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ORIGINAL ARTICLE

Macroeconomic shock effects on beef carcass premiums

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Abstract

An overview of how macroeconomic shocks affect beef quality-grade premiums and discounts in the U.S. fed cattle market is discussed. We review the shock transmission linkages along the beef industry supply chain and determine the economic implications for the finished cattle market. The analysis provides insight into how the fed cattle market responds to macroeconomic shocks. The economic implications of financial risk associated with the behavior of beef carcass quality-grade premiums and discounts associated with the Great Recession and the COVID pandemic are contrasted and assessed.

Data analysis indicates that macroeconomic shocks affect the quality-grade premium pricing mechanism for finished cattle. The origins of the shock (aggregate demand versus aggregate supply) and government fiscal policy intervention determines how premium levels and premium volatility responds to a macroeconomic shock. Thus, beef carcass quality-grade premiums are not only subject to industry idiosyncratic risk, such as swings in the seasonal demand for beef, but are also subject to systematic risk associated with business cycle fluctuations.

KEYWORDS
COVID-19, grid pricing, macroeconomic shocks, markets, supply chain

JEL CLASSIFICATION
E30, E65, Q11, Q13

1 | INTRODUCTION

Market conditions in the U.S. are affected by business cycle fluctuations. Negative macroeconomic shocks generally increase unemployment and decrease consumer income. Consequently, as consumer demand weakens, overall spending in the economy declines. As consumer spending declines, firms operating in individual markets typically experience rising inventories, resulting in declines in production and prices. Negative economic shocks to the U.S. economy are infrequent random events. The two most recent economic shocks affecting the U.S. economy are: (a) the Great Recession of 2008–09 (U.S. Bureau of Labor Statistics, 2023a), and (b) the COVID pandemic of 2020–2023 (CDC, 2024). The U.S. beef industry is not immune to business cycle fluctuations.[1]

Academic research on household food expenditure elasticities indicates that as consumer income declines so does the demand for beef (e.g., Okrent & Alston, 2012). Declining demand for retail beef, ceteris paribus, results

[1] In this study we are using carcass premium data published under the authority of The Livestock Mandatory Reporting (MPR) Act of 1999 (Fausti, Qasmi et al., 2010). The U.S. did experience a recession in 2001, that began in March and ended in November 2001. However, MPR reports did not begin until April 2001. Given the timing of the initial release of MPR reports, we did not include the 2001 recession in this study.

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in declining prices along the supply chain. Economic theory states that prices along the beef supply chain are determined by a dynamic price adjustment mechanism, connecting upstream linkages in the beef supply chain to the retail market (Hahn, 2004).[2]

In the fed cattle market, the value of any individual animal is determined by the deviation of carcass quality (as determined by the USDA grading system) from the market determined price for the industry standard carcass specification of yield-grade 3, quality-grade choice, and a hot-carcass-weight ranging from 600 to 900 pounds (e.g., Fausti et al., 1998). An animal's quality-grade and yield-grade scores determine if the carcass will receive a premium or discount relative to the industry standard carcass.[3] Given that the industry standard for the quality-grade of a carcass is choice, prime carcasses receive a premium relative to choice. Select and standard carcasses receive a discount relative to choice.[4]

The market value of a finished steer or heifer is informed by the price discovery process (Anderson & Bastian, 2021). The price discovery process takes into consideration market valuation of carcass quality characteristics (e.g., Fausti, Diersen et al., 2010). The dynamic price adjustment process determines the market valuation of carcass quality attributes at each stage along the beef supply chain.

The study's general theme focuses on the effect of macroeconomic shocks on quality-grade premiums and the economic implications of the systematic risk associated with macroeconomic shocks for fed cattle producers. The objectives of this study are to determine if the two most recent economic shocks affected: (a) weekly quality-grade premium/discounts levels, premium volatility, and premium relative volatility when compared to pre-shock levels, (b) to determine if the nature of a macroeconomic shock dictates how the quality-grade premium structure reacts to a shock, and (c) to provide insight on how the type of fiscal policy response to a macroeconomic shock affects quality-grade premium behavior.[5]

1.1 | Literature review

1.1.1 | The beef industry and the great recession

The great recession began with a liquidity crisis in U.S. financial markets that spread to global financial markets, resulting in a dramatic decline in aggregate demand, and disrupted international trade patterns resulting in an economic contraction lasting 18 months (e.g., Blinder & Zandi, 2010; Grusky et al., 2011; Peters et al., 2009; Shane et al., 2009).

