards. This step enables us to determine how introducing varying premiums and discounts affects traditional hedging risk.
3. The analysis then incorporates quality and premium variability over time assuming producers have perfect foresight of quality of each pen hedged. To accomplish this analysis, a random pen of cattle is selected each week from the commercial feedyard data noted above. In this way, quality variation is introduced, but since it is assumed that the producer perfectly anticipates the quality of each pen, there is no quality uncertainty. This segment enables incremental measurement relative to the previous scenario of how introducing quality variation impacts hedging risk and premium/discount variation over time.

4. Finally, imperfect quality guesses are introduced by adding random errors to predicted quality distributions based on the above-referenced feedyard data. This segment enables incremental variation from above scenarios adding quality uncertainty.

My approach highlights increasing complexity and variability in basis risk as grid pricing systems dominate the market. Understanding this complexity is critical for producers because it directly impacts the effectiveness of traditional risk management tools. Producers, policymakers, and market participants must recognize these dynamics to develop innovative tools and strategies that better address the unique risks posed by grid pricing.

Price risk management in fed cattle markets is of greater importance than ever, with high price levels and elevated price risk. However, traditional hedging instruments are designed for hedging commodity cattle sold using negotiated cash prices. However, with grid pricing, valuing cattle based on carcass merit has become the dominant fed cattle valuation method, and the basis risk for cattle hedging is poorly understood. Traditional hedging instruments enable only base price protection but do nothing to manage varying premiums and discounts on uncertain cattle carcass quality. This study will demonstrate how basis risk changes as cattle are grid-priced and quantify the amount of price risk unhedged for grid-valued cattle. The study will also explain how much of this variation is due to premium/discount variation and uncertainty about varying cattle quality. The findings will provide critical insights for evolving price risk management tools for cattle producers and inform policymakers in designing LRP risk management programs. Depending on the extent of unhedgeable risk identified, new price risk management tools or institutions may be needed to mitigate the increasing price risk associated with grid pricing.

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Chapter 1 - Introduction

The fed cattle industry is the backbone of the U.S. beef supply chain, transforming raw biological inputs into high-value protein products consumed domestically and globally. Yet beneath these familiar systems lies a growing complexity in how value is determined, transmitted and managed across the supply chain. Over the past three decades, the evolution from live and dressed weight pricing toward value-based marketing systems such as grid pricing has fundamentally changed how cattle are valued – and how producers experience and manage price risk.

As consumer preferences shifted toward more consistent and higher-quality beef, the industry's pricing systems adapted to reward carcass merit rather than simply live weight. Grid pricing, now accounting for roughly 70 percent of all fed cattle transactions, ties the final price of each animal to carcass characteristics such as quality grade, yield grade, carcass weight, and defect status. While this system more accurately reflects end-product value, it also exposes producers to new dimensions of price uncertainty. Premiums and discounts fluctuate weekly, carcass outcomes vary across pens, and packer-specific grids remain largely opaque. These factors combine to create volatility that is not reflected in Live Cattle futures markets or fully addressed by Livestock Risk Protection (LRP) insurance products.

For producers, this environment presents both opportunities and challenges. On one hand, value-based pricing rewards management decisions that improve beef quality and algin with consumer demands. On the other, it introduces uncertainty in final revenue that traditional hedging tools cannot effectively offset. The result is a widening gap between expected and realized prices – a challenge that falls under the broader concept of basis risk. In live-weight markets, basis risk was largely driven by predictable regional supply and demand conditions, however, basis variability increasingly reflects changes in carcass traits and fluctuations in the premium and discounts applied by packers (Coelho et al., 2008; Coffey, Tonsor, & Schroeder, 2018).

This growing unpredictability in price realization motivated my decision to study fed cattle basis risk under grid pricing. Seeing how pricing volatility affects feedyard decision making, profitability, and confidence in risk management tools. Conversations with feedyard managers, buyers, and analysts revealed a recurring theme: while producers have learned to manage commodity risk, they are increasingly challenged by unhedgeable risk embedded in value-based pricing systems. This disconnect between how cattle are priced and how they are hedged has meaningful implications not only for individual producers but for market efficiency and the long-term sustainability of value-based systems.

The purpose of this research is to better understand how grid-based pricing influences the behavior of basis risk in fed cattle markets. Specifically, this study measures how volatility in weekly premiums and discounts and cattle quality contributes to unhedgeable variability in realized prices for cattle feeders. Kansas market information is used because it serves as an ideal case study given its central role in the U.S. fed cattle sector and its widespread adoption of grid and formula-based marketing. By analyzing commercial pen-level data alongside regional cash and futures prices, this study quantifies how fluctuations in grid components and cattle translate into changes in basis, and to identify the conditions under which conventional hedging tools may not fully protect producer margins.

The broader significance of this research extends beyond academic analysis. Understanding drivers of basis risk under grid pricing is essential to improving existing risk management instruments. As grid pricing continues to evolve, producers, insurers, and policymakers must adapt their strategies to manage risk in an environment where the value of carcass – and a producer's revenue – can shift weekly based on packer-specific incentives and consumer demand.

This thesis reflects both an analytical and personal interest in bridging the gap between economic theory and the realities of cattle marketing. By quantifying how premiums and discounts shape price variability, I aim to contribute to a more transparent and resilient market system – one that rewards quality without punishing producers through increasing uncertainty. This work seeks not only to clarify the mechanics of grid-based basis risk but also to help ensure that the next generation of risk management tools reflects the complexity of todays' cattle markets.

Chapter 2 – Background

Historically, fed cattle in the United States were marketed based on live weight, with producers receiving a set price per hundredweight at the time of sale. This method dominated much of the 20th century and was valued for simplicity and transactional clarity. However, live pricing did not account for carcass merit, meaning producers received the same price regardless of the animals' marbling, muscling, or processing efficiency. As consumer demand shifted towards more consistent, higher-quality beef, the industry found itself constrained by a system that failed to reward those quality signals (Schroeder et al., 1998).

In response, dressed pricing – also known as carcass weight pricing – emerged as a transitional step. This method is based on the hot carcass weight (HCW) after slaughter, capturing dressing percentage, and reducing some inefficiencies in live pricing. Still, dressed pricing failed to reflect differences in quality grade or yield grade, leaving producers with little incentive to manage toward carcass traits valued by consumers and packers (Ward et al., 1999).

To better align incentives along the beef supply chain, the industry adopted grid pricing during the 1990s. Under this system, cattle are assigned a base price, which is then adjusted based on a predefined schedule of premiums and discounts. Traits such as USDA Prime or Certified Angus Beef (CAB) quality grades receive positive adjustments, while undesirable attributes like Yield Grade 4 or 5, carcass weights outside a specified range, or visual defects (e.g., dark cutters) are penalized. Over time, grid pricing gained traction due to its ability to reward carcass merit, reduce cross-subsidization, and strengthen alignment between production and consumer preferences (Fausti et al., 2002).

By the early 2000s, grid pricing became the dominant marketing channel in major cattle-feeding regions, particularly in Kansas, Nebraska, and Texas. Today, more than 70% of all fed cattle transactions are structured using some form of value-based pricing. While this shift represents a more efficient and differentiated pricing mechanism, it also introduced greater complexity and risk for producers (Tonsor et al., 2004).

Chapter 2.1 - The Changing Nature of Basis

In agricultural markets, basis is defined as the difference between the local cash price and the price of a corresponding futures contract. In the context of fed cattle, basis traditionally reflected localized supply and demand conditions, transportation costs, and region-specific infrastructure. Since these components tend to follow seasonal patterns, producers historically relied on predictable basis trends to improve hedging effectiveness (Parcell et al., 2000).

However, grid pricing introduces a fundamental change to the nature of basis. Since final price realization depends on post-slaughter carcass traits, producers may not know their true revenue until after cattle are processed. This means that even with a well-timed futures hedge, actual price outcomes may differ sharply from expectations if carcass performance or premium and discounts deviate from expectations. Several studies have documented the causes and consequences of this evolving risk. Coelho et al., (2008) demonstrated that basis variability increased significantly for producers using grid pricing, particularly when cattle grading outcomes are uncertain or when grid schedules are volatile. Fausti et al., (1998) found that grid pricing introduces carcass-level revenue variability that is disconnected from broader market trends, especially during periods of shifting consumer preferences. These findings underscore a growing gap between hedgeable and realized revenues in grid-based cattle marketing.

Chapter 2.2 - Volatility in Premiums and Discounts

One of the key drivers of unhedgeable basis risk under grid pricing is the volatility in weekly premiums and discounts. These adjustments are determined by packers of a variety of dynamic factors: boxed beef cutout values, labor availability, fabrication efficiency, export demand, and seasonal shifts in consumer preferences. For instance, premiums for Prime or CAB may widen significantly in the spring grilling season or during export surges, while penalties for overweight or over-fat cattle may increase during labor shortages or processing slowdowns. (Graff and Schroeder, 1998).

Notably, grid schedules are not standardized across packers or plants. Each buyer maintains its own internal valuation system, often updated weekly and not publicly reported. This makes it difficult for producers to forecast grid values with precision, especially when marketing on a negotiated grid or formula arrangement. This lack of transparency is a critical constraint on producer decision-making and contributes to pricing uncertainty that extends beyond the physical traits of cattle.

The inconsistency of grid values across buyers and over time introduced a structural source of basis error. Even when producers accurately predict carcass quality, changing packer incentives can shift the value of those traits' week to week. For example, a yield grade 1 carcass may receive a strong premium in one month but a modest adjustment the next, depending on fabrication demand and operational throughput. These shifts directly affect cash revenue but are not reflected in futures markets, creating discrepancies between hedged and realized returns (Coelho et al., 2008).

Chapter 2.3 - Kansas: A Focal Region for Grid Pricing

Kansas serves as an ideal case study for analyzing basis risk under grid pricing. The state is home to several of the largest commercial feedyards in the country, and grid-based marketing practices are widely adopted. Kansas also benefits from proximity to major packers and robust transportation and feed infrastructure, allowing it to support year-round finishing and high volumes of fed cattle throughput (Parcell et al., 2000).

Despite these structural advantages, Kansas producers face unique challenges in managing basis. Since the region participates heavily in grid and formula arrangements, realized prices are increasingly influenced by grid schedule volatility and carcass grading outcomes. Moreover, many Kansas producers rely on negotiated grid sales where the base price is determined weekly, introducing additional uncertainty relative to formula-based forward contracts (Parcell et al., 2000).

Recent trends in Kansas suggest that basis volatility has increased over time, particularly during marketing windows when packer incentives shift rapidly in response to wholesale boxed beef values, fabrication capacity, or seasonal changes in consumer demand. These price shifts, when combined with uncertainty in carcass outcomes, have resulted in more frequent and more extreme basis prediction errors. In this context, Kansas not only represents a major source of grid-fed cattle but also a region where the limitations of conventional hedging strategies are apparent.

