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Hay: A Hedonic Study

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HAY: A HEDONIC STUDY

by

Chester R. Broadbent

A plan B thesis submitted in partial fulfillment

of the requirements for the degree

of

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in

Agribusiness

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ABSTRACT

Hay: A Hedonic Study

by

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Utah State University, 2024

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Hedonic pricing theory suggests that the price of a product or service is influenced by the utility consumers garner from the various characteristics or attributes it possesses. Hay, as a commodity, exhibits numerous traits that contribute to its utility, catering to diverse end users. Consequently, the hay industry stands to benefit from a comprehensive analysis utilizing hedonic regression techniques. While previous hedonic hay studies have been conducted, often they have been limited in their scope and scale of analysis leaving room for a more expansive approach.

The attributes of hay affecting its price and usability are predominantly qualitative and were examined using hedonic regression to determine their impact on overall product pricing. The analysis revealed that factors such as year, location, seed type, crop variety, test quality, bale size, and shipping options significantly influence transaction prices. Notably, California and Texas commanded higher marginal prices compared to other western states, while 3-tie bales were identified as having the highest marginal impact when considering bale size. Certain grass varieties such as orchard, teff, and timothy were also identified as having comparatively high marginal impacts on price, with organic classification commanding a premium over conventional hay. Additionally, hay quality ranks were found to be positively, but not linearly corelated with price. Sellers offering delivery services received premiums over transactions conducted on a Free on Board (FOB) basis.

While this study offers comprehensive insights into the marginal values of hay attributes, certain limitations affect the overall generalizability and implications of the results. These limitations include a lack of consistently reported tonnage data per transaction as well as no data availability for the western states of Utah, Nevada, and Arizona. However, notwithstanding these limitations, the findings still offer valuable insights into the expansive and diverse hay industry.

(39 Pages)

PUBLIC ABSTRACT

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Hedonic price theory posits that the price of a product is influenced by the values consumers assign to its individual attributes. Hay is a versatile commodity with variation across several attributes helping to cater to diverse needs of consumers. A detailed analysis using hedonic regression techniques within hay pricing can help producers, stakeholders, and educators more fully understand the marginal values consumers place on diverse hay attributes. Previous studies focused on limited scopes within the hay industry or other sectors, allowing room for broader investigation. This study examines qualitative attributes impacting hay pricing, revealing significant influences from factors like location, seed type, and quality. Notably, California and Texas are found to command higher marginal prices relative to other western states, while certain hay varieties and smaller bale sizes are also identified as having higher comparative marginal value on average. Identification of the average marginal values of individual hay attributes offers valuable insights into the dynamic hay industry.

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Chester Broadbent

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Introduction

Assessing the value of commodities involves a complex interaction of quantitative and qualitative factors. Whether a manufactured good or a naturally occurring agricultural commodity, specific inherent values or quality traits contribute significantly to the product's overall desirability and economic value. However, these intangible attributes, such as the aroma of freshly baked bread or the tenderness of a prime cut of steak, are frequently left unquantified, creating a gap in our understanding of the true worth of the products we encounter daily.

Hedonic regression analysis is one method that seeks to define the implicit values of individual attributes within products. This analytical approach enables researchers to assign a monetary value to those qualitative attributes that might be overlooked using traditional valuation methods. (Goodman, 1998)

Applying hedonic regression is particularly compelling in the context of agricultural commodities with a myriad of qualitative attributes influencing their perceived value. One such commodity that displays this complexity is hay—an essential component of livestock nutrition and a significant element in the agricultural supply chain. Unlike many standardized goods, hay price is influenced by many factors, including but not limited to the state of origin, crop type, and quality after harvest. The challenge lies in analyzing these qualitative attributes and assigning economic value to them, which hedonic regression analysis is uniquely equipped to undertake.

This study aims to estimate the marginal values of the most significant attributes impacting hay prices, focusing strictly on hay type, packaging, location, and similar factors directly observed in the hay.

Literature Review

Regression analysis is a valuable tool for insights into the influences of various variables on specific outcomes. For instance, regression analysis can be applied to discern the key attributes and performance statistics that significantly contribute to an NBA player's overall salary. However, this methodology extends beyond sports, finding application in diverse fields to display meaningful insights.