The Great Recession inflicted systemic damage to the U.S. economy that lingered beyond the starting point of economic recovery in the spring of 2009. Real gross domestic product dropped in the second half of 2008 and only reached pre-recession levels in 2011.[6] The economic shock resulted in substantial and persistent unemployment.[7] A prolonged decrease in real median household consumer income[8] that coincided with rising retail food prices, resulted in a decline in household expenditures[9] (Kumcu & Kaufman, 2011; Saksena et al., 2018).[10]

This simultaneous occurrence of negative economic pressures on households generated a shift in consumer shopping behavior (e.g., Lusk & McFadden, 2021; Nevo & Wong, 2019). Changes in consumer behavior included shifting from food away from home (FAFH) to food at home (FAH), substituting generic food products for brand name products, and substituting across alternative meat protein products (beef, chicken, pork, turkey, etc.) as income levels changed during the recession. Intra-product substitution included substituting ground beef for higher quality beef products (steak), as consumer income declined (Lusk & McFadden, 2021; Lusk & Tonsor, 2016). According to Tonsor et al. (2018), beef retail demand declined during the Great Recession relative to 2006 levels. They note that following the Great Recession beef products have become more income sensitive and less price sensitive. Their conclusion suggests the role of macroeconomic shocks in determining beef demand is increasing.

[2] Darbandi and Saghaian (2016) provide empirical evidence of price integration across beef supply chain segments consistent with Hahn's dynamic price adjustment mechanism. Their empirical work documents the dynamic nature of the price transmission mechanism during the Great Recession.

[3] The U.S. grading system refers to the premium for choice cattle as the choice/select discount. Quality-grade refers to the percentage of intramuscular fat content (i.e., marbling score). The USDA has four quality-grade categories: (a) prime, (b) choice, (c) select, and (d) standard. The highest carcass quality ranking is prime, the lowest is standard.

[4] In addition to quality-grade, the other major categories having premiums and discounts with respect to the overall market value of a beef carcass are: (a) yield grade, (b) light weight and heavy weight carcasses, (c) animal age, (d) Certified Angus Beef (**CAB**) and Non-Hormone Treated Cattle (**NHTC**) certified cattle, and (e) dark cutter and hard-bone discounts.

[5] Specifically, our focus is on changes in premium and premium volatility within a time interval that contains both the pre-shock event period and the shock event. Thus, we are not comparing premium levels across shocks, we are comparing *changes in premium levels and premium volatility behavior* as a result of a shock event.

[6] See: https://fred.stlouisfed.org/series/GDPC1.

[7] See: https://fred.stlouisfed.org/series/UNRATE.

[8] See: https://fred.stlouisfed.org/series/MEHOINUSA672N.

[9] See: https://fred.stlouisfed.org/series/DPHCRC1A027NBEA.

[10] The National Bureau of Economic Research dates the Great Recession beginning in January 2008 and ending in June of 2009. The U.S. economy was operating at full employment output in December of 2007 with an unemployment rate at 5% (Federal Reserve Bank of St. Louis). The unemployment rate in the U.S. peaked in the summer of 2009 at 9.9% and did not return to 5% until December of 2015 (footnote 6). Saksena et al. (2018) estimates total household expenditures on food did not fully recover to pre-recession levels until 2015.

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Given the large decline in consumer income during the Great Recession, one can reasonably speculate that consumers shifted from purchasing high quality beef to lower quality beef. The choice/select discount report is published weekly by the USDA and shows, on average, a significant narrowing in the select discount (on a per cwt. of carcass basis) during the Great Recession (−$5.19) relative to the level of the discount for the year 2007 (−$9.72) (USDA, 2023b).[11] This decline in the select discount is consistent with a decline in the demand for beef as consumers shifted expenditures toward lower cost meat products that include quality-grade select beef products at the expense of quality-grade choice beef products in reaction to declining consumer income.

1.1.2 | The beef industry and the COVID pandemic

The origin of the macroeconomic shock associated with the COVID pandemic began in the fall of 2019. The virus spread rapidly across the globe, resulting in public lockdowns that shut down the global economy. Brodeur et al. (2021) provides an overview of the economic and social costs. They identify three areas of economic activity negatively affected by the pandemic: (1) a direct effect of the lockdowns resulting in a dramatic decline in employment, income, and consumer spending, (2) a negative effect on financial markets resulting in a negative wealth effect reducing consumer spending, and (3) a disruption of the global supply chain.

In the United States, the negative consequences of the initial economic shock to wealth, employment, income, and consumer spending were severe. U.S. unemployment was 3.5% in February of 2020, rising dramatically to 14.9% in April 2020, and then declining to 5.0% by September 2020 due to government intervention (see footnote 7). The rapid injection of government spending dissipated the negative demand shock to household income and consumer spending (Romer, 2021). However, supply chain disruptions lingered well into 2022.[12]

The COVID economic disruptions to the beef industry supply chain have been widely discussed in the literature. The economic lockdown and subsequent widespread outbreak of COVID illness amongst the meatpacking industry's workforce resulted in persistent beef supply chain disruptions (e.g., Giri et al., 2021). The consequences of plant shutdowns resulted in market disruptions all along the beef supply chain. Beef product shortages at the retail level resulted in panicked buying by consumers and increased retail price volatility. Simultaneously, fed cattle producers were unable to deliver finished cattle because of plant shutdowns. As a result, excessive inventories of finished cattle lingered in feedlots waiting for plants to reopen. In turn, feeder cattle from cow/calf operations were unable to enter feedlots and were forced to remain on farms (Peel, 2021). Beef prices and price volatility along the supply chain increased due to demand exceeding the supply for fresh/processed beef products, as household income recovered because of government COVID relief funding (Romer, 2021).