Figure 1. Kansas Weekly Cash Negotiated Fed Steer Basis (2005-2024)
Source: USDA AMS vis LMIC

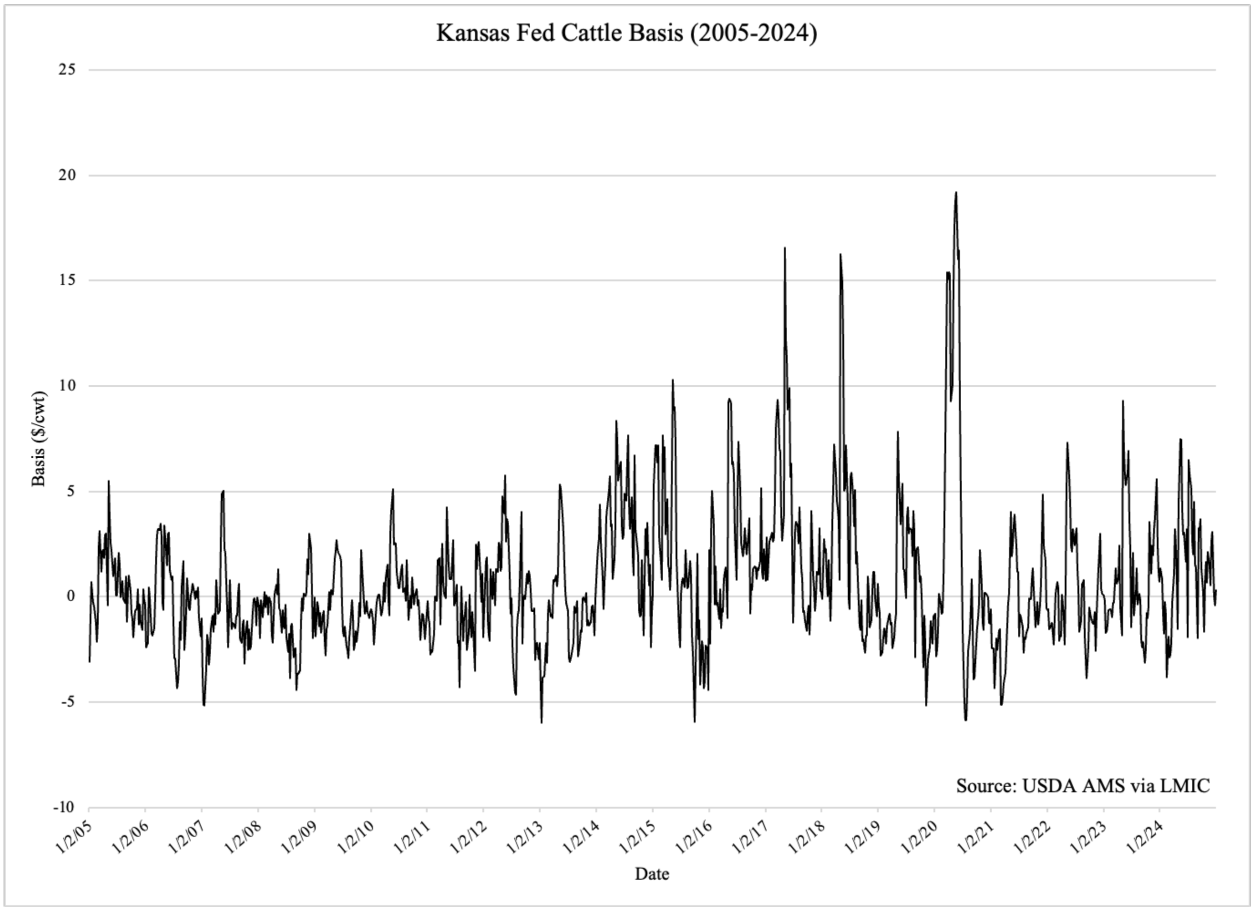


Figure 1 illustrates weekly fed cattle basis in Kansas from 2005 to 2024. The chart shows a clear trend of increasing volatility, especially from 2015 onward. Early years of the series exhibit relatively tight fluctuations around zero, while later years show more extreme spikes and dips—particularly during the 2015 cattle market adjustment, the 2019 Holcomb plant fire, and the COVID-19 disruptions of 2020. These patterns suggest that structural changes in grid marketing, carcass expectations, and packer capacity have materially increased fed cattle basis variability.

Chapter 3 – Data and Methodology

This study evaluates how grid pricing contributes to fed cattle basis risk by combining commercial feedyard records, weekly Kansas cash and futures prices, and packer grid schedules. The framework is structured around three primary scenarios and two additional extensions that isolate the role of cattle quality extremes. After constructing basis, expected basis, and basis error for each scenario, regression models are estimated to explain the drivers of unanticipated basis variation.

Chapter 3.1 - Data Sources

The primary dataset comes from commercial Kansas feedyards and consists exclusively of native steer pens. To ensure reliability and comparability, only pens with 50 or more head were retained. Each pen reports carcass information as percentage distributions that always sum to 100 percent for each separate trait set. This includes major trait sets of USDA quality grades (Prime, Certified Angus Beef [CAB], Choice, Select, and Standard) and USDA yield grades (1 through 5).

Carcass weights are categorized into three classes: lightweight (500–650 lbs.), base weight (650–900 lbs.), and heavy weight (950 lbs. and above). Each pen record also includes the average dressing percentage (yield), which is critical for converting dressed-weight values into live-weight equivalents so they can be directly compared with CME Live Cattle futures. Defect categories such as dark cutters and hardbone carcasses were included in the dataset as zero values because no occurrences of these defects were reported in the available feedyard records. In effect, these variables contribute to the overall grid framework but do not introduce variation within this dataset, as all observations represent pens without recorded carcass defects.

Weekly Kansas live fed cattle prices and weekly average nearby CME Live Cattle futures settlements were obtained from the Livestock Marketing Information Center (LMIC). Cash and futures prices are reported in live-weight terms. In the benchmark scenario, both the cash and futures prices are expressed on a live-weight basis to represent traditional hedging practice under live pricing systems. In the grid-adjusted scenarios, carcass-based grid values are converted to live-weight equivalents using pen-specific dressing percentages so that resulting basis values remain directly comparable across all pricing systems.

Finally, weekly packer grid schedules of premiums and discounts were taken from LMIC. These schedules include adjustments for quality grade, yield grade, carcass weights, and defects, expressed in dollars per hundredweight dressed. They were mapped directly onto the feedyard categories, stored as positive values for premiums and negative values for discounts, and checked for completeness each week. Missing values were carried forward from the most recent available week.

During the October 2013 USDA reporting gap, no federally reported cash fed cattle prices were available due to the government shutdown. Because weekly Kansas cash prices are a critical component of the basis calculation, omitting these weeks would have created gaps in the time series and disrupted the rolling three-year expected basis calculation. To maintain continuity while preventing artificial volatility, cash prices for these weeks were imputed by adding the expected basis to the corresponding nearby futures price:

$$4). \quad P_t^{cash} = P_t^{fut} + \widehat{Basis}_t$$

This ensured that the observed basis equaled the expected basis by construction, and basis error was set equal to zero. The expected basis represents the historical average difference between the local cash price and the corresponding futures price for a given marketing week, calculated using a rolling three-year window of available Kansas data. This measure reflects the level of basis that producers would have reasonably anticipated at the time, based on prior market behavior rather than current observations. The rationale for this adjustment is that, in the absence of reported market activity, producers would have relied on these historical expectations to guide hedging decisions rather than observed transactions. Treating these weeks as "neutral" prevents the dataset from overstating volatility that was purely the result of a reporting interruption rather than a genuine market event. By making this adjustment, the analysis preserves the integrity of the time series and avoids biasing the distribution of basis error with noise unrelated to market fundamentals.

Chapter 3.2 - Basis and Basis Error

A central concept in hedging and risk management is the basis, defined as the difference between the local cash price and the futures market price. In this study, the cash price is either the Kansas negotiated live price (Scenario 1) or a grid-adjusted dressed price converted into a live weight equivalent (Scenarios 2 and 3), while the futures price is the nearby CME Live Cattle contract. Formally, basis in week t is given by:

$$1).\quad Basis_t = P_t^{cash} - P_t^{fut}$$

where P_t^{cash} is the Kansas live or grid-adjusted live-equivalent cash price in week t, and P_t^{fut} is the nearby CME Live Cattle futures settlement. The sign and magnitude of basis provide information about how closely the local cash market aligns with the national futures market. A positive basis indicates that Kansas cash prices are higher than the futures price, while a negative basis reflects the opposite. Importantly, this difference is not random. Basis reflects underlying factors such as transportation costs, packer demand, local supply conditions, and, in the case of grid pricing, carcass-level valuation.

Since hedging decisions must be made in advance, producers cannot know the actual basis at the time of marketing. Instead, they rely on historical seasonal patterns to form an expected basis. Following Coffey, Tonsor, and Schroeder (2018), this study calculates expected basis as a three-year moving average of actual basis values from the same calendar week in prior years:

$$2).\quad \widehat{Basis}_{y,t} = \frac{1}{3}\sum_{y-3}^{y-1} Basis_{y,t}$$

Where *t* refers to week, $Basis_{y,t}$ represents the realized basis in year y and week t. For notational convenience, the subscript *w* will be dropped in subsequent equations, but all analyses are completed weekly. This specification captures seasonal regularities in fed cattle basis while providing a practical forecast measure consistent with how producers typically benchmark expectations. Using the same calendar week ensures that recurring seasonal influences—such as holiday demand shifts, grilling season premiums, or winter supply constraints—are embedded in the forecast. The three-year horizon balances stability with adaptability, smoothing short-term noise while allowing forecasts to adjust to changing market conditions.

The difference between weekly realized basis and expected basis is termed the basis error:

$$3).\quad BasisError_t = Basis_t - \widehat{Basis}_t$$

Basis error represents the unanticipated component of pricing outcomes—the portion not explained by historical seasonal patterns and therefore not reasonably predictable by hedgers. Positive values indicate cash prices exceeded expectations, while negative values reflect weaker-than-expected cash outcomes relative to futures. In this study, basis error serves as the dependent variable in regression analysis, as it provides a direct measure of unhedgeable risk.

Chapter 3.3 - Scenario Framework

Scenario 1: Benchmark (No Carcass Adjustments)

In the benchmark case, basis is constructed using the weekly Kansas live price as the cash market value and the nearby CME Live Cattle contract settlement as the futures price. This setup reflects the traditional approach producers have historically faced when marketing fed cattle without the influence of carcass-level grid adjustments. Formally, the benchmark basis is given by:

$$1).\quad Basis_t = P_t^{cash(live)} - P_t^{fut}$$

where $P_t^{cash(dressed)}$ is the reported live-weight cash price for Kansas in week t, and P_t^{fut} is the corresponding nearby futures settlement price Both are expressed on a live-weight basis, consistent with how producers hedge fed-cattle sales in practice. No adjustments are made for dressing percentage or carcass characteristics in this baseline scenario. This configuration serves as a reference point for evaluating traditional hedging performance, isolating the price relationship between the cash and futures markets before introducing grid-related adjustments in subsequent scenarios. It captures the fundamental futures–cash relationship that producers face when selling cattle. By holding cash price construction to the simplest possible form, Scenario 1 provides the reference point for evaluating the additional risk that arises when grid pricing mechanisms are introduced.

Scenario 2: Constant Cattle Quality, Varying Grid Schedules

Scenario 2 incorporates packer grid schedules into the cash price but holds cattle quality constant at representative averages drawn from the dataset. The cash price is calculated using the Dressed Net Grid Price (DNGP), which adds the weighted sum of premiums and discounts for carcass traits to the Kansas base live price:

$$5).\quad DNGP_t = P_t^{cash} + \sum_k (CarcassTraitPercentage_{(k,t)} \times GridAdj_{(k,t)})$$

This dressed value is then converted to a live-weight equivalent using a fixed dressing percentage ($Yield_t$). For this scenario, $Yield_t$ is held constant across all weeks and pens to isolate basis variation attributable solely to price movements rather than carcass yield differences. The fixed dressing percentage was set at 63.6%**,** calculated as the simple average dressing percentage across all pens in the dataset**.**

$$6).\quad LiveAdjustedDNGP_t = DNGP_t \times Yield_t$$

The resulting live-equivalent grid price serves as the cash price in Scenario 2, and basis is then calculated as:

$$7).\quad Basis_t = LiveAdjustedDNGP_t - P_t^{future}$$

The purpose of Scenario 2 is to isolate the effect of grid schedules themselves. By holding cattle quality constant at the representative averages (e.g., approximately 56% Choice, 22% Select, 17% CAB, balanced yield grades, and 93% base-weight carcasses), this scenario measures how grid valuation changes across weeks—even without changes in cattle quality—contribute to basis volatility. In other words, it shows how producers face additional hedging uncertainty simply because the premiums and discounts applied to a “typical” pen fluctuate over time.

Scenario 2.1: Low- Quality Stress Test

Scenario 2.1 extends Scenario 2 by applying grid schedules to a constant low-quality pen composition. This pen is deliberately constructed to represent cattle that perform poorly on grid marketing, with higher percentages of Select and Standard carcasses and a distribution skewed toward higher cutability yield grades.

The DNGP is again calculated as:

$$5).\quad DNGP_t = P_t^{cash} + \sum_k (CarcassTraitPercentage_{(k,t)} \times GridAdj_{(k,t)}),$$

with trait percentages reflecting the low-quality profile (e.g., 55% Select, 5% Standard, 40% Choice, yield grades weighted heavily toward YG2 and YG3). After converting to a live-weight equivalent, the resulting cash price is used to construct basis.

This stress test demonstrates the downside exposure of hedgers marketing cattle that consistently receive grid discounts. Because grid schedules impose larger penalties on poor quality, the average basis level shifts lower and the variability of basis error increases. Scenario 2.1 highlights the vulnerability of lower-quality cattle to unanticipated changes in grid valuation, illustrating how basis risk compounds when cattle performance aligns poorly with buyer incentives.

Scenario 2.2: High-Quality Stress Test

Scenario 2.2 takes the opposite approach by constructing a constant high-quality pen composition. This pen includes higher shares of Prime and CAB carcasses, while also incorporating more YG4 and YG5 cattle, which receive premiums for marbling but penalties for excessive fat cover.