In the agricultural sector, researchers have harnessed the capabilities of hedonic regression analysis specifically to discern the value associated with individual traits within a given product. This is evident in several studies, including one focusing on the cattle industry. The study titled "Transportation and Quality Adjusted Basis: Does the Law of One Price Hold for Feeder Cattle?" by Feuz et al. (2008) examines the impact of various cattle quality traits on market prices, investigating the validity of the law of one price in this context. This in-depth study of the cattle industry demonstrates that many qualitative traits drive price, including location. Hay, being a commodity that has many qualitative traits and locations it can be sourced from as well, would benefit from a similar analysis.

Another noteworthy study, "Hedonic Price Analysis of Used Tractors" by Feuz (2022), takes a closer look at tractors. This research delves into the qualities influencing the value of used tractors, with major items like brand, year, and power levels, including additional features like cabs, HVAC systems, 4x4 capability, and the number of hydraulic remote circuits. Regression analysis is employed to discern the individual impacts of these traits on the overall sale/auction prices, providing insights into consumer preferences within the used tractor market. The use of interaction terms here notably displayed that some related variables, such as cabs and HVAC systems, could be combined into one singular variable due to high correlation. It is hypothesized that the hay industry also has innate correlations, such as quality and bale size, and a similar method of testing for correlation and interactions will be employed.

Two other studies performed similar analyses using hedonic regression pertaining to the hay industry. "Factors Affecting Hay Prices at Auction: A Hedonic Analysis" by Peake et al. (2019) and “Determining Implicit Prices for Hay Quality and Bale Characteristics” by Rudstrom et al. (2004). Both studies analyze hay auctions in their respective states of Kentucky and Minnesota. They utilize hedonic regression analysis to dissect each hay lot based on various qualitative attributes. These attributes include bale size, bale weight, type (Alfalfa vs. non-alfalfa), Relative Feed Value (RFV), Total Digestible Nutrients (TDN), and lot size. Despite their limited geographical scope and timeframe, they both offer valuable insights into the factors driving hay prices. Both studies conclude that quality, measured in RFV, is a significant driver of hay price, and thus, we will include quality in this current analysis using USDA quality grades. The USDA categorizes hay according to quality using a ranking system from low quality (Utility) to high quality (Supreme). Additional details surrounding the USDA grading system can be found in the Appendix (Figure A1). The USDA grading system takes quantitative measurements, such as RFV, and uses them to categorize hay for easier organization and pricing. Within this current study, the bale size and crop type will be expanded further, adding to the limited literature on hedonic analyses of hay. The bale size attribute in this current study will be expanded to include more than small square bales and large rounds, as in Peake et al. (2019). This expansion of the bale size attribute should provide a more complete understanding of the effect that bale size has on the overall price. The crop type attribute will be similarly expanded beyond alfalfa and non-alfalfa, as in Rudstrom et al. (2004), to identify marginal values of other hay crop types.

In a final study "Alfalfa Hay Quality and Alternative Pricing Systems" conducted by Hopper, Peterson, and Burton Jr. (2004), a hedonic analysis similar to previous investigations on alfalfa hay was undertaken. The primary aim of this research was to identify how attributes inherent in alfalfa products auctioned in Wisconsin influence their respective prices. The study employed key explanatory variables within the hedonic model, including RFV, tonnage sold, and bale type, along with other pertinent values such as Crude Protein (CP), Acid Detergent Fiber (ADF), and Neutral Detergent Fiber (NDF). The authors expanded the bale type category in comparison to the Peake et al. (2019) hedonic hay study to three classifications: small square bales, large square bales, and large round bales. Results indicated that large round bales exhibited a reduction in price compared to both large and small square bales. This finding was attributed to the perceived inconvenience associated with the shipping and handling of round bales in contrast to square bales. The inclusion of the tons sold variable aimed to determine whether a discount or premium existed for larger lots at the auction. Interestingly, the study revealed that individuals were willing to pay premiums for larger lots, albeit at a decreasing rate. This trend underscored hay buyers' willingness to pay to secure an adequate quantity of feed to meet their requirements.

Hopper et al. (2004) explored the quality attribute through four distinct models. The first model, focusing on calculated RFV, employed a ranking system with six categories. The highest quality grade, "Prime," translated to a "Good" ranking on the current USDA scale, with qualifying RFV values exceeding 151. Subsequent ranks, ranging from 1 to 5, exhibited a decline in RFV value, with the lowest category, "5," having an RFV of less than 75. The authors found that individual quality grades had varying nonlinear effects on price underscoring the importance of including quality grade attributes within hay hedonic pricing models. In this current study we include quality grade through referencing the current prevailing USDA quality guidelines.