1.2 | Carcass quality-grade premiums and discounts

The value based market system (VBMS) for fed cattle production and marketing has been widely promoted by the beef industry and broadly adopted by fed cattle producers. The VBMS can trace its origins back to the late 1980s. According to the literature, the beef industry's goal in the promotion of the VBMS is to increase the production of higher quality cattle, improve the efficiency of lean meat production, reward producers for high quality cattle, and increase the competitive position of beef products relative to pork and poultry (e.g., Fausti, Diersen et al., 2010).

The premium and discount structure that determines the carcass quality component of the price paid for fed cattle is commonly referred to as the grid pricing system (Johnson & Ward, 2006; McDonald & Schroeder, 2003). The grid pricing system is a reward and penalty mechanism for carcass quality attributes (see footnote 3). The literature indicates that carcass quality-grade is an important factor in the determination of the quality component of the price paid for finished cattle sold on a grid (e.g., Anderson & Zeuli, 2001; Fausti et al., 2014; Hogan & Ward, 2005). The literature indicates the choice/select discount has been empirically shown to be a significant variable in determining the market price of fed cattle.

A fed cattle producer's management decision to embrace VBMS practices is a long-run strategic decision. USDA market reporting data suggests that producers have embraced VBMS. Examining USDA market reports (USDA, 2023a) for the weekly percentage of carcasses grading choice or prime, a significant change has occurred over the last 20 years. In 2002 the average percentage of

[11] In March and April of 2009, the choice/select discount was consistently less than $2.00, ranging from $1.60 to $.93. On average, the differential between choice and select carcass narrowed by 46.7% during the recession relative to the pre-recession period.

[12] Labonte and Weinstock (2022) provide an excellent discussion of direct and indirect effects of the COVID shock to the U.S. economy within an aggregate demand/aggregate supply framework. They trace out the impacts of COVID and government pandemic funding on employment, spending, and income within a traditional macroeconomic theoretical framework.

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weekly USDA graded beef carcasses grading choice was 58.5% and for prime 3.8%. In 2019, the average weekly percentage grading choice was 73.3%, and for prime 8.9%.

A producer's ability to react to random macroeconomic shocks having a negative effect on the beef market, however, is limited. The adoption of VBMS, however, requires producers to accept the financial risk of selling on a grid. Thus, the introduction of systematic risk associated with random macroeconomic shocks and their potential to negatively affect premiums add another layer of financial risk associated with carcass quality as average quality increases.

1.3 | Data and empirical methodology

1.3.1 | Data sources

A United States Department of Agriculture (USDA-AMS) market report, (LM_CT 169), provides weekly beef carcass quality-grade premiums and discounts for the choice/select discount and the prime premium.[13] Data were collected for the pre-Great recession period (10-27-03) to the end of the Great recession (07-06-09). The National Bureau of Economic Research (NBER) officially determines the length of economic contractions in the U.S., and the data is reported by the Bureau of Labor Statistics (U.S. Bureau of Labor Statistics, 2023b). Data were also collected for the COVID pandemic period. The pre-COVID time interval is from January 2016 to February 2020. The COVID pandemic time interval is from March 2020 until February 20, 2023).[14] The dating of the pandemic period is based on Center for Disease Control (CDC) dating of the COVID waves effecting the U.S. population. During the time interval from January 2020 to May, 2023, the CDC determined the U.S. experienced six major waves that resulted in significant increases in positive cases, hospitalizations, and deaths. Examining CDC data, the first wave began in March 2020 and the sixth wave ended in February 2023 (https://covid.cdc.gov/covid-data-tracker/#trends_weeklydeaths_testpositivity_00).

A four-year length for the pre-shock time intervals is selected to ensure the pre-shock periods capture representative premium behavior prior to the shock. Given that eleven years separate the end of the Great Recession and the beginning of the COVID pandemic, the premium data collected are deflated using the Producer Price Index for slaughter cattle published by the Bureau of Labor Statistics (U.S. Bureau of Labor Statistics, 2023b) to remove any inflation distortions.[15]

The weekly grid premium and discount data provide the intra-weekly average premium and intra-weekly statistical range for the choice/select discount and quality-grade premium for beef carcasses. With respect to the choice/select discount, this reported premium is the discounted value of a quality-grade select carcass relative to a quality-grade choice carcass. This value is reported as a negative dollar value. To simplify the discussion, we convert the reported choice/select discount to a positive value. Therefore, the choice/select discount now reflects the premium for a quality-grade choice carcass relative to a quality-grade select carcass.