The DNGP is again formed as:

$$5).\quad DNGP_t = P_t^{cash} + \sum_k (CarcassTraitPercentage_{(k,t)} \times GridAdj_{(k,t)}),$$

with trait percentages reflecting the high-quality profile (e.g., 20% Prime, 40% CAB, 30% Choice, and greater shares of higher numerical yield grades). The dressed value is converted to a live-equivalent price using the fixed dressing percentage, and basis is calculated accordingly.

This stress test captures the dual nature of high-quality cattle under grid marketing. On one hand, premiums for Prime and CAB strengthen average basis outcomes. On the other hand, volatility remains significant because the value of these premiums fluctuates week to week, and penalties for lower cutability yield grades can offset quality gains. Scenario 2.2 demonstrates that even pens designed to capture premiums are not insulated from basis risk; instead, the source of risk shifts from outright discounts to volatility in premium valuation.

Scenario 3: Varying Cattle Quality and Varying Grid Schedules (Real-World)

Scenario 3 represents the most realistic marketing environment by allowing both cattle quality and grid schedules to vary simultaneously. Each week in the dataset is matched with a randomly drawn pen without replacement from the commercial feedyard data, ensuring that pen-level trait distributions reflect the actual diversity of cattle marketed over time. The DNGP is computed for each pen using the same formula:

$$5).\ \ DNGP_t = P_t^{cash} + \sum_k (CarcassTraitPercentage_{(k,t)} \times GridAdj_{(k,t)}),$$

and then converted to live weight via the pen-specific yield:

$$6).\ LiveAdjustedDNGP_t = DNGP_t \times Yield_t$$

Basis is calculated as before:

$$7).\ \ Basis_t = LiveAdjustedDNGP_t - P_t^{fut}$$

Scenario 3 captures the full complexity of fed cattle marketing, where basis risk arises from the interaction of three forces: (i) week-to-week fluctuations in packer grid schedules, (ii) variability in carcass outcomes across pens, and (iii) standard hedging risk variation presents between cash and futures price. By combining actual pen data with contemporaneous grid adjustments, this scenario provides the most comprehensive measure of unhedgeable risk faced by producers. It reflects the reality that no pen of cattle is "average" and that variation in both cattle traits and buyer valuations interact to drive basis volatility. One limitation to this more complex analysis that cattle pens are selected randomly without making any adjustments to expected basis for factors a cattle feeder might adjust basis expectations in response to. For example, a cattle feeder might accurately expect higher or lower quality grade for a particular pen of cattle at placement, and they could potentially adjust expected basis accordingly. This analysis does not consider that possibility and as such, might be an upper estimate of basis risk in such circumstances.

Regression Models

To better understand the drivers of basis risk under grid pricing, regression models were estimated using weekly data. These models evaluate how various factors—including market conditions, carcass traits, contract specification changes, and seasonality—influence basis error for fed cattle marketed under grid pricing systems. Basis error, defined as the difference between realized basis and the expected three-year same-week average, serves as the dependent variable in these regressions.

Two versions of the model were estimated for each of the grid-valued scenarios (2 and 3). The first specification includes weight-related measures (Light Weight and Heavy Weight indicators), while the second excludes them. This dual approach provides two insights: (i) it tests how packer-preference weight categories interact with other drivers of basis error, and (ii) it evaluates model robustness when weight data are not available or excluded from forecasting frameworks.

The regression framework is expressed as:

$$8).\ BasisError_t = \alpha + \beta_1 CashPrice_t + \beta_2 StDevCashPrice_t + \beta_3 NetQual_t + \beta_4 NetYield_t + \beta_5 HvyWeights_t + \beta_6 LtWeights_t + \gamma MonthDummies_t + \delta ContractChanges_t + \epsilon_t$$

where the explanatory variables are defined as follows (in regression models, *t* refers to week):

- $CashPrice_t$ - Cash Price: The weekly Kansas base live price, capturing broad market conditions and the overall level of cattle values.
- $StDevCashPrice_t$ - Cash Price Volatility (Six-Month Standard Deviation): A rolling six-month standard deviation of weekly Kansas live cash prices, included as $StDevCashPrice_t$. This variable reflects short-run market uncertainty: when the cash market is more volatile, basis becomes harder to forecast, and basis errors increase.
- $NetQual_t$ - Net Quality Grade and $NetYield_t$ - Net Yield Grade: Constructed as share-weighted averages of the pen's quality and yield grade distributions (on a dressed weight), multiplied by weekly grid adjustments. These variables measure how carcass composition interacts with grid schedules to affect realized basis outcomes.
- $HvyWeights_t$ (Heavy) and $LtWeights_t$(Light) - Weight Variables: These variables represent the discount-weighted share of carcasses falling outside packer-preferred weight thresholds. Specifically, each variable equals the proportion of carcasses in a pen exceeding (for Heavy) or falling below (for Light) the packer's threshold multiplied by the corresponding grid discount in that week.

- $ContractChanges_t$ - Contract Specification Changes: Dummy variables marking the 2017, 2018, and 2021 changes to CME Live Cattle futures contract specifications. These revisions altered how grid premiums and discounts translated into futures values, potentially shifting the basis relationship.
- $MonthDummies_t$ - Month Dummies: Monthly fixed effects account for systematic seasonal variation in cattle marketing, including demand peaks in grilling and holiday seasons and supply constraints in winter.

By including both market-level variables (cash price and volatility) and carcass-specific measures (quality, yield, weight indicators), alongside structural and seasonal controls, these regressions provide a comprehensive framework for isolating the drivers of basis error. Comparing specifications with and without weight indicators allows the analysis to determine how much of unanticipated basis variation is attributable to weight-related penalties versus other carcass traits or market conditions. These variations in including and excluding weight-related impacts were motivated by observed multicollinearity noted later in results.

Chapter 3.4 - Analytical Strategy

The scenario design allows this study to separate distinct sources of basis risk. Scenario 1 represents traditional hedging risk without carcass adjustments, capturing the futures–cash relationship in its simplest form. Scenario 2 incorporates grid schedules while holding carcass quality constant, which isolates the volatility that arises strictly from changes in packer premiums and discounts. Scenarios 2.1 and 2.2 extend this framework by applying grid schedules to low- and high-quality stress-test pens, thereby highlighting the sensitivity of basis risk to cattle that fall at the extremes of carcass performance. Finally, Scenario 3 reflects the full complexity of marketing conditions by applying grid schedules to randomly drawn Kansas pens, capturing the interaction of real-world carcass variability with week-to-week grid valuation. Regression analysis then attributes basis error variation to a set of explanatory factors, including market price levels, carcass composition, weight categories, seasonal demand patterns, and structural contract changes. Taken together, this approach provides a comprehensive framework for quantifying and explaining the unhedgeable risk that arises in fed cattle markets under grid pricing.

Chapter 4 – Results and Analysis

Building on the framework described in the previous section, this chapter presents the results of the scenario simulations and econometric models designed to evaluate basis risk under grid pricing. The findings illustrate how pricing systems that account for carcass merit—while improving market alignment—also introduce greater variability in realized revenue for Kansas feedyards. The results are organized into three main parts.

Chapter 4.1 – Benchmark (No Carcass Adjustments)

The first section examines the simulated scenarios, beginning with the traditional benchmark and progressing through increasingly complex representations of grid-based marketing. These comparisons reveal how carcass variability and grid volatility interact to amplify unhedgeable risk. The second section presents regression results that quantify the relative contribution of market conditions, carcass traits, and structural contract changes to basis outcomes. Finally, the chapter concludes with a summary of key findings and their implications for producers, risk managers, and policymakers seeking to improve hedging effectiveness in value-based cattle markets.

The first scenario establishes a benchmark for comparison by examining basis behavior in a traditional pricing environment—one that excludes carcass-based premiums and discounts. This framework reflects the historical fed cattle market where price determination was based on live or dressed weight rather than individual carcass merit. Evaluating this baseline provides critical context for understanding how the introduction of grid pricing alters both the magnitude and structure of basis risk. Table 1 summarizes the key descriptive statistics for this benchmark scenario.

Table 1. Scenario 1 Summary Statistics $/cwt Live Weight, Weekly Data, 2005-2024
Source: Livestock Marketing Information Center (LMIC, 2025)

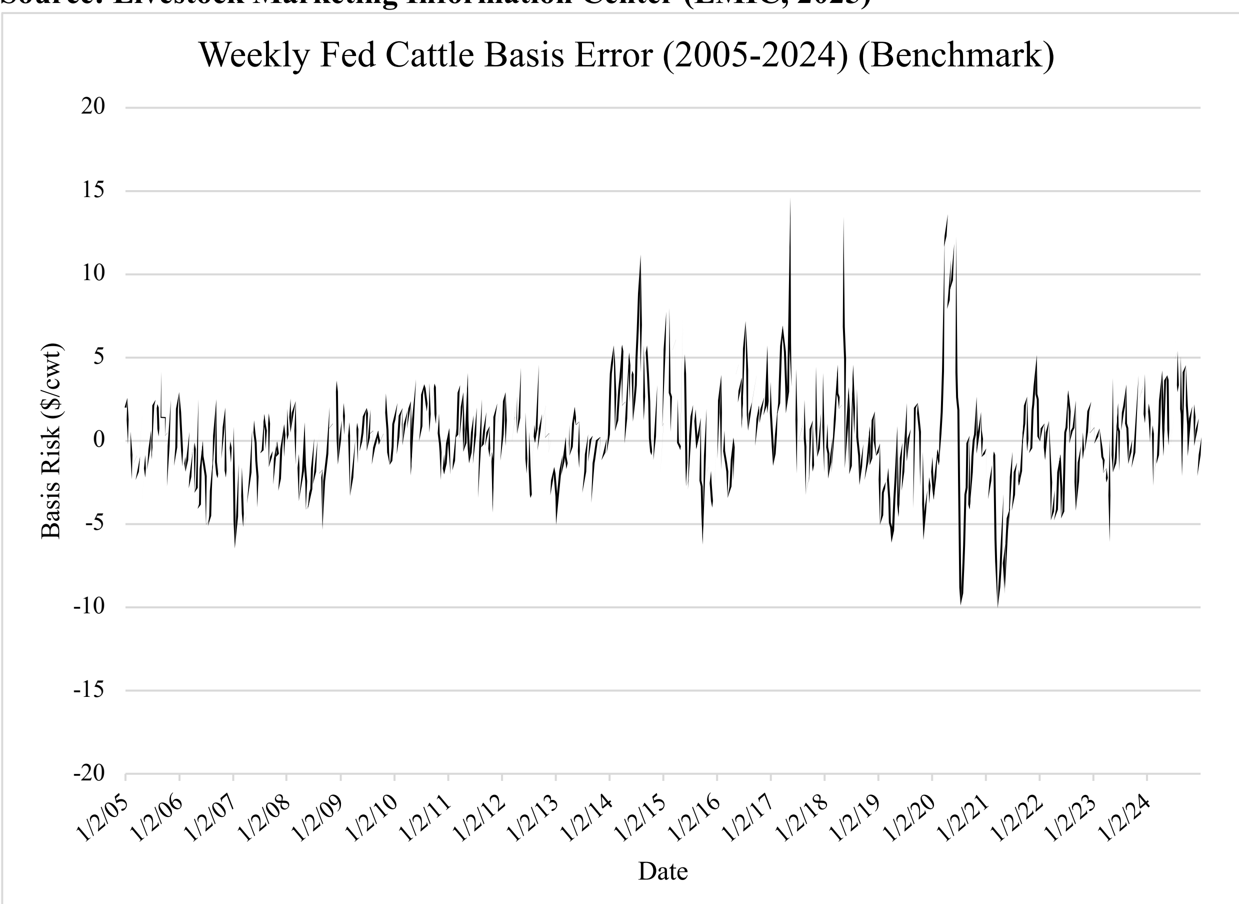
Scenario 1 Summary Stats					
	Cash Price	**Futures Price**	**Basis**	**Expected Basis**	**Basis Error**
Mean	120.41	119.67	0.74	0.52	0.21
St.Dev	28.67	28.16	3.28	2.15	2.92
Min	78.04	74.66	-6.02	-5.10	-10.05
Max	192.33	192.013	19.20	11.09	14.63

Scenario 1 represents the benchmark for evaluating fed-cattle basis risk in the absence of grid pricing or carcass-specific adjustments. As summarized in Table 1, the mean basis over the 2005–2024 period was $0.74 per cwt, indicating that Kansas cash prices averaged slightly above the nearby Live Cattle futures. This narrow, positive basis is consistent with efficient market alignment, where futures prices serve as reliable predictors of regional cash values.

The basis error standard deviation of $2.92 per cwt reflects modest volatility and predictable seasonal behavior typical of traditional live-weight marketing systems. Such levels of variability are well within historical norms documented by Parcell et al. (2000) and Tonsor et al. (2004), who found that basis movements in the pre-grid era were primarily driven by transportation costs, feedyard location, and short-term supply–demand imbalances. The relative stability of this series suggests that, under conventional pricing, producers could hedge with a high degree of confidence using standard futures strategies.