Seeing the value these prior studies have brought to their respective spheres, there is good reason to believe there will be additional information and value gained by utilizing hedonic regression analysis and expanding the scope of independent variables for this study of the hay industry. This study will encompass a larger geographic location and include additional attributes as explanatory variables to better understand the significant influences in the western hay market.

Data and Methods

At its core, hedonic price analysis is rooted in the concept that a product's price is a reflection of the utility derived from its individual attributes. Drawing from the neoclassical economic framework, this method assumes that consumers make rational decisions based on the perceived value of specific characteristics and that the market price is the result of these utility-maximizing decisions (Rosen, 1974).

The theoretical model employed in this analysis posits that the market price (Y_i) is a function of various product attributes ($X_{1i}, X_{2i}, \ldots, X_{ki}$), each with its own associated parameter ($\beta_1, \beta_2, \ldots, \beta_k$):

1) $$Y_i = \beta_0 + \beta_1 X_i + \beta_2 X_{2i} + \cdots + \beta_k X_{ki} + \varepsilon_i$$

The intercept term (β_0) captures the baseline value, while the coefficients ($\beta_1, \beta_2, \ldots \beta_k$) signify the marginal contributions of individual attributes to the overall market price. The error term (ε_i) accommodates unobserved factors, aligning with the theoretical assumption of rational decision-making.

Data for this study will be used from the USDA Direct Hay Report as of August 2023 (Hay Report-AMS). This dataset is composed of 70,652 total transaction observations in the raw data. There are numerous traits recorded per transaction that are used as explanatory variables for price. However, it is not a perfect dataset, with data for some western states unavailable and with other variables recorded inconsistently. While the majority of the hay transactions were listed with a per-ton price, there was a small minority of transactions listed as “Per-Bale.” Adjustments to “Per-Bale” transactions were made to include these observations within the current study. The adjustments assumed weights of bale sizes as follows: 2 tie bales= 75LBS, 3 tie bales= 95LBS, 3x3 Bales= 800LBS, 3x4 bales= 1300LBS, 4x4 Bales= 1900LBS, Round= 1600LBS. (Rudstrom, 2004), (Horse Riding Guide, 2021).

The initial regression equation estimated is specified as

2) $$Price_i = \alpha_0 + \beta_1 Year_i + \beta_2 Quality\ Rank_i + \beta_t \sum_{t=3}^{10} Location_i + \beta_{11} Organic_i + \beta_t \sum_{t=12}^{16} Bale\ Size_i + \beta_{17} Delivered_i + \beta_t \sum_{t=18}^{33} Crop_i + e_i$$

Where Year is a continuous linear trend variable from 2000 to 2023, $Location_i$ is a series of dummy variables corresponding to the state in which the hay was sold, $Organic$ is a dummy variable equal to 1 if the hay is certified organic and equal to 0 otherwise, $Crop_i$ is a series of dummy variables corresponding specific crop type of hay, $Quality\ Rank_i$ is a discrete continuous variable ranging from 1-9 corresponding to the various USDA quality grades, $Bale\ Size_i$ is a series of dummy variables corresponding to the bale size (e.g., small 2-tie, round, 3x4, etc.), $Delivered_i$ is a dummy variable equal to 1 if the price includes delivery and equal to 0 otherwise, and e_i is the random error term. The locations included in the series of state dummy variables include the Western region states of Texas, California, Colorado, Idaho, Montana, New Mexico, Oregon, Washington, and Wyoming[1]. The organic dummy variable will capture the effects of additional farming practices applied or omitted to qualify the crop as organic or conventional for different sale markets. The crop types included in the Crop dummy series are trimmed to include only pure crops, no crop mixes, as these are typically

[1] No data was present in the report regarding Utah, Arizona, or Nevada.

viewed as an inferior product vs. the crop being totally clean and of only itself. These crops will include the following:

Alfalfa, Bermuda Grass, Barley, Blue Grass, Brome Grass, Klein Grass, Millet, Oats, Orchard Grass, Prairie Grass, Rye Grass, Sorghum, Sudan Grass, Teff Grass, Timothy, Triticale, and Wheat.