1.4 | Empirical framework

An empirical framework developed by Fausti, Qasmi et al. (2010), defines the grid premium and discount reporting requirements at the plant level with respect to premium reporting by meatpacking firms within the MPR regulatory structure is adopted. Paraphrasing Fausti et al., it is assumed there are m firms in the beef packing industry. Assume that Xijt denotes firm i's weekly (t) reporting of grid premiums for its j^{th} plant, assuming n plants. For each grid premium category, the reported carcass quality-grade premium intra-weekly mean (μ_t), and premium intra-weekly extreme values for the industry are defined as:

$$\mu_t = (m*n)^{-1} \sum_{i=1}^{m} \sum_{j=1}^{n} X_{ijt}, \tag{1}$$

$$X_t^{max} = maxX_{ijt}, \tag{2}$$

$$X_t^{min} = minX_{ijt}. \tag{3}$$

[13] The premium and discount data are collected by the USDA-Agricultural Marketing Services (link: https://www.ams.usda.gov/rules-regulations/mmr/lmr/background). Summary statistical tables are provided in appendix.

[14] The COVID pandemic interval is based on weekly case count data obtained from the CDC (March 2020 thru February 2023). The COVID economic contraction began in March 2020. The pandemic was declared over on May 11, 2023 (https://archive.cdc.gov/#/details?url=https://www.cdc.gov/coronavirus/2019-ncov/your-health/end-of-phe.html).

[15] Given the relationship between the market value of a finished steer and the choice/select discount, we concluded that the BLS PPI index for slaughter cattle (base year 1982) is the most appropriate inflation index for converting carcass quality-grade premiums from nominal to real values. To support this assumption, using our data sample, we ran a simple correlation analysis using the choice premium and USDA estimate for Box Beef Cutout value based on a 1000-pound choice Kansas steer carcass. The Pearson correlation estimate is .49. The relatively high correlation value suggests that there is a statistically significant relationship between the choice premium and the market value of a choice steer carcass. Data downloaded from Livestock Marketing Information Center (LMIC, 2023).

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As mentioned, the AMS, in its weekly report only provides the intra-weekly average premium and the statistical range ($R = X_t^{max} - X_t^{min}$) for the industry. Adopting the approach by Fausti, Qasmi et al. (2010), the statistical range is used to derive an approximation for the intra-weekly standard deviation associated with beef carcasses grading choice and grading prime. The proxy for the intra-weekly standard deviation is based on Chebyshev's (Theorem) Inequality (e.g., Walpole & Myers, 1985). Chebyshev's Theorem states that for a random variable X, the realization of X will be within "k" standard deviations of the mean of X. The probability of the realization of X falling within "k" standard deviations (σ) of the mean (μ) is:

$$P(\mu - k\sigma < X < \mu + k\sigma) \geq 1 - \frac{1}{k^2}. \quad (4)$$

If the premium data are non-normal, then Chebyshev's Theorem indicates that a "k" value of six will result in a probability of .97 (Hozo et al., 2005). The selected proxy for the intra-weekly standard deviation is the statistical range divided by six:

$$\sigma_t = \frac{X_t^{max} - X_t^{min}}{6}. \quad (5)$$

The third variable of interest in the current discussion is the intra-weekly coefficient of variation (COV). The COV provides a measure of relative variation. The COV is defined as the ratio of the standard deviation divided by the mean for the industry:

$$COV_t = \frac{\sigma_t}{\mu_t}. \quad (6)$$

1.5 | Statistical methodology

The variables of interest for beef carcass quality-grade premiums are the intra-weekly first and second moment point estimators, and the intra-weekly COV point estimator. Premiums for both choice and prime are adjusted for inflation. Hypotheses tests will determine if there is statistical evidence of a difference in levels (central tendency) of the variables of interest resulting from the effect of the two macroeconomic shocks discussed above.

To accomplish this task, the behavior of (carcass quality-grade) premiums during the economic shock periods will be compared to their behavior for a four-year period preceding each shock. Data diagnostics were performed on the variables of interest (SAS Institute Inc., 2018). Normality tests indicated that all variables of interest failed the normality test.[16] As a result, nonparametric tests were selected to determine if there is significant (statistical) evidence that a variable of interest's location or central tendency parameter (e.g., mean, median) was affected by a macroeconomic shock. Many of the popular nonparametric procedures perform a test for changes in location (point estimator) across independent random samples with symmetric distributions. Thus, the only difference between the two samples is location.[17]

In this study, we tested the symmetry assumption of the pre-shock and shock periods to determine if the Wilcoxon Two-Sample test was appropriate for assessing differences in location parameters between two random samples. Unfortunately, all variables of interest associated with the Great Recession and COVID periods failed the symmetry test.[18] If the symmetry assumption is violated, Rosenkranz (2010) recommends reporting the median differential between the two samples (pp. 165–166). Therefore, we relied upon the Median test (Daniel, 1978, p. 76) to determine if there are differences in parameter locations for two independent samples and report the median differentials in Tables 1, 2, and 3.[19] Pre-shock and shock period weekly data provide the intra-weekly average premium, the intra-weekly standard deviation of the premium, and the intra-weekly COV of the premium. The mean and median location parameters of central tendency for each of these three variables of interest are estimated as inter-weekly first moment statistics. The mean and median inter-weekly standard deviation point estimators represent the estimated central tendency of intra-weekly premium volatility. The mean and median of inter-weekly COV point estimators represent the estimated central tendency of intra-weekly relative volatility. Both the standard deviation and the COV are standard measures of financial risk.