The minimum and maximum basis errors (–$10.05 to +$14.63 per cwt) coincide with well-known market disruptions. The 2015 cattle-price adjustment—following rapid herd expansion and weaker boxed-beef demand—produced extended positive basis deviations as cash prices fell below expectations. Similarly, early-2020 supply-chain shocks during the COVID-19 outbreak generated brief negative deviations when packer bids temporarily exceeded futures settlement prices. Despite these shocks, the benchmark basis quickly reverted toward trend, illustrating the strong convergence between futures and cash prices in a live-weight pricing system. The average basis error of $0.21 per cwt remained small and centered near zero, indicating that over time the futures market provided an unbiased predictor of local cash prices. In other words, deviations were largely short-term and balanced between positive and negative values, consistent with an efficient market where basis variability stems primarily from timing and local marketing conditions rather than structural bias. This stability underscores that, under traditional live-weight pricing, producers could rely on conventional futures hedging to manage price risk with relatively high precision.

Figure 2. Scenario 1 Weekly Basis Error, 2005-2024
Source: Livestock Marketing Information Center (LMIC, 2025)



From a risk-management standpoint, this scenario establishes a baseline of hedgeable price risk. Producers operating under traditional live or dressed-weight sales could anticipate basis behavior with relative accuracy, allowing for effective margin protection through futures or Livestock Risk Protection (LRP) contracts. The narrow dispersion observed here serves as the reference point against which the added volatility of grid-based pricing will be measured in subsequent scenarios. As the following sections demonstrate, incorporating carcass merit and packer-specific valuation schedules fundamentally changes this stability, creating new layers of unhedgeable risk within modern fed-cattle marketing systems.

Chapter 4.2 – Scenario 2 – Constant Cattle Quality, Varying Grid Schedules

Scenario 2 introduces grid pricing into the analysis while holding cattle quality constant across all weeks. This design isolates the portion of basis risk that arises strictly from fluctuations in weekly packer valuation schedules rather than differences in carcass performance. Table 2 summarizes the representative carcass composition held constant and used in this scenario, including the distribution of USDA quality and yield grades and the corresponding average premiums and discounts. These percentages approximate the quality mix typical of Kansas feedyard pens and serve as the fixed carcass profile through which weekly grid adjustments are applied. By keeping cattle quality stable, the scenario allows any change in basis variability to be attributed directly to grid-level volatility in packer premiums and discounts.

Table 2. Scenario 2 Carcass Composition
Source: Commercial Feedyard Dataset

Scenario 2 Carcass Composition			
Grade	**Percent**	**Average Premium/Discount ($/cwt Dressed)**	**St. Dev. Premium/Discount**
Prime	2.6%	11.78	3.82
CAB	17.3%	3.30	1.06
Choice	56.3%	0	0
Select	22.1%	-11.51	6.27
Standard	1.2%	-24.26	6.78
Hardbone	0.0%	-32.47	3.53
Dark Cutters	0.0%	-24.26	4.60
Yield Grade 1	9.7%	3.31	0.37
Yield Grade 2	36.4%	1.53	0.20
Yield Grade 3	40.2%	0	0
Yield Grade 4	12.4%	-12.10	1.00
Yield Grade 5	1.3%	-17.64	1.13
Light Weight	2.6%	-17.53	2.94
Base Weight	92.9%	0	0
Heavy Weight	4.5%	-19.32	2.97

Table 3. Scenario 2 Summary Statistics, Weekly Data, 2005-2024
Source: Livestock Marketing Information Center (LMIC, 2025), Commercial Feedyard Dataset

Scenario 2 Summary Stats								
	Premium/Discount Adjusted Cash Price ($/cwt Live Wt)	**Futures Price ($/cwt Live Wt)**	**Basis ($/cwt Live Wt)**	**Expected Basis ($/cwt Live Wt)**	**Basis Error ($/cwt Live Wt)**	**Historical Standard Deviation ($/cwt Live Wt)**	**Quality Grade Net ($/cwt Dressed)**	**Yield Grade Net ($/cwt Dressed)**
Mean	117.76	119.67	-1.91	-1.86	-0.05	4.94	-1.97	-0.83
St.Dev	28.43	28.16	3.34	2.55	2.96	2.17	1.35	0.22
Min	74.49	74.66	-9.46	-7.98	-12.04	1.41	-6.32	-1.29
Max	188.33	192.01	15.94	11.33	13.73	12.32	0.18	-0.53

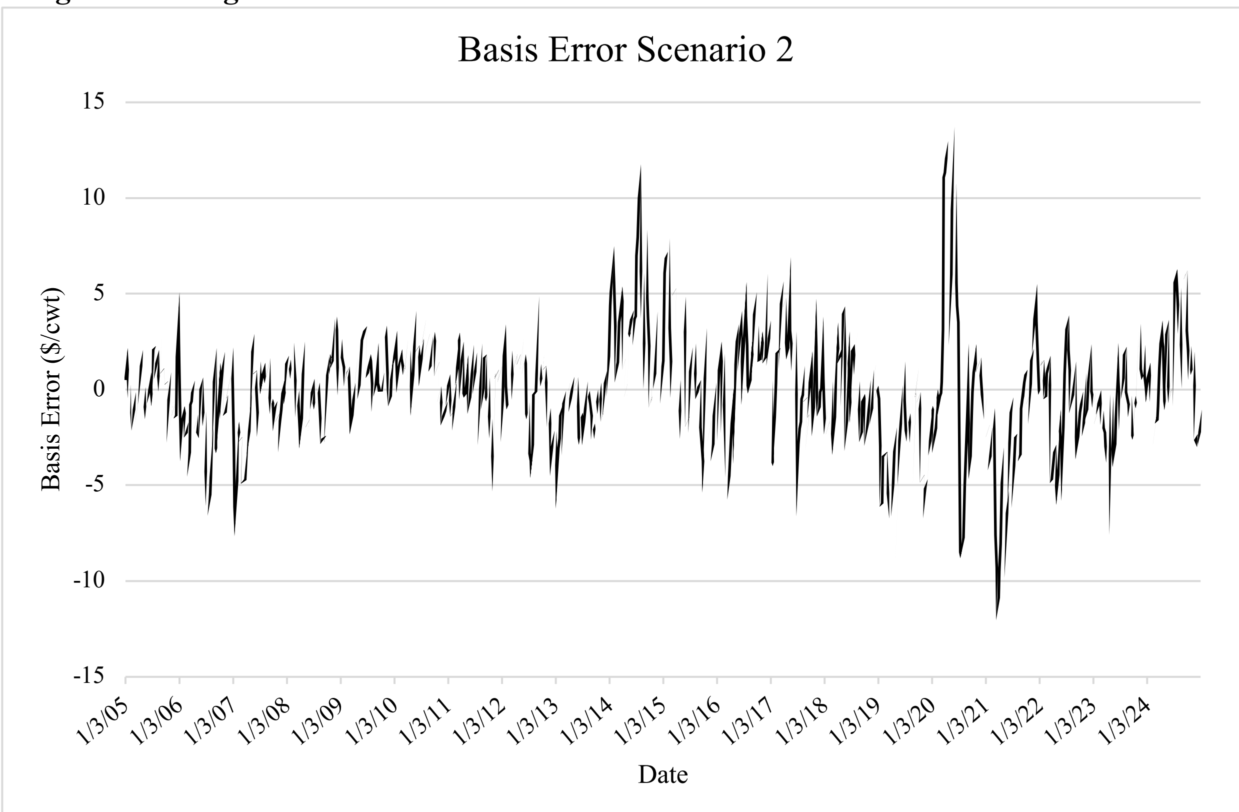
Scenario 2 quantifies how volatility in packer grid schedules alone affects basis behavior when cattle quality is held constant. As shown in Table 3, the mean basis for this scenario is –$1.91 per cwt, roughly $2.65 lower than the benchmark scenario average of +$0.74. This downward shift reflects the impact of weekly changes in grid premiums and discounts that modify the realized cash value, even when cattle composition is held fixed. The variability of this adjusted basis, measured by a standard deviation of $3.34 per cwt**,** is comparable to the benchmark but exhibits wider tails, with extremes ranging from –$9.46 to +$15.94 per cwt**.** These broader deviations highlight how packer-driven pricing adjustments can create unpredictable revenue outcomes independent of production performance.

The small mean basis error (–$0.05 per cwt) and its standard deviation of $2.96 suggest that grid volatility does not bias average returns but increases dispersion around expected outcomes. This finding aligns with the premise that grid adjustments introduce *symmetric but unhedgeable* price variability. The net quality grade (–1.97) and net yield grade (–0.83) averages reflect the predominance of Choice and Yield Grade 3 carcasses in the simulated pen (see Table 2), indicating that even typical feedyard cattle experience a modest penalty when premium opportunities narrow or discount schedules widen.

From a market-risk perspective, Scenario 2 demonstrates that grid pricing transforms basis stability into a function of weekly packer valuation rather than producer actions. When grid schedules widen—for example, during high Choice–Select spreads or carcass weight penalties—the realized basis can deviate sharply from expectations, despite identical cattle quality. This result is consistent with observations by Coffey, Tonsor, and Schroeder (2018), who found that thinner cash trade and value-based pricing amplify price momentum effects and weaken futures convergence. For Kansas feedyards, this means that even with predictable performance, volatility in packer premiums and discounts can materially alter hedging outcomes from week to week.

Figure 2 illustrates the pattern of basis error in Scenario 2, where cattle quality is fixed and only grid schedules vary. The time series highlights distinct episodes of volatility that correspond to major market shocks and packer valuation shifts. From 2005 through roughly 2013, basis error remains relatively contained within ± \$5 per cwt, mirroring the stability observed in the benchmark scenario. Beginning in 2014, however, deviations widen substantially—first during the 2014–2015 market adjustment and again around 2020, when the COVID-19 pandemic disrupted slaughter capacity and widened grid discounts for heavy carcasses. The pronounced positive spikes in 2015 and 2021 correspond to periods of record-wide Choice–Select spreads, when packer grids sharply rewarded higher-quality carcasses.

Figure 3. Weekly Basis Error under Constant Quality and Varying Grids, 2005-2024 Source: Livestock Marketing Information Center (LMIC, 2025), USDA AMS Weekly Weighted Average Data.



What stands out in this figure is that substantial volatility persists even when cattle quality is held constant, suggesting that packer-level grid adjustments may contribute to price uncertainty beyond the variation already present in traditional cash–futures relationships. This pattern warrants further comparison across scenarios; if basis errors under Scenario 2 exhibit greater dispersion than those under the benchmark case, it would confirm that changing packer premiums and discounts amplify short-term basis movements, even absent quality-driven effects. This pattern supports earlier findings by Coffey et al. (2018), who noted that thinner cash trade and value-based pricing amplify short-term price momentum and reduce the effectiveness of standard hedging tools. For Kansas feedyards, this behavior implies that even consistent performance cannot guarantee stable hedge outcomes when grid schedules fluctuate rapidly across plants or packers.

Chapter 4.2.1 – Low-Quality Stress Test

To evaluate how carcass composition interacts with grid volatility, Scenarios 2.1 and 2.2 apply identical packer valuation schedules to two contrasting pen profiles: a low-quality pen dominated by Select carcasses and Yield Grade 1-2 cattle, and a high-quality pen concentrated in Prime, CAB, and Yield Grade 4-5 carcasses. These stress tests illustrate the extremes of grid exposure that Kansas feedyards can experience under identical market conditions.

Scenario 2.1 represents a *low-quality stress test* designed to examine how carcass discounts interact with grid volatility. The pen composition shown in Table 4 reflects cattle that grade predominantly Select or lower, with limited premiums available from quality but premiums for yield performance. By maintaining the same grid schedules used in Scenario 2, this case isolates how the concentration of discounted carcasses magnifies basis variability and drives negative deviations in realized price outcomes. These distributions mirror the lower tail of carcass performance typically observed in Kansas feedyard data during periods of reduced feed efficiency or extended days-on-feed.

Table 4. Scenario 2.1 Carcass Composition

Scenario 2.1 Carcass Composition	
Grade	Percent
Prime	0.0%
CAB	0.0%
Choice	40.0%
Select	55.0%
Standard	5.0%
Hardbone	0.0%
Dark Cutters	0.0%
Yield Grade 1	15.0%
Yield Grade 2	40.0%
Yield Grade 3	40.0%
Yield Grade 4	5.0%
Yield Grade 5	0.0%
Light Weight	2.6%
Base Weight	92.9%
Heavy Weight	4.5%

Table 4 presents the carcass composition for this scenario. The pen consists of 55 percent Select and 5 percent Standard carcasses, with only 40 percent Choice animals and negligible representation in Prime or CAB categories. Yield grades are skewed toward Grade 2–3, but 5 percent of carcasses fall into the discounted Grade 4 category. This mix typifies feedyard pens characterized by lower genetic potential, or limited access to premium marketing programs.