There are numerous other varieties and mixes commonly sold on the domestic and international markets, yet for the purposes of the objectives of this study, all other crop types are omitted from this analysis. Straw transactions were also omitted due to residue crops differing from hay crops, and the USDA quality guidelines do not list straw as a category. Quality Rank variable converts the USDA ranking to a numeric ranking from 1-9, where "1" corresponds to Utility and "9" to Supreme. For this analysis, the Bale Size variable includes 2-tie small bales, 3-tie small bales, 3x3 medium square bales, 3x4 large square bales, 4x4 large square bales, and round bales. Again, many other packaging types are used and commonplace in different areas of the nation; however, the bale sizes selected for this analysis are perhaps the most common and can be found in both the domestic and international markets.

With these variables taken into consideration and relying on previous knowledge of the hay industry, a general hypothesis was made that most of these variables will be significant, with each category possessing individual attributes that will have both positive and negative impacts. For example, in the bale size category, with 3x4s being the omitted variable (reference or base category), bales smaller than this will have a positive impact, while larger bale sizes will have a negative effect on the per ton hay price. The following is the perceived ranking of importance of variable categories and their impact on the price from greatest to lowest:

Year, Location, Quality, Crop type, Bale size, Seed Type, Delivery vs F.O.B.

After appropriately cleaning the dataset to include only the variables mentioned above, the data used for the analysis dropped from a total of 70,652 observations to 29,984. Table 1 displays summary statistics for all the variables included in the data set. Additional summary statistics organized by state are found in the Appendix, Figures A3-3.3

Table 1: Summary Statistics

State		**Quality**	
CA	4.96%	Utility	0.28%
TX	76.00%	Utility/Fair	0.92%
WY	1.57%	Fair	5.57%
WA	1.64%	Fair/Good	3.46%
CO	2.86%	Good	22.14%
OR	2.79%	Good/Premium	5.87%
ID	1.19%	Premium	34.56%
NM	8.04%	Premium/Supreme	6.70%
MT	0.94%	Supreme	20.50%
Crop		**Bale Size**	
Alfalfa	88.66%	2 tie	43.56%
Timothy	0.92%	3 tie	3.71%
Bermuda	4.68%	3x3	2.64%
Millet	0.11%	3x4	11.73%
Rye Grass	0.11%	4x4	33.78%
Oat	0.40%	Round	4.57%
Prairie	0.55%		
Triticale	0.53%		
Barley	0.14%		
Wheat	1.06%	**Seed Type**	
Orchard	1.29%	Organic	0.77%
Sorghum	0.42%	Conventional	99.23%
Sudan	0.81%		
Teff	0.17%		
Bluegrass	0.01%	**Shipping**	
Brome grass	0.03%	Average of F.O.B	50.91%
Klein Grass	0.11%	Average of Delivered	49.09%

*Note: Number of observations = 29,984

The complete regression Equation with all variables included is as follows:

3) $Price_i = \alpha_0 + \beta_1 YEAR_i + \beta_2 Quality\ Rank_i + \beta_3 California_i + \beta_4 Colorado_i + \beta_5 Idaho_i + \beta_6 Montana_i + \beta_7 New\ Mexico_i + \beta_8 Oregon_i + \beta_9 Texas_i + \beta_{10} Washignton_i + \beta_{11} Organic_i + \beta_{12} 2\ Tie\ Small\ Bales_i + \beta_{13} 3\ Tie\ Small\ Bales_i + \beta_{14} 3x3\ Bales_i + \beta_{15} 4x4\ Bales_i + \beta_{16} Round\ Bales_i + \beta_{17} Delivered_i + \beta_{18} Timothy_i + \beta_{19} Bermuda_i + \beta_{20} Millet_i + \beta_{21} Rye\ Grass_i + \beta_{22} Oat_i + \beta_{23} Prarie_i + \beta_{24} Triticale_i + \beta_{25} Barley_i + \beta_{26} Sorghum_i + \beta_{27} Sudan_i + \beta_{28} Teff_i + \beta_{29} Bluegrass_i + \beta_{30} Bromegrass_i + \beta_{31} Kleingrass_i + \beta_{32} Orchardgrass_i + \beta_{33} Wheat_i + \varepsilon_i$

Conventional (as opposed to organic) 3x4-baled alfalfa hay produced in Wyoming and paid for F.O.B. are the reference categories omitted from the model to avoid the dummy variable trap. They are used as the reference for the other variables in their respective categories to identify either positive or negative value relative to the omitted reference. Stata software (StataCorp, 2023) is used to estimate the regression equation. The summary of results for equation 3 are displayed in Table 2.