[16] The SAS proc univariate procedure was selected for normality testing. Normality tests were conducted on the pre-shock and shock periods.

[17] An example of a popular nonparametric test is the Wilcoxon Two-Sample (rank sum) Test (Walpole & Myers, 1985, p. 540). The limiting assumption is that the Wilcoxon Scores associated with the two independent samples are symmetric.

[18] Rosenkranz (2010: p. 165) suggest one should evaluate the median plots of the two independent samples to determine if the Wilcoxon Scores distribution is symmetrically distributed with respect to the median score to verify the robustness of the statistic. We evaluated the Wilcoxon Scores symmetry assumption.

[19] Wilcoxon hypothesis test statistics (unreported) corroborate the Median test results repoted in Tables 1 and 2. In Table 3, (Covid Recession vs. Covid Supply Chain results) the Wilcoxon test results indicated no statistical difference in in median values for the Choice CV hypothesis test vs. the Median test result indicating the median differential is significant at the 10% level.

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TABLE 1 Non-parametric results for great recession dataset† (October 2003 until July 2009).

Obs.	Recession = 1	Variable	Median	Mean	Symmetry	Median *P*-value	Median differential†
219	0	PrimeAvg	12.08	11.44	No	$P < .01$	2.57
78	1	PrimeAvg	9.51	9.74	Yes		
219	0	PrimeSD	3.04	2.82	No	$P < .01$	.54
78	1	PrimeSD	2.5	1.92	No		
219	0	PrimeCV	.24	.24	Yes	$P = .019$	.03
78	1	PrimeCV	.21	.19	No		
219	0	ChoiceAvg	7.62	7.97	No	$P < .01$	3.63
78	1	ChoiceAvg	3.99	3.96	Yes		
219	0	ChoiceSD	.47	.48	Yes	$P = .45$	.05
78	1	ChoiceSD	.42	.47	No		
219	0	ChoiceCV	.057	.07	Yes	$P < .01$	−.058
78	1	ChoiceCV	.115	.16	No		

†Data reflect premiums and premium dispersion differential estimates.

TABLE 2 Non-parametric results for COVID data set† (January 2016 until February 2023).

Obs.	COVID = 1	Variable	Median	Mean	Symmetry	Median *P*-value	Median differential†
217	0	PrimeAvg	7.73	8.18	No	$P < .01$	−.88
156	1	PrimeAvg	8.61	9.50	Yes		
217	0	PrimeSD	.85	1.11	No	$P < .01$	−1.56
156	1	PrimeSD	2.41	2.90	No		
217	0	PrimeCV	.117	.128	Yes	$P < .01$	−.168
156	1	PrimeCV	.285	.28	No		
217	0	ChoiceAvg	5.95	6.93	No	$P < .01$	−3.19
156	1	ChoiceAvg	9.14	9.11	Yes		
217	0	ChoiceSD	.486	.51	Yes	$P < .01$	−.344
156	1	ChoiceSD	.83	.894	No		
217	0	ChoiceCV	.071	.104	No	$P < .01$	−.025
156	1	ChoiceCV	.096	.104	Yes		

†Data reflect premiums and premium dispersion differential estimates.

The hypotheses tested focus on the inter-weekly median point estimator and test for equality across periods for each variable of interest. The variables are defined as follows: (a) PrimeAvg is the intra-weekly average premium for Prime, (b) ChoiceAvg is the intra-weekly average premium for Choice, (c) PrimeSD is the intra-weekly standard deviation for Prime, (d) ChoiceSD is the intra-weekly standard deviation for Choice, (e) PrimeCOV is the intra-weekly coefficient of variation for Prime, and (f) ChoiceCOV is the intra-weekly coefficient of variation for Choice.

The hypotheses tests are identical for each of the variables of interest: PrimeAvg, PrimeSD, PrimeCOV, ChoiceAvg, ChoiceSD, ChoiceCOV.

The null hypothesis is:

$$H_0: \ Median_{Shock} = Median_{preshock} \ vs. \qquad (7)$$

$$H_1: \ Median_{Shock} \neq Median_{preshock}$$

2 | RESULTS AND DISCUSSION

Tables 1 and 2 provide the non-parametric hypothesis test results for the Great Recession and the COVID periods, respectively. Based on the results of the median test, the null hypothesis of equality between pre-shock and shock period is rejected at the 2% level or lower for all

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The Journal of the International Association of Agricultural Economists

TABLE 3 Non-parametric results for location statistics for pre-COVID and COVID pandemic sub-periods.[†]