With this composition, carcass discounts dominate the pricing outcome. Table 5 summarizes the resulting descriptive statistics for Scenario 2.1.

Table 5. Scenario 2.1 Summary Statistics, Weekly Data, 2005-2024
Source: Livestock Marketing Information Center (LMIC, 2025), Commercial Feedyard Dataset

Scenario 2.1 Summary Stats							
	Premium/Discount Adjusted Cash Price ($/cwt Live Wt)	Futures Price ($/cwt Live Wt)	Basis ($/cwt Live Wt)	Expected Basis ($/cwt Live Wt)	Basis Error ($/cwt Live Wt)	Quality Grade Net ($/cwt Dressed)	Yield Grade Net ($/cwt Dressed)
Mean	114.94	119.67	-4.73	-4.40	-0.33	-1.26	0.52
St.Dev	27.76	28.16	3.90	2.93	3.40	0.33	0.17
Min	70.60	74.66	-15.31	-12.05	-12.82	-2.12	0.17
Max	183.51	192.01	11.89	8.37	13.98	-0.66	0.75

The average adjusted cash price of $114.94 per cwt is roughly $2.8 below the constant-quality scenario and more than $5 below the benchmark. The resulting mean basis of –$4.73 per cwt confirms a pronounced downward shift in realized value once discounts for Select and Standard carcasses are applied. Volatility also expands: the basis standard deviation of $3.90 per cwt exceeds the benchmark's $2.92 per cwt, with extremes spanning from –$15.31 to +$11.89 per cwt. The near-zero mean basis error (–$0.33 per cwt) indicates no systematic bias but greater dispersion—evidence of higher unhedgeable variability introduced purely by grid dynamics.

Figure 4. Weekly Basis Error Scenario 2.1, 2005-2024
Source: Livestock Marketing Information Center (LMIC, 2025), USDA AMS Weekly Weighted Average Data.

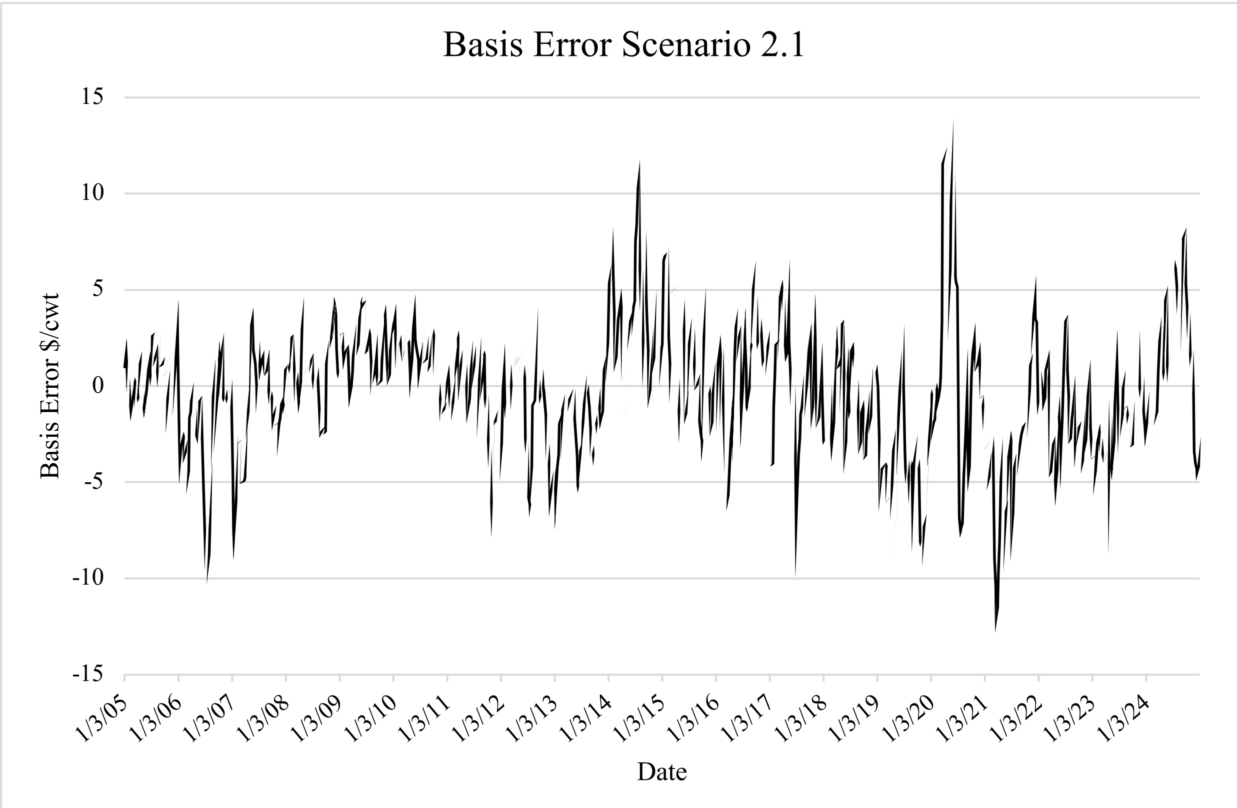


Figure 4 shows the corresponding time series of basis error. Early years (2005–2012) remain relatively stable within ± \$5 per cwt, but volatility intensifies after 2014, peaking during the 2015 cattle-price adjustment and again in 2020 when processing disruptions forced packers to widen discounts for off-spec and overweight carcasses. Even during normal market conditions, minor week-to-week swings of 3–5 per cwt persist, underscoring that discount-heavy cattle remain vulnerable to routine grid adjustments.

Economically, Scenario 2.1 illustrates that down-quality cattle primarily experience a downward shift in overall price level rather than a marked increase in volatility. The average basis and expected basis both decline relative to the benchmark, but the dispersion of expected basis remains similar, indicating that lower carcass quality reduces expected returns more than it increases price uncertainty. This pattern reflects the asymmetric structure of packer grids: discount schedules are steeper and more rigid than premium schedules, so weak carcass performance consistently lowers price outcomes even when variability does not expand substantially. In practical terms, producers feeding lower-quality cattle face systematic revenue disadvantages rather than heightened randomness in grid returns. These findings are consistent with Coelho, Mark, and Azzam (2008), who observed that cattle of inferior carcass quality under value-based pricing earn persistently lower returns and exhibit weaker correlation with futures prices. For Kansas feedyards, this scenario underscores the economic importance of carcass-quality management—not only as a means of capturing premiums but as a strategy to avoid the persistent downward bias in expected revenue embedded in modern grid systems**.**

Chapter 4.2.2 – High-Quality Stress Test

Scenario 2.2 represents the *high-quality stress test*, designed to evaluate how premium-grade carcasses respond to changing packer grid schedules. By applying the same weekly valuation schedules used in earlier simulations, this scenario isolates the protective effect of carcass quality on basis behavior while still capturing the volatility inherent in grid-based pricing.

Table 6 reports the carcass composition for this high-quality pen. The lot is dominated by Prime (20 %)**,** Certified Angus Beef (CAB, 40 %)**,** and Choice (30 %) carcasses, with only a small proportion grading Select. However, a sizable share falls into higher yield-grade categories—Yield Grades 4 and 5 account for 40 % of carcasses combined—which introduces potential trimming and overweight discounts. This composition mirrors feedyard pens focused on marbling improvement but with less emphasis on leanness optimization.

Table 6. Scenario 2.2 Carcass Composition

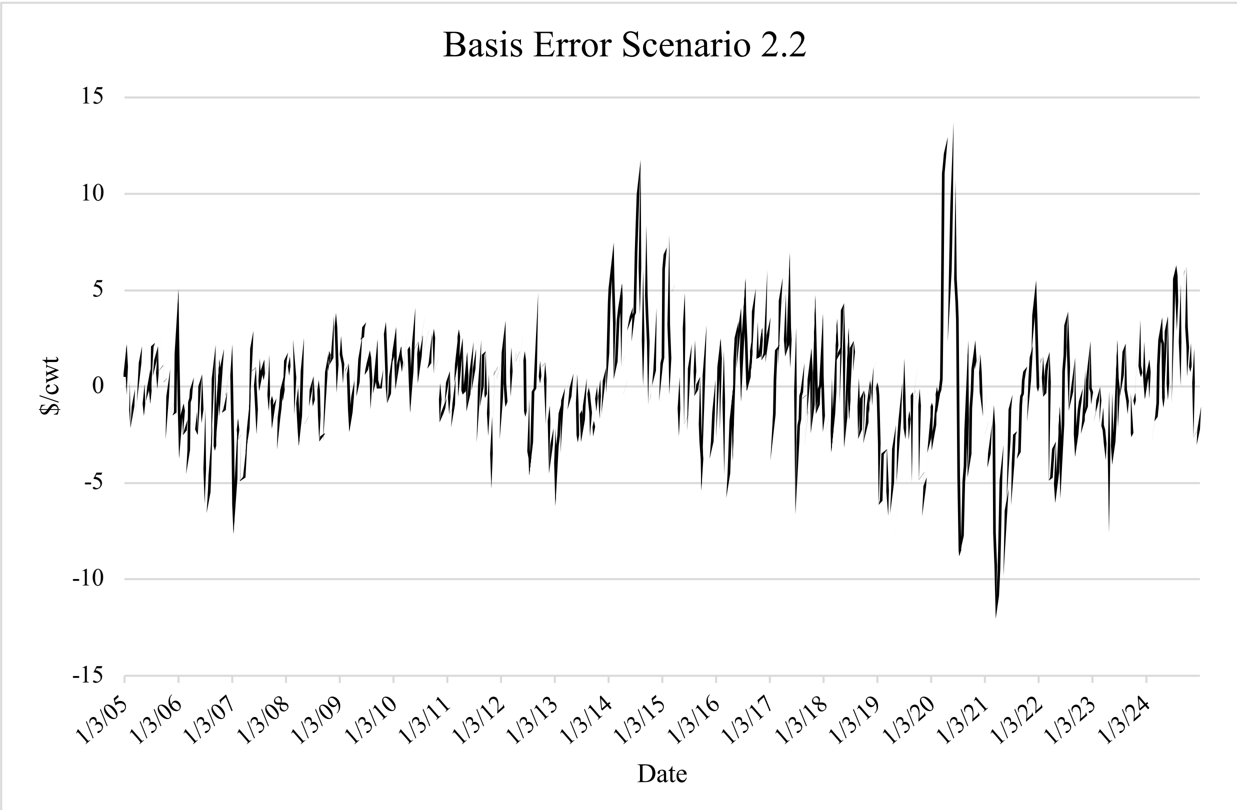
Scenario 2.2 Carcass Composition	
Grade	Percent
Prime	20.0%
CAB	40.0%
Choice	30.0%
Select	10.0%
Standard	0.0%
Hardbone	0.0%
Dark Cutters	0.0%
Yield Grade 1	0.0%
Yield Grade 2	20.0%
Yield Grade 3	40.0%
Yield Grade 4	30.0%
Yield Grade 5	10.0%
Light Weight	2.6%
Base Weight	92.9%
Heavy Weight	4.5%

Table 7. Scenario 2.2 Summary Statistics, Weekly Data, 2005-2024
Source: Livestock Marketing Information Center (LMIC, 2025), Commercial Feedyard Dataset

Scenario 2.2 Summary Statistics					
	Premium/Discount Adjusted Cash Price ($/cwt Live Wt)	Futures Price ($/cwt Live Wt)	Basis ($/cwt Live Wt)	Expected Basis ($/cwt Live Wt)	Basis Error ($/cwt Live Wt)
Mean	118.07	119.67	-1.60	-1.77	0.17
St.Dev	29.03	28.16	3.39	2.67	2.89
Min	74.70	74.66	-8.47	-9.06	-11.45
Max	189.57	192.01	16.74	11.77	13.53

The average basis of –$1.60 per cwt is moderately negative, showing that even high-quality pens can experience lower realized values when yield-grade discounts counteract quality premiums. Nonetheless, volatility remains contained relative to lower-quality pens: the basis standard deviation (3.39 per cwt) is slightly below the 3.90 per cwt observed in Scenario 2.1, and the range (–8.47 to +16.74 per cwt) indicates fewer extreme negative outliers. The positive mean basis error (+$0.17 per cwt) suggests a slight upward bias, implying that on average the grid slightly over-rewards this carcass profile relative to futures expectations.