Obs. Wks.	Contraction = 1 supply shock = 2 pre-COVID = 3	Variable	Median	Mean	Median differential (3-1)[‡]	Median differential (3-2)[‡]	Median differential (2-1)[‡]
9	1	PrimeAvg	6.21	5.84	1.52***	−1.02***	2.54***
147	2	PrimeAvg	8.75	9.72			
217	3	PrimeAvg	7.73	8.18			
9	1	PrimeSD	.507	.52	.343**	−1.68***	2.023***
147	2	PrimeSD	2.53	3.05			
217	3	PrimeSD	.85	1.11			
9	1	PrimeCV	.079	.094	.039*	−.171***	.21***
147	2	PrimeCV	.289	.291			
217	3	PrimeCV	.118	.128			
9	1	ChoiceAvg	6.9	5.73	−.95	−3.52***	2.57***
147	2	ChoiceAvg	9.47	9.32			
217	3	ChoiceAvg	5.95	6.93			
9	1	ChoiceSD	.523	.469	−.043	−.45***	.407***
147	2	ChoiceSD	.93	.92			
217	3	ChoiceSD	.48	.51			
9	1	ChoiceCV	.083	.086	−.012	−.028***	.016*
147	2	ChoiceCV	.099	.106			
217	3	ChoiceCV	.071	.104			

[†]Data reflect premiums and premium dispersion differential estimates for the Pre-COVID, COVID-Contraction, and COVID supply shock time-intervals.
[‡]Median Two-Sample test for location. Significance level notation: *** indicates *P*-value < .01, ** indicates *P*-value < .5, * indicates *P*-value < .10.

variables associated with the Great Recession case except for ChoiceSD (choice standard deviation) (see Table 1). For the COVID case, the null hypothesis is rejected for all variables of interest (*P*-value < .01: see Table 2).

2.1 | The effect of the great recession on premiums

In Table 1, a review of the reported statistical results indicates that a negative aggregate demand shock that severely affects employment, income, and consumer household expenditures lowers choice and prime premium levels and premium volatility relative to the pre-shock period. The empirical evidence, however, is mixed with respect to the risk to return tradeoff (COV) for producers. For producers selling quality-grade choice cattle, uncertainty per dollar of premium increased during the Great Recession, but COV declined slightly for producers selling prime cattle.

A comparison of the prime median point estimator relative to the choice median point estimator for volatility measures (SD and COV) indicates that uncertainty was significantly higher during the 2003–09 period irrespective of the business cycle stage (economic expansion prior to the Great Recession verses economic contraction during the Great Recession) for prime carcasses.[20] This suggests that aligning production management strategies to maximize the production of cattle grading prime incurred greater absolute and relative financial risk irrespective of the stage in the business cycle during this period. This pattern is also present in the COVID data.

Focusing on choice premiums, statistical test results in Table 1 indicate that the median-point estimator for the premium level declined during the Great Recession, that is, 3.99 versus 7.62. Conversely, the point estimator for relative volatility increased (.115 vs. .057). This latter result indicates that the choice premium's risk to return tradeoff increased during the recession. In the pre-recession period, for every $1.00 in the choice premium, producers accepted a level of premium dispersion of $.057. During the Great Recession the risk to return tradeoff doubled to $.115 for every dollar of premium.

The effect of the Great Recession on prime premium behavior mostly mirrored that of the choice premium. That is, a significant decline occurred in the median point estimators for the prime premium and premium volatility relative to the pre-shock period during the Great

[20] Pre-recession point estimator comparison (Table 1): PrimeSD> ChoiceSD, and PrimeCV>ChoiceCV. Recession point estimator comparison (Table 1): PrimeSD>ChoiceSD, and PrimeCV>ChoiceCV.

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Recession. However, the prime premium's COV also declined. Table 1 indicates that during the pre-recession period, for every $1.00 in the prime premium, producers accepted a level of premium dispersion of $.24. However, during the Great Recession the risk to return tradeoff improved to $.21 for every dollar of premium. Thus, producers selling quality-grade prime cattle experienced lower volatility per dollar of premium when marketing prime cattle during the Great Recession relative to the pre-recession period.

2.2 | The effect of the COVID pandemic on premiums

In Table 2, the mean and median estimators from the statistical metrics of the prime and choice premiums data are provided for the pre-COVID period ($N = 217$) and the COVID period ($N = 156$). Statistical analysis indicates that for prime carcasses, the premium level, the premium volatility, and the premium relative volatility increased during the COVID pandemic relative to the pre-COVID period: that is, 8.61 versus 7.73, 2.41 versus .85 and .285 versus .117, respectively. Producers selling prime cattle in the market benefited from higher premiums but faced greater premium risk (absolute and relative). From Table 2, the relative risk point-estimators indicate that in the pre-COVID period for every $1.00 in the prime premium, producers accepted a level of premium dispersion of $.117. During the COVID period, however, relative volatility increased to $.285, indicating the risk to return tradeoff for every dollar of premium more than doubled during the COVID period.

In Table 2, for choice carcasses sold during the pandemic relative to the pre-pandemic period, producers encountered increased premium levels, premium volatility, and relative volatility: that is, 9.14 versus 5.95, .83 versus .486, .096 versus .071, respectively. The relative risk results indicate that in the pre-COVID period for every $1.00 in the choice premium, producers had to accept a level of premium dispersion of $.071. During the COVID period the risk to return tradeoff increased to $.096 for every dollar of premium.