Figure 5. Weekly Basis Error Scenario 2.2, 2005-2024
Source: Livestock Marketing Information Center (LMIC, 2025), USDA AMS Weekly Weighted Average Data.



As shown in Figure 5, basis error in this scenario generally oscillates within ± $5 per cwt, punctuated by distinct positive spikes during 2015 and 2021 when Choice–Select spreads widened sharply and packers elevated Prime and CAB premiums. Negative deviations are shallower than in the discount-heavy case, reflecting the revenue protection that premium carcasses provide even under volatile grid schedules.

Economically, Scenario 2.2 demonstrates that high-quality cattle reduce downside risk but remain exposed to short-term premium volatility. Because premium categories are recalibrated weekly, rapid changes in packer incentives can still cause unexpected revenue swings, though typically in the producer's favor. This supports findings by Coffey, Tonsor, and Schroeder (2018), who showed that value-based marketing increases expected returns but does not stabilize them. For Kansas feedyards specializing in premium programs, the implication is clear: while quality enhances average revenue, effective risk management must still account for the timing and volatility of grid-based premiums that can shift dramatically with boxed-beef demand and packer throughput.

Chapter 4.3 – Scenario 3 – Varying Cattle Quality and Grid Schedules

Scenario 3 represents the most realistic application of this study's framework, capturing both the week-to-week volatility of packer grid schedules and the natural variation in feedyard carcass quality. Unlike prior scenarios, which fixed carcass traits or applied stylized stress tests, this scenario draws from the observed Kansas pen-level data distribution to simulate the market environment feedyards face when marketing mixed-quality cattle under grid pricing. This approach reflects heterogeneity in genetics, feeding regimes, and management decisions, providing a comprehensive depiction of modern fed-cattle price risk.

Table 8. Scenario 3 Carcass Composition
Source: Commercial Feedyard Dataset

Scenario 3 Carcass Composition		
Grade	Pen Average	Pen Standard Deviation
Prime	2.5%	0.03
CAB	17.7%	0.10
Choice	56.3%	0.11
Select	22.0%	0.12
Standard	1.2%	0.02
Hardbone	0.0%	0.00
Dark Cutters	0.0%	0.00
Yield Grade 1	9.6%	0.08
Yield Grade 2	35.9%	0.10
Yield Grade 3	40.5%	0.09
Yield Grade 4	12.4%	0.08
Yield Grade 5	1.3%	0.02
Light Weight	2.7%	0.11
Base Weight	92.7%	0.12
Heavy Weight	4.6%	0.06

This composition reflects the carcass-quality distribution of the randomly selected feedyard pens used in this study, which provides a representative example of pen-level variation rather than a formal statewide average. The moderate representation of Choice (56.3%) and Select (22.0%) carcasses, combined with roughly 20% premium-eligible cattle (Prime + CAB), reflects typical marketing conditions for native steers. The inclusion of standard deviations captures the inherent variability within and across pens, emphasizing that carcass composition itself is a dynamic contributor to price risk under grid systems.

Table 9. Scenario 3 Summary Statistics, Weekly Data, 2005-2024
Source: Livestock Marketing Information Center (LMIC, 2025), Commercial Feedyard Dataset.

Scenario 3 Summary Stats							
	Premium/Discount Adjusted Cash Price ($/cwt Live Wt)	Futures Price ($/cwt Live Wt)	Basis ($/cwt Live Wt)	Expected Basis ($/cwt Live Wt)	Basis Error ($/cwt Live Wt)	Quality Grade Net ($/cwt Dressed)	Yield Grade Net ($/cwt Dressed)
Mean	117.73	119.67	-1.94	-1.90	-0.04	-0.97	-0.44
St.Dev	28.53	28.16	3.85	2.79	3.65	1.34	0.70
Min	73.34	74.66	-15.62	-11.52	-13.89	-8.03	-3.17
Max	189.26	192.01	15.65	12.16	14.61	3.50	1.24

The descriptive statistics in Table 9 show that when both carcass quality and grid schedules vary, basis risk widens considerably compared with the controlled environments in Scenarios 1 and 2. The mean basis of –$1.94 per cwt mirrors the average deviation seen in fixed-quality grids but with notably greater dispersion. The standard deviation of $3.85 per cwt and a total range of more than $31 per cwt (from –$15.62 to +$15.65) indicate that price outcomes fluctuate widely as carcass composition and packer discounts interact.

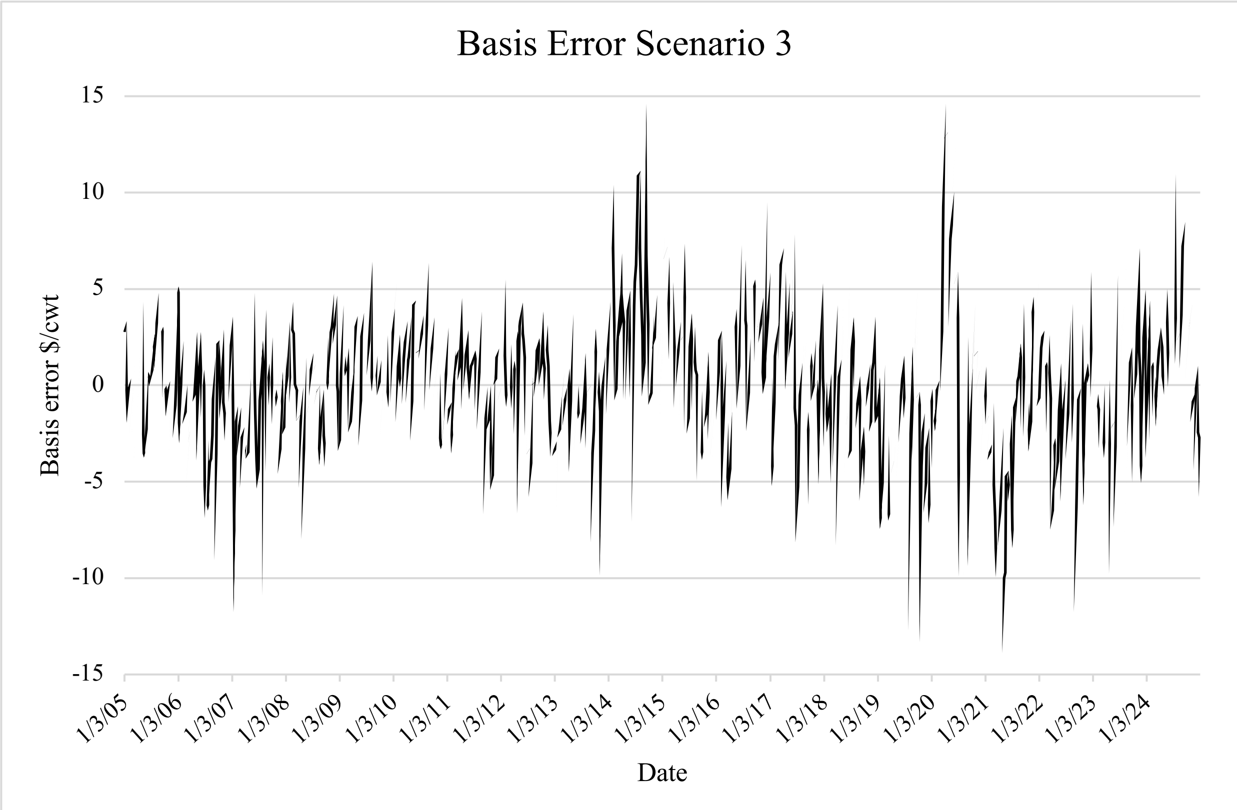
The average basis error of –$0.04 per cwt is essentially neutral, confirming that the futures market remains unbiased on average; however, the spread of ± $14 per cwt demonstrates that week-to-week variation remains substantial. Mean net quality grade (–0.97) and net yield grade (–0.44) reflect a carcass mix centered near average industry performance, suggesting that most Kansas feedyards operate around the equilibrium of typical Choice-3 carcasses with moderate yield characteristics.

Volatility in this scenario arises from the interaction of multiple forces: changing packer grid valuations, differences in carcass merit across pens, and shifts in market fundamentals. As grid spreads widen—for instance, when the Choice–Select differential spikes or yield-grade discounts intensify—basis dispersion expands correspondingly. The extreme positive basis values in 2015 and 2021 coincide with years of record-wide quality spreads, while large negative deviations align with 2014–2015 and 2020 market corrections when packers imposed steeper discounts on heavy carcasses.

In practical terms, Scenario 3 confirms that grid pricing embeds biological and operational variability directly into price outcomes**.** Even when futures markets perform efficiently, realized fed-cattle prices deviate according to the distribution of carcass quality delivered to packers and the timing of grid adjustments. The result is a fundamentally different form of basis risk—one driven less by regional price differences and more by the interaction between production decisions and packer valuation behavior.

For Kansas feedyards, this evidence highlights the need for integrated risk-management approaches that combine traditional hedging with carcass-performance forecasting and monitoring of grid-premium trends. Managing price risk under modern grid systems therefore requires not only market timing but also precise understanding of the biological and economic variables that now determine fed-cattle value.

Figure 6. Weekly Basis Error Scenario 3, 2005-2024
Source: Livestock Marketing Information Center (LMIC, 2025), USDA AMS Weekly Weighted Average Data.



The time-series plot of Scenario 3 basis error (Figure 6) visually reinforces the heightened volatility identified in the summary statistics. While the mean deviation remains close to zero, the amplitude of positive and negative swings widens markedly after 2014, corresponding with periods of record-wide grid spreads and CME contract revisions. Several sharp positive spikes appear in 2015 and 2021, when rapid price rallies and changing packer premiums temporarily lifted cash values well above expectations. Conversely, the deep negative excursions during 2008–2009 and again in 2020 coincide with economic downturns and market disruptions that compressed cash prices and expanded grid discounts. The persistent oscillations around zero suggest that the futures market continues to perform efficiently on average, yet short-term divergence between futures valuation and packer-adjusted carcass prices remains substantial. Overall, the figure illustrates that grid pricing has transformed basis behavior from a relatively stable convergence pattern into a high-frequency, quality-sensitive volatility process, underscoring the need for empirical modeling—such as the regression analysis that follows—to identify the structural and biological factors driving these deviations.

Chapter 4.4 – Regression Model Results

While the scenario simulations provide valuable insight into how grid pricing reshapes fed cattle basis behavior, they do not quantify the individual factors that drive this variability or how market behavior affects the degree of hedge effectiveness. To address this, regression models were developed to identify the principal determinants of basis error and to isolate the interaction between carcass-level traits, grid-schedule volatility, and broader futures-market dynamics.

The analysis uses weekly data from 2005 through 2024, combining carcass-level characteristics, grid-based pricing information, and market indicators with structural variables representing changes in the CME Live Cattle futures contract specifications. Explanatory factors include cash price levels, net quality and yield grades, carcass-weight categories, grid premiums and discounts, and seasonal demand indicators, along with a set of contract identifiers designed to capture the impacts of the CME specification change from 55% Choice/45% Select to 70% Choice/30% Select in the underlying delivery standard.

Table 10. Average Contract Change Binary Variables, 2004 – 2024 Effects
Source: CME Group

Contract Averages	
Contract 1(2017)	0.05
Contract 2 (2018)	0.12
Contract 3 (2021)	0.20

As shown in Table 10, these averages represent the proportion of observations in the dataset corresponding to each CME Live Cattle contract specification period between 2004 and 2024. Specifically, about 5 percent of the weekly observations occurred while the first specification (Contract 1, implemented in 2017) was in effect, 12 percent under the second specification (Contract 2, 2018), and 20 percent under the current specification (Contract 3, 2021). These binary variables serve as structural indicators in the regression analysis, allowing the model to capture whether weeks occurring under each contract period experienced systematically different basis behavior. In other words, the variables do not measure the *size* of the contract's effect but instead identify when the market operated under each specification, making it possible to estimate how each contract revision altered the cash–futures relationship once other factors were controlled.

Including these contract-specification variables within the regression framework allows the model to isolate structural effects on basis error apart from grid volatility and carcass composition. By jointly accounting for production-side factors**,** pricing-system dynamics**,** and contract-standard adjustments, the regression analysis provides a comprehensive evaluation of the evolving sources of unhedgeable basis risk in grid-priced fed cattle markets. This integrated approach clarifies how structural changes in the futures market interact with the growing dominance of value-based marketing to shape the volatility Kansas feedyards face in real-world hedging outcomes.