Discussion of the COVID economic shock would be incomplete without acknowledging and examining how the unique economic circumstances associated with the COVID pandemic effected carcass premiums.[21] As discussed earlier, the COVID economic shock encompassed a severe economic contraction lasting 2 months, followed by a protracted economy-wide supply shock due to a pandemic induced supply chain disruption.

Table 3 provides summary statistics for the period of economic contraction (U.S. Bureau of Labor Statistics, 2023b) during COVID ($N = 9$ weeks), the COVID period encompassing the supply chain constraint ($N = 147$ weeks), and the pre-COVID period ($N = 217$ weeks). The median (location) parameters highlight differences between the COVID subperiods, and each of these with respect to the pre-COVID period; that is, initial contractionary phase versus the supply chain constraint during the COVID period, and versus the pre-COVID time interval.

The first question addressed is if the COVID economic contractionary phase affected premium levels relative to the pre-COVID period. The median two sample test indicates that prime premium, prime standard deviation, and prime coefficient of variation were lower during the contractionary phase of COVID relative to the pre-COVID period; that is, 6.21 versus 7.73, .507 versus .85, and .079 versus .118, respectively. However, for the choice premium location variables, there is no statistical evidence of an effect (Table 3).

The next issue to be addressed is if the COVID supply chain constraint affected prime and choice location parameters relative to the pre-COVID period. Statistical evidence (Table 3) indicates that the prime and choice premium location parameters are higher during the supply shock time interval relative to the pre-COVID period. The last issue to be addressed is to determine if there is a difference between premium location parameters for the contractionary episode relative to the supply shock interval. Statistical results reported in Table 3 indicate that for the contractionary COVID interval the median point estimators were lower relative to their median values during the supply shock time interval. This implies that as macroeconomic conditions shifted from a contractionary phase to an expansionary phase, premiums and premium volatility reversed direction. However, this reversal in the premium and premium volatility trend did not alter the statistical results reported in Table 2.

One final note, when comparing summary statistics in Tables 1 and 3, the behavior of premium and premium volatility during the COVID contractionary period and the Great Recession were similar. This suggests, negative aggregate demand shocks reduce premium and premium volatility, but may increase relative volatility.[22] Evidence from the COVID period suggests that negative macroeconomic supply shocks increase premium levels, premium volatility, and relative volatility.

[21] We thank an anonymous referee for pointing this issue out.

[22] A caveat is necessary with this conclusion because the COVID contractionary phase is only 9 weeks.

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2.3 | Lessons from macroeconomic shocks: the U.S. beef industry

Evidence presented indicates that macroeconomic shocks associated with the Great Recession and COVID, in general, affected the beef industry negatively. With respect to fed cattle markets, macroeconomic shocks influenced price uncertainty associated with carcass quality-grade premiums. The literature and data discussed indicates that the key differences in how the beef market may react to the economic disruption is linked to: (a) how a macroeconomic shock affects aggregate demand and supply, and (b) the role of (government) fiscal policy to mitigate the impact of the shock on the economy.

The Great Recession resulted in a significant and prolonged decline in aggregate demand. As a result, household consumption expenditures deteriorated and income remained dampened well after the recession officially ended (see footnotes 8 and 9, respectively). While federal intervention increased social safety net expenditures, fiscal policy action was unable to reverse the decline in household income and household expenditures to pre-recession levels in a timely fashion. Government fiscal and monetary policy during this period focused on providing support to the financial sector of the economy and maintaining corporate financial stability (Blinder & Zandi, 2010). Fiscal policy decisions to support financial and industrial sectors of the economy relative to the household sector of the economy during this period contributed to the decline in the demand for beef that extended beyond the recessionary period. According to Tonsor et al. (2018, figure 3.4) beef demand only started a slow recovery process beginning in 2010, as employment, consumer income, and expenditures began to gradually recover after June of 2009.

Conversely, the COVID economic shock experience was very different. The pandemic resulted in a rapid shutdown of industrial supply chains across the U.S., leading to both a decline of aggregate supply and aggregate demand. Once again, the Federal government intervened with fiscal and monetary policy measures seeking to offset the ensuing recession. A key difference during the COVID pandemic compared to the Great Recession was the government's policy decision to provide income support to households through direct transfer of funds. As a result, household income and expenditures recovered quickly (footnotes 8 and 9), supporting a recovery in aggregate demand. Global and U.S. supply chain constraints, however, remained an issue.

The demand for beef initially declined in the spring of 2020 and then increased swiftly once household income and expenditures recovered by the summer of 2020 (Tonsor, 2023). Moreover, due to supply chain constraints confronting the industry (Peel, 2021), the beef sector was not able to fully respond to the increase in consumer demand. These conflicting economic forces affecting the beef industry increased the level of price volatility in the beef market. In turn, the level of volatility associated with beef carcass intra-weekly premiums rose dramatically. A beneficial lesson for the beef industry is that the selection of fiscal policy tools to combat declines in aggregate demand largely determines how the beef market responds to macroeconomic shock(s).