To quantify the factors driving basis risk when cattle quality is held constant, regression models were estimated using data from Scenario 2, where only grid-schedule volatility and market conditions vary. Two versions of the model were evaluated: one including carcass-weight categories to capture the direct effects of heavy and light carcasses, and another excluding these variables to test their independent contribution to basis variation. Both models employ ordinary least squares (OLS) with robust standard errors using weekly data from 2005 – 2024**.**

The dependent variable is basis error—the deviation between realized and expected basis values—while explanatory variables include the cash price level, carcass-composition indicators (net quality and yield grades), monthly seasonal dummies, and indicator variables for major CME Live Cattle contract specification changes.

Table 11. Fixed Cattle Quality Weekly Basis Error Regression Results, 2005-2024

	Fixed Cattle Quality			Fixed Cattle Quality w/o Carcass Weight		
	Coefficient	p-value	Standardized Beta	Coefficient	p-value	Standardized Beta
Constant	0.658	0.808	---	-4.396	0.000	---
Cash Price	0.049	0.000	0.469	0.042	0.000	0.411
St. Dev. Price	0.022	0.641	0.016	0.029	0.531	0.021
January	-0.867	0.039	-0.082	-0.874	0.040	-0.083
February	-1.145	0.012	-0.104	-1.192	0.009	-0.107
March	-1.715	0.000	-0.160	-1.689	0.000	-0.158
April	-1.074	0.015	-0.099	-0.981	0.028	-0.091
May	-0.800	0.057	-0.076	-0.681	0.109	-0.064
June	0.314	0.453	0.029	0.377	0.372	0.035
July	-0.293	0.480	-0.028	-0.574	0.565	-0.023
August	-0.515	0.223	-0.049	-0.387	0.364	-0.037
September	-0.559	0.188	-0.052	-0.475	0.267	-0.044
October	-0.362	0.381	-0.034	-0.358	0.392	-0.034
November	-0.393	0.344	-0.036	-0.367	0.384	-0.034
Net Quality Grade	0.487	0.000	0.222	0.447	0.00	0.203
Net Yield Grade	-0.042	0.963	-0.003	-1.205	0.032	-0.088
Light Weight	-5.222	0.276	-0.125	---	---	---
Heavy Weight	7.195	0.000	0.334	---	---	---
Contract Spec Change #1 (2017)	0.171	0.712	0.013	0.108	0.806	0.008
Contract Spec Change #2 (2018)	-2.343	0.000	-0.255	-0.579	0.072	-0.063
Contract Spec Change #3 (2021)	-4.545	0.000	-0.611	-2.002	0.000	-0.269
Number of Observations	1044			1044		
Prob > F	0.000			0.000		
R- squared	0.164			0.139		
Adj. R- squared	0.148			0.125		
Root MSE	2.730			2.768		

The regression results indicate that even when cattle quality is fixed, market price levels and structural contract adjustments are the dominant influences on basis behavior. The cash price variable is highly significant in both specifications ($p < 0.001$), with standardized betas near 0.45, indicating that as overall fed-cattle prices rise, basis values tend to strengthen relative to expectations. This positive relationship suggests that when market conditions improve, grid-based adjustments—such as yield or weight discounts—tighten more slowly than the futures response, allowing realized basis to improve.

Seasonal effects are also apparent. Negative coefficients for January through April indicate that early-year marketings typically yield weaker-than-expected basis values. This seasonal pattern reflects the interaction of tighter winter-fed cattle supplies with packer behavior—grids tend to impose larger discounts for excess weight or lower cutability during the early months, when carcass quality variability is higher. The magnitude of the March effect (–1.72 cwt) underscores the consistent downward seasonal pull-on basis during the late-winter marketing period.

Even with fixed cattle quality, carcass composition variables remain meaningful predictors of basis error. The net quality grade coefficient is positive and highly statistically significant in both models, showing that as net quality premiums increase (for example, when Choice-Select spread widens) stronger than expected basis occurs. This finding reinforces that modest shifts in carcass premiums or discounts influence realized pricing more than producers might expect. The net yield grade variable becomes statistically significant only when carcass-weight terms are removed, suggesting that yield-grade effects are related to corresponding out-weight penalties. This is the main reason the two models were estimated to test sensitivity among these related variables.

The weight variables coefficients are somewhat perplexing. The coefficient on heavy weight cattle (7.20, $p < 0.001$) indicates that as heavy-weight discounts increase, basis error increases (becomes less negative or more positive). In other words, actual basis increases relative to expected basis. This is hard to explain at the surface as increased discounts for heavy-weight cattle should cause negative basis errors. Conversely, the light-weight coefficient (–5.22) is negative, as expected, but statistically insignificant, implying that discounts for underweight do not contribute to large basis errors. Since only 2.6% of cattle are lightweight in this scenario, the light-weight discount would not have a large impact on basis, especially since this discount has been relatively constant over time.

Perhaps the most important structural finding involves the CME contract specification changes. The 2017 modification shows no measurable effect, but the 2018 and 2021 changes—representing the transition of the CME Live Cattle contract's underlying grade mix from 55 % Choice/45 % Select to 70 % Choice/30 % Select—produce large, negative, and statistically significant coefficients (–2.34 and –4.55, respectively). These results reveal that basis declined following the grade-composition shift, likely because the futures contract was catching up to the quality distribution of the cash market. That is, an increase in futures contract quality specifications simply shifts the futures price up relative to cash prices and the coefficients in these regression models simply illustrate the associated change in basis caused by those contract changes.

Overall model fit is modest ($R^2 = 0.16$, Adj. $R^2 \approx 0.15$), which is reasonable given the complexity of weekly cash–futures relationships and the number of unobserved market factors that influence fed cattle pricing. The results suggest that even when cattle quality is fixed, a meaningful share of basis variation—around fifteen percent—can be attributed to a combination of market-level dynamics, seasonality, and changes in contract specifications. While these effects are not dominant, their statistical significance indicates that grid volatility and structural pricing adjustments are nontrivial components of hedging uncertainty in value-based markets. The findings therefore point to emerging patterns of basis variability that traditional futures hedging may not fully capture. Rather than implying that institutional changes cause unhedgeable risk, the results highlight that such factors contribute to the evolving complexity of risk exposure feedyards face under grid-based pricing and underscore the importance of monitoring these structural shifts as part of comprehensive risk-management strategies.

While the Scenario 2 models indicate that price level, contract specification, and seasonality explain part of the observed basis variation, the role of carcass weight deserves closer attention. Grid data from 2005–2024 reveal that discounts for heavy carcasses—those exceeding upper weight thresholds—have fluctuated substantially over time. In the mid-2000s, packers routinely applied discounts of –\$8 to –\$12 per cwt, reflecting fabrication limitations and the market's preference for moderate carcass sizes. As industry efficiencies improved and boxed-beef demand strengthened through the 2010s, those penalties gradually narrowed, often ranging between –\$4 and –\$6 per cwt.

This trend reversed beginning around 2018, coinciding with the CME contract specification changes that increased the Choice grade share in the futures contract benchmark from 55 % to 70 %. During this same period, carcass weights reached record highs, especially in 2020–2021 when pandemic-related processing delays caused cattle to remain on feed longer. Packers responded by expanding heavy-weight penalties once again, reinforcing the divergence between cash grid values and futures pricing. The overlap between these events helps explain the sensitivity of the regression models to the inclusion of carcass-weight variables. When weight categories are omitted, much of the variation stemming from shifting packer discounts is captured indirectly by the contract-change indicators, amplifying their apparent effect. Including explicit weight terms isolates that volatility within the grid itself, producing smaller structural coefficients and improving the model's explanatory clarity.

Correlation analysis supports this interpretation. The share of heavy carcasses is positively correlated with basis error ($\rho \approx 0.30$), meaning that as the proportion of overweight cattle rises, realized basis values tend to strengthen relative to expectations—likely because packers temporarily relax penalties during tight supply conditions. Conversely, the correlation between cash price and heavy-weight discount magnitude is negative ($\rho \approx -0.40$), indicating that higher overall price levels are typically associated with narrower weight penalties. These relationships illustrate that carcass-weight dynamics bridge the link between biological production outcomes and institutional pricing adjustments, serving as a key channel through which grid-level factors translate into basis variability. Recognizing this connection clarifies why weight variables materially alter model fit and interpretation, and it sets the foundation for the more complex analysis of fully variable carcass quality presented in Scenario 3.

To evaluate how true carcass variability interacts with grid volatility and market factors, regression models were estimated for Scenario 3, which reflects randomly drawn Kansas feedyard pens rather than fixed-quality cattle. This scenario captures the most realistic marketing environment by allowing carcass traits, grid adjustments, and market dynamics to fluctuate simultaneously. Two model specifications were again tested: one including carcass-weight categories to account for grid weight adjustments, and another excluding those variables to isolate the contribution of carcass quality and yield alone. Both models were estimated using OLS with robust standard errors on weekly data from 2005 to 2024.

Table 12. Varying Cattle Quality Regression Results, 2005-2024

	Varying Cattle Quality			Varying Cattle Quality w/o Carcass Weight		
	Coefficient	p-value	Standardized Beta	Coefficient	p-value	Standardized Beta
Constant	-1.454	0.014	---	-2.046	0.002	---
Cash Price	0.040	0.000	0.317	0.039	0.000	0.309
St. Dev. Price	-0.012	0.802	-0.007	-0.009	0.852	-0.006
January	-0.789	0.077	-0.061	-0.658	0.179	-0.051
February	-1.084	0.019	-0.079	-1.026	0.042	-0.075
March	-1.686	0.000	-0.128	-1.723	0.001	-0.131
April	-0.992	0.029	-0.075	-1.228	0.014	-0.093
May	-0.389	0.383	-0.029	-0.376	0.443	-0.028
June	0.537	0.234	0.040	0.568	0.252	0.042
July	-0.131	0.769	-0.010	-0.082	0.867	-0.006
August	0.139	0.757	0.011	-0.386	0.432	-0.029
September	0.050	0.912	0.004	-0.509	0.305	-0.038
October	-0.229	0.605	-0.018	-0.217	0.656	-0.017
November	-0.157	0.728	-0.012	-0.314	0.384	-0.024
Net Quality Grade	1.083	0.000	0.397	1.094	0.000	0.401
Net Yield Grade	1.182	0.000	0.228	1.396	0.000	0.269
Light Weight	0.642	0.000	0.335	---	---	---
Heavy Weight	0.619	0.000	0.208	---	---	---
Contract Spec Change #1 (2017)	-0.535	0.228	-0.032	-0.709	0.145	-0.042
Contract Spec Change #2 (2018)	-0.973	0.001	-0.086	-0.861	0.010	-0.076
Contract Spec Change #3 (2021)	-2.085	0.000	-0.227	-1.887	0.000	-0.206
Number of Observations	1044			1044		
Prob > F	0.000			0.000		
R- squared	0.352			0.218		
Adj. R-squared	0.339			0.204		
Root MSE	2.96			3.25		

The regression results for Scenario 3 indicate that allowing carcass quality to vary across pens reveals additional relationships that were not observable under the fixed-quality design. Incorporating variation in net quality grade, yield grade, and carcass weight captures a broader set of pricing dynamics relevant under grid marketing conditions. In both model specifications, the constant term is negative and statistically significant, suggesting that, even after accounting for observed factors, realized basis values tend to fall slightly below expectations. This result reflects residual uncertainty inherent in packer grid evaluations and timing differences in how grids adjust to market signals. Rather than implying a direct improvement in explanatory power relative to the fixed-quality models, these findings show that heterogeneity in carcass composition introduces new sources of variability in basis behavior that futures markets are not designed to hedge against.

The cash price variable remains positive and highly significant ($p < 0.001$), with standardized coefficients near 0.30 in both specifications. This pattern indicates that periods of higher market prices are generally associated with stronger realized basis performance, though the relationship likely reflects correlated movements in carcass premiums and grid spreads rather than a simple causal effect. Net quality grade and net yield grade also emerge as major explanatory factors: their positive and statistically significant coefficients confirm that pens with higher quality or more efficient carcasses tend to realize stronger basis values, consistent with value-based pricing incentives. The significance of carcass-weight variables in the full model further demonstrates that weight interacts closely with grid adjustments—its influence diminishes when omitted, causing part of that variation to be absorbed by structural variables such as the CME contract-change indicators. Together, these results suggest that under realistic, variable-quality conditions, basis behavior reflects an intricate interplay among market levels, carcass composition, and evolving contract standards rather than a single dominant driver of risk.

Both net quality grade and net yield grade emerge as the most powerful predictors of basis error in this model. The coefficient for net quality grade (1.08, $p < 0.001$) carries the largest standardized beta (0.40), signifying that higher-quality carcasses consistently strengthen realized basis values. Similarly, net yield grade (1.18, $p < 0.001$) shows a significant and positive influence ($\beta \approx 0.23$–0.27), confirming that carcasses with higher cutability improve price realization relative to futures expectations. These findings align with the economic intuition that packers reward high-performing carcasses with premiums that widen the cash–futures spread, and they empirically validate the scenario-based results showing premium-driven basis improvement in Scenarios 2.1 and 2.2.