2.4 | Lessons from macroeconomic shocks: U.S. fed cattle producers

Empirical evidence indicates that macroeconomic shocks represent a systematic risk for the beef industry. For producers selling finished cattle, the type of macroeconomic shock, and the ensuing fiscal policy response, determines how premiums and discounts associated with carcass quality-grade will react to business cycle events.

The Great Recession was an aggregate demand shock that negatively affected consumer income and expenditures. As a result, retail choice beef demand declined. In the fed cattle market, producers experienced a $2.57/cwt (21.3%) decline in the median premium for prime carcasses and $3.63/cwt (47.6%) decline in the median premium for choice carcasses, relative to pre-shock premium levels (Table 1). Absolute volatility (SD) associated with quality-grade premiums also declined during the recessionary period. Relative volatility (COV) increased for producers selling choice cattle, but declined for producers selling prime cattle. However, when accounting for the full pre-recession and recession period together, the risk to return tradeoff was determined to be significantly higher for producers selling prime cattle relative to cattle grading choice.

Conversely, the COVID pandemic was an event that disrupted the U.S. supply chain at all levels of economic activity, and negatively affected consumer income and expenditures in the short-run. Nonetheless, in this (macroeconomic shock) situation, timely government fiscal policy intervention reversed the decline in employment (footnote 7), income (footnote 8) and household expenditures (footnote 9). As a result, retail choice beef demand initially declined in the spring of 2020 and then rebounded quickly during the summer of 2020 (Tonsor, 2023). In the fed cattle market during the COVID pandemic period, on average, producers experienced a $.88/cwt (11.4%) increase in the median premium of prime carcasses and a $3.19/cwt (53.6%) increase in the median premium of choice carcasses, relative to pre-shock premium levels (Table 2).

As anticipated given the prolonged supply (chain) shock compared to the rather brief demand (income) shock, absolute volatility (SD) associated with choice and prime premiums increased during the COVID pandemic. Rela-

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tive volatility (COV) increased for producers selling both choice and prime cattle. However, this risk to return trade-off was significantly higher for producers selling prime cattle relative to cattle grading choice in the pre-pandemic and pandemic periods.

The economic insights for producers when comparing the two macroeconomic shocks evaluated in this study provide a set of stylized facts germane to producers selling finished cattle:

1. Existing literature has established that fed cattle producers face idiosyncratic (e.g., feedlot management) risk associated with carcass quality-grade uncertainty.
2. Fed cattle producers face systematic (business cycle) risk associated with carcass quality-grade premium uncertainty.
3. Systematic relative-risk (COV), defined as the level of dispersion per dollar of premium for choice cattle was found to increase regardless of the origin of the macroeconomic shock (aggregate demand vs. aggregate supply).
4. The resulting carcass quality-grade premium level and the volatility (SD) of the premium are dependent on the origin of the macroeconomic shock and the fiscal policy response to the shock.
5. Empirical evidence gleaned from the Great Recession and the COVID pandemic periods suggest that; (a) negative aggregate demand shocks suppress premium and premium volatility levels, and (b) negative aggregate supply shocks increase premium and premium volatility levels.
6. Producers selling prime cattle in the market confront a higher level of absolute and relative premium volatility as compared to producers selling choice cattle, regardless of the stage in a business cycle (economic expansion vs. contraction).
7. Producers selling prime cattle in the market confront a higher level of absolute and relative premium volatility as compared to producers selling choice cattle, regardless of the nature or origin of a macroeconomic shock.

2.5 | Summary & conclusions

This study provides an overview of the economic consequences of the Great Recession and COVID pandemic on the U.S. economy, the remedial government policy applied, and their respective effects on the U.S. beef industry. The literature indicates that the characteristics and complexity of the two macroeconomic events, and the U.S. government's response to the shocks, elicited very different market responses along the beef supply chain.

Empirical evidence indicates that the type of macroeconomic shock influences how the beef market in general, and the fed cattle market in particular, will react to a negative macroeconomic shock and the ensuing effect it has on carcass quality-grade premiums. The reaction is dependent on whether the origin of the shock emanates from the demand-side or supply-side of the economy. The resulting severity of the shock transmitted to the beef industry and cattle markets is partially conditional on the type of fiscal policy measures that are taken to abate consumer economic hardship caused by a macroeconomic shock.

We conclude that macroeconomic shocks impact quality-grade premium levels, premium volatility, premium relative volatility. Thus, beef carcass quality-grade premiums are not only subject to idiosyncratic risk, such as swings in the seasonal demand for beef, but are also subject to systematic risk associated with business cycle fluctuations. In addition, government policy seems to have an indirect role in mitigating systematic risk associated with carcass quality-grade financial risk. *Empirical research is needed on this issue beyond our initial inquiry to gain insight into the economic implications of macroeconomic shocks for agricultural markets*.

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DATA APPENDIX AVAILABLE ONLINE

A data appendix to replicate the main results is available in the online version of this article. Please note: Wiley-Blackwell is not responsible for the content or functionality of any supporting information supplied by the authors. Any queries (other than missing material) should be directed to the corresponding author for the article

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