The inclusion of carcass-weight variables remains perplexing. Both lightweight (0.64, $p < 0.001$) and heavy-weight (0.62, $p < 0.001$) coefficients are positive and statistically significant. The heavy-weight suggests that if excessively heavy cattle out-weights increase or discounts for these increase, actual basis strengthens relative to expected. This is not what we expect and as with Scenario 2, led me to drop the weight variables from the model to test robustness. In contrast to Scenario 2, dropping the weight variables from Scenario 3 models did not have large impacts on the remaining coefficients.

Seasonality continues to exert a moderate influence. February through April display statistically significant negative coefficients (ranging from –0.99 to –1.69), consistent with the seasonal tightening of packer capacity and weaker basis during the spring. These months coincide with periods of volatile grid adjustments, particularly when higher-quality carcasses capture expanding premiums while average cattle experience relative basis erosion. By contrast, summer and fall months show small, insignificant coefficients, indicating that seasonal effects are most pronounced early in the year when carcass-quality spreads and slaughter bottlenecks are greatest.

Finally, the regression results confirm the enduring impact of CME contract specification changes. While the 2017 adjustment remains statistically insignificant, the 2018 and 2021 specification changes — corresponding to the transition of the CME contract from 55% Choice / 45% Select to 70% Choice / 30% Select—produce sizable and significant negative effects on basis performance (–0.97 and –2.09, respectively). These findings reinforce the conclusion that structural contract modifications adjusted temporary misalignment between futures-grade assumptions and the actual carcass distribution marketed under grid pricing. Even after accounting for carcass composition and market levels, the post-2021 contract environment exhibits greater divergence between futures and cash prices, confirming that institutional changes have become a key source of basis uncertainty.

Taken together, the Scenario 3 results demonstrate that carcass variation is the single largest contributor to basis error in grid-priced fed cattle markets. When quality, yield, and weight characteristics are allowed to vary, their combined influence explains roughly one-third of observed basis deviations. These outcomes illustrate that grid pricing transforms basis risk from a simple market convergence issue into a multidimensional function of carcass performance and contract structure. For Kansas feedyards, this means that effective risk management increasingly depends not only on futures hedging but also on carcass-quality forecasting, pen-level data analysis, and awareness of evolving packer grid strategies. The model provides empirical evidence that structural changes in both the cash and futures markets are reshaping the nature of hedging effectiveness in value-based cattle marketing systems.

Chapter 5 – Discussion and Implications

Table 13. Summary Statistics Scenario's 1-3

Summary Statistics				
Scenario	Average Basis Error ($/cwt)	St. Dev. ($/cwt)	Min Error ($/cwt)	Max Error ($/cwt)
Benchmark	0.21	2.92	-10.05	14.63
Fixed Cattle Quality	-0.05	2.96	-12.04	13.73
Low Quality Stress Test	-0.33	3.4	-12.82	13.98
High Quality Stress Test	0.17	2.89	-11.45	13.53
Vary All Traits	-0.04	3.65	-13.89	14.61

The combined results from Scenarios 1 through 3 and the accompanying regression analyses reveal a clear structural evolution in fed cattle basis behavior as the U.S. industry transitioned from live- and dressed-weight pricing to value-based grid marketing. Each scenario isolates a different layer of price risk—from traditional hedging environments to grid-driven volatility and finally to full carcass-quality variation—allowing a stepwise assessment of how the composition of basis risk has changed over time.

In Scenario 1, where carcass adjustments are excluded, basis behavior follows historical expectations: the mean basis is near zero and relatively stable, with predictable seasonal variation but little unexplained volatility. This pattern reflects the effectiveness of conventional futures hedging in a market where cattle were sold on uniform, weight-based pricing. Basis risk in this benchmark environment primarily reflected timing and transportation differences between local cash markets and the national futures contract.

When grid pricing is introduced in Scenario 2, basis risk becomes more complex even though cattle quality remains fixed. Here, volatility emerges entirely from changes in packer grid schedules—weekly adjustments to premiums and discounts that redefine carcass valuation independent of market fundamentals. The mean basis turns negative, and its standard deviation widens, indicating that fluctuations in packer pricing behavior create additional, unhedgeable variance. The Scenario 2 regression results confirm that cash price levels, seasonality, and the CME's contract-specification shifts are significant determinants of these deviations. The large negative coefficients for the 2018 and 2021 specification changes demonstrate that structural adjustments in the futures market itself changed basis levels. Under grid pricing, therefore, hedging precision becomes increasingly sensitive to institutional factors rather than purely to market supply-demand forces.

The introduction of true carcass variability in Scenario 3 further transforms the nature of basis risk. Allowing quality, yield, and weight traits to fluctuate across pens raises the model's explanatory power substantially ($R^2 \approx 0.35$), showing that carcass heterogeneity is now the dominant driver of basis error. The regression results reveal that net quality grade and net yield grade together account for the largest share of variation, confirming that higher-quality and better-yielding cattle consistently outperform hedged expectations. These effects persist even after controlling for market price levels and contract changes, underscoring that the shift to grid pricing has embedded biological and management variability directly into price outcomes. Basis risk, once primarily a function of market timing, now reflects the intersection of biological performance and pricing algorithms.

Comparing Scenarios 2 and 3 also highlights a critical asymmetry in risk exposure. While superior carcass performance improves expected returns, it does not eliminate volatility; rather, it converts downside risk into a mix of unhedgeable upside and downside variance. The widening of the Choice–Select spread in certain years, coupled with evolving grid penalties for overweight carcasses, produces both windfall gains and unexpected losses that standard futures contracts cannot offset. The feedyard's realized hedge outcome thus depends on the alignment between its pen-level carcass distribution and the packer's current grid structure, a relationship that changes weekly.

Table 14. Statistical Significance Between Scenarios (Pairwise Levene Tests)

Statistical Significance Test Between Scenarios					
	Scenario 1	Scenario 2	Scenario 2.1	Scenario 2.2	Scenario 3
Scenario 1	-	0.69	0.00	0.69	0.00
Scenario 2		-	0.00	1.00	0.00
Scenario 2.1			-	0.00	0.24
Scenario 2.1				-	0.00
Scenario 3					-

The statistical evidence further reinforces this shift in risk dynamics. Pairwise Levene tests show that Scenarios 1, 2, and 4 all exhibit statistically similar variance ($p > 0.69$), indicating that when cattle quality is either excluded entirely (Scenario 1), held constant at average levels (Scenario 2), or held constant at high-quality levels (Scenario 4, the high-quality stress test), basis error remains relatively stable and predictable. In other words, grid pricing by itself does not materially increase volatility when biological performance does not vary across pens.

In contrast, Scenario 3—the low-quality stress test—and Scenario 5, which incorporates real-world variation in carcass quality, yield, and weight, both exhibits significantly greater variance than all scenarios with fixed or no quality ($p < 0.001$). This shows that once biological traits begin to vary, basis transitions into a fundamentally different and much higher volatility regime. The fact that Scenario 3 and Scenario 5 are statistically indistinguishable (p =

0.24) indicates that the rise in variance is driven primarily by the presence of biological variability itself, not necessarily by the specific quality distribution or grid structure. Together, these results provide strong quantitative confirmation that modern basis risk arises chiefly from the interaction between cattle biology and packer grid schedules, rather than from traditional cash–futures market dynamics.

Taken together, these results demonstrate that the composition of basis risk in fed cattle markets has fundamentally changed. Traditional sources—regional price differentials, transportation costs, and futures timing—have been supplanted by grid-specific volatility, carcass heterogeneity, and structural contract effects. The statistical evidence confirms that while cash price remains a key predictor of short-term deviations, grid adjustments and carcass-quality interactions explain a growing share of the variance in hedging outcomes. For Kansas feedyards, this means that managing price risk under grid pricing now requires integrating production management, marketing timing, and futures strategy.

From a policy and industry perspective, the findings suggest that existing risk-management tools such as Livestock Risk Protection (LRP) or futures hedges could be enhanced by incorporating grid-based quality parameters. Futures contracts more closely tied to carcass-value indices or regional grid averages could reduce the structural misalignment identified in the regression models. Similarly, feedyard-level decision tools that forecast expected grid returns based on pen composition could help producers anticipate periods of heightened basis risk.

Overall, the comparative analysis underscores a central conclusion of this thesis: as the U.S. fed cattle market continues to shift toward value-based pricing, basis risk is no longer purely a market-timing problem—it is a multidimensional management challenge that spans carcass performance, packer valuation behavior, and contract design. Understanding and quantifying these relationships is essential to developing next-generation risk-management tools that reflect the realities of grid-priced fed cattle production.

Chapter 6 - Conclusion

This study set out to evaluate how the shift from live-weight pricing to value-based grid systems has transformed the nature of basis risk in fed cattle markets. Using commercial Kansas feedyard data from 2005 through 2024, the analysis quantified how carcass quality, packer grid volatility, and structural changes in the CME Live Cattle futures contract jointly influence the predictability and stability of fed cattle basis performance. Through a series of simulation scenarios and regression models, the results reveal that the primary sources of basis risk have evolved from external market factors toward internal production and pricing dynamics embedded within the grid system itself.

In the traditional live or dressed pricing environment represented by Scenario 1, basis behavior was stable and predictable. Futures hedging performed effectively because price relationships were governed primarily by uniform market fundamentals. However, with the introduction of grid pricing in Scenario 2, basis variability increased even when cattle quality was held constant. Weekly adjustments to packer premiums and discounts—driven by grid valuation schedules rather than aggregate market forces—introduced new, unhedgeable variation. The regression analysis confirmed that these grid-level dynamics, along with seasonal effects and structural contract modifications, have become significant contributors to basis volatility.

Allowing carcass composition to vary across pens in Scenario 3 exposed the full extent of this transformation. Once real-world differences in carcass quality, yield, and weight were introduced, model explanatory power more than doubled, underscoring that biological variation in cattle performance now directly translates into pricing uncertainty. Net quality and yield grades emerged as the strongest predictors of basis error, proving that the profitability and risk profile of a hedge increasingly depend on the alignment between pen-level carcass traits and packer grid behavior. Importantly, these results demonstrate that while high-quality cattle improve expected returns, they do not eliminate volatility—premium carcasses still experience unpredictable swings due to changing grid incentives, fluctuating Choice–Select spreads, and contract revisions in the futures market.

Taken together, the evidence shows that grid pricing fundamentally reshaped how fed cattle price risk behaves. Basis is no longer a simple market-level wedge between cash and futures; it is a value-based risk rooted in carcass outcomes and packer-specific schedules. Producers cannot hedge this dimension of risk with futures or LRP, because traditional tools protect price, not value. Even with high-performing cattle, grid schedules can erode margins through adjustments that the futures market does not reflect. This creates a growing divergence between hedged expectations and realized outcomes, particularly when cattle quality varies across pens or when packer grids adjust rapidly week to week.

This study also highlights a gap in the prior literature. Most previous research has measured basis using live-weight or dressed-weight cash prices and has not incorporated carcass-level quality distributions into basis prediction. By explicitly accounting for yield grade, quality grade, and carcass weight, this analysis demonstrates that a significant portion of basis volatility originates from the biological and value-based dimensions of cattle that earlier studies did not observe. As grid pricing now accounts for roughly 70% of fed cattle transactions, incorporating carcass-level detail is no longer optional for understanding hedging performance—it is fundamental.

From an applied standpoint, these findings have important implications for producers, risk managers, and policymakers. For feedyards, managing price risk under grid systems requires an integrated strategy that includes carcass-quality forecasting, grid-trend monitoring, and packer-specific pricing behavior in addition to futures hedging. For policymakers and market designers, the results suggest that existing instruments such as Livestock Risk Protection could be refined to incorporate grid-based parameters or carcass-value indices, allowing coverage to better reflect the true pricing uncertainty producers face under value-based systems.

Ultimately, this study demonstrates that as market institutions evolve, so too must the tools used to manage risk. Understanding how grid volatility, carcass traits, and contract standards interact provides the foundation for developing next generation hedging and insurance mechanisms that reflect the realities of modern fed cattle marketing. The shift toward value-based pricing has improved market efficiency and consumer alignment, but it has also introduced new dimensions of uncertainty that traditional price-based hedging cannot fully offset. Quantifying and managing those dimensions are essential to ensuring that producers remain competitive and resilient in an increasingly differentiated beef market. In the end, the more precisely a producer understands their cattle, the more accurately they can anticipate and manage basis risk.

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