TABLE 2: Initial Output Hedonic Hay Model

Variable	Coefficient	Std. err.	t	P>t
Year	8.946782	0.0757912	118.05	0
Quality Rank	11.24925	0.2056104	54.71	0
Location				
TX	41.63918	3.110696	13.39	0
CA	61.85079	3.20505	19.3	0
CO	26.94091	3.525689	7.64	0
ID	32.60092	4.189301	7.78	0
MT	49.91787	4.497423	11.1	0
NM	37.87541	3.083366	12.28	0
OR	40.25727	3.522817	11.43	0
WA	50.6348	3.890606	13.01	0
Seed Type				
Organic	28.99106	4.069361	7.12	0
Crop				
Bermuda	-34.92742	2.03382	-17.17	0
Millet	-22.39864	10.32467	-2.17	0.03
Rye Grass	-29.72296	10.27859	-2.89	0.004
Oat	-51.16064	5.460008	-9.37	0
Prairie Grass	-1.180118	4.859718	-0.24	0.808
Barley	-44.02124	9.30045	-4.73	0
Bluegrass	-169.1221	34.07149	-4.96	0
Brome Grass	8.750481	20.90479	0.42	0.676
Klein Grass	-102.7202	10.4129	-9.86	0
Timothy	22.75451	3.826575	5.95	0
Sorghum	-43.08563	5.711111	-7.54	0
Sudan	-59.72486	3.96822	-15.05	0
Teff	32.10887	8.353767	3.84	0
Orchard	57.95144	3.359251	17.25	0
Wheat	-42.4448	3.609818	-11.76	0
Triticale	-56.72752	4.850757	-11.69	0
Shipping				
Delivered	24.89757	0.7988475	31.17	0
Bale Size				
2 tie	14.91529	1.580694	9.44	0
3 tie	57.89582	2.214249	26.15	0
3x3	26.76192	2.548578	10.5	0
4x4	0.58169	1.656764	0.35	0.726
round	-57.3603	2.495359	-22.99	0
_cons	-17927.03	153.1866	-117.03	0

*Note Number of observations = 29,983, R^2 = 0.5696

For all the dummy variables, the values of the estimated coefficients are the added dollar value to the overall price of hay when a particular hay transaction possesses the trait corresponding to the dummy variable. These values represent either premiums or discounts expected from the base value (represented by the constant term) corresponding to 3x4 baled-conventional-alfalfa hay produced in Wyoming and paid for F.O.B. All variables are identified as being highly significant ($p<0.05$) other than Prairie Grass, Brome Grass, and 4x4 bale size. California, Orchard Grass, and 3-tie bales have the highest magnitude of coefficients, suggesting a large marginal effect for these attributes relative to the reference group. The only non-dummy variables were the Year, which has a positive linear effect of $8.95 each year, and the Quality Rank, which is a continuous scale ranging from 1-9. Each numerical increase in quality ranking is expected to result in an additional $11.24/ton.

After a review of this model, a few alterations are made before re-estimating a final model. First, we considered the continuous scale of the quality ranking variable. The continuous linear specification implicitly assumed a linear effect from moving from lower to higher quality rankings. However, there is no evidence to suggest that this assumption is correct, and it is likely that the effect of quality could be nonlinear moving from “Fair” to “Good” could be a different increase in value than when moving from “Premium” to “Supreme.” Thus, to allow for a nonlinear effect of quality, the quality-ranking variable is broken down into a series of dummy variables as in Hopper et al. (2004).

In addition to the Quality Rank dummies, the year variable is rescaled to range from 0-23 rather than from 2000-2023. This is done to readjust the constant term to a more intuitively understood value. Additionally, prices were converted to August 2023 real prices using the Consumer Price Index (CPI) (See APPENDIX, Figure A2), published by the Bureau of Labor Statistics (BLS), to hold constant the effects of inflation when estimating the yearly time trend variable. After the initial regression, a scatterplot of residuals with predicted values was generated to evaluate the model for heteroscedasticity. Upon generation of this scatterplot (found in APPENDIX, Figure A3), it was apparent, due to the pronounced cone shape demonstrating increased dispersion of predicted values with increasing hay prices, that the model was heteroskedastic. To adjust for this, robust standard errors were employed. Using robust standard errors is a suitable method to correct for heteroscedasticity when working with large sample sizes (Kaufman 2013). After making these changes, the regression equation is updated and estimated as:

4) $$Price_i = \alpha_0 + \beta_1 YEAR_i + \beta_2 California_i + \beta_3 Colorado_i + \beta_4 Idaho_i + \beta_5 Montana_i + \beta_6 New\ Mexico_i + \beta_7 Oregon_i + \beta_8 Texas_i + \beta_9 Washignton_i + \beta_{10} Organic_i + \beta_{11} 2\ Tie\ Small\ Bales_i + \beta_{12} 3\ Tie\ Small\ Bales_i + \beta_{13} 3x3\ Bales_i + \beta_{14} 4x4\ Bales_i + \beta_{15} Round\ Bales_i + \beta_{16} Delivered_i + \beta_{17} Timothy_i + \beta_{18} Bermuda_i + \beta_{19} Millet_i + \beta_{20} Rye\ Grass\ _i + \beta_{21} Oat_i + \beta_{22} Prarie_i + \beta_{23} Triticale_i + \beta_{24} Barley_i + \beta_{25} Sorghum_i + \beta_{26} Sudan_i + \beta_{27} Teff_i + \beta_{28} Bluegrass_i + \beta_{29} Bromegrass_i + \beta_{30} Kleingrass_i + \beta_{31} Orchardgrass_i + \beta_{32} Wheat_i + \beta_{38} Utility/Fair_i + \beta_{34} Fair_i + \beta_{35} Fair/Good_i + \beta_{36} Good_i + \beta_{37} Good/Premium_i + \beta_{38} Premium_i + \beta_{39} Premium/Supreme_i + \beta_{40} Supreme_i + \varepsilon_i$$

All the prior omitted references stayed the same, with the additional omitted variable of “Utility” in the quality category.

RESULTS

The summary of results for equation 4) are displayed in Table 3.

Table 3: Final Output Hedonic Hay Model

Variable	Coefficient	ROBUST std. err.	t	P>t
Years	5.418145	0.0645997	83.87	0
Location				
TX	68.04467	2.034651	33.44	0
CA	69.70949	2.556533	27.27	0
CO	24.77405	2.34239	10.58	0
ID	47.25797	3.534063	13.37	0
MT	61.25709	4.047301	15.14	0
NM	39.9871	2.455074	16.29	0
OR	40.12138	2.647101	15.16	0
WA	61.97467	3.639642	17.03	0
Seed Type				
Organic	27.18979	5.256013	5.17	0
Crop				
Timothy	16.59663	3.936681	4.22	0
Bermuda	-52.95946	2.165494	-24.46	0
Millet	-35.13978	7.120419	-4.94	0
Rye Grass	-25.41684	6.975563	-3.64	0
Oat	-51.28459	5.336833	-9.61	0
Prairie Grass	-10.89611	4.160872	-2.62	0.009
Triticale	-59.32026	3.619307	-16.39	0
Barley	-36.65066	4.709738	-7.78	0
Wheat	-56.43839	3.925864	-14.38	0
Orchard	47.341	3.56311	13.29	0
Sorghum	-55.85576	5.4959	-10.16	0
Sudan Grass	-58.08087	3.947162	-14.71	0
Teff	20.10674	10.60482	1.9	0.058
Bluegrass	-165.7977	49.81696	-3.33	0.001
Brome Grass	-3.064913	26.00012	-0.12	0.906
Klein Grass	-112.9071	11.58663	-9.74	0
Quality Rank				
Utility/Fair	31.62983	7.283298	4.34	0
Fair	36.55988	6.48138	5.64	0
Fair/good	44.31688	6.460633	6.86	0
Good	71.74905	6.37414	11.26	0
Good/premium	82.75537	6.351261	13.03	0
Premium	110.7892	6.367594	17.4	0
Premium/supreme	113.3078	6.457631	17.55	0
Supreme	125.3446	6.395513	19.6	0
Bale Size				
2 tie	32.40883	1.545945	20.96	0
3 tie	61.41956	2.603022	23.6	0
3x3	32.07921	2.387992	13.43	0
4x4	-7.544284	1.601626	-4.71	0
round	-64.09251	2.502108	-25.62	0
Shipping				
Delivered	28.17429	0.7214871	39.05	0
_cons	31.3241	6.633782	4.72	0

*Note: Number of Observations = 29,984, R^2= 0.5031

As was hypothesized, the magnitude of the change from the base quality of "Utility" to any other quality level differed by quality grade. By converting these values to dummy variables, this is better displayed. Interestingly, the quality rank "Supreme" had the highest coefficient value of $124.99/ton. This dethroned the prior highest coefficient value of $101.06 that "Supreme" had when multiplying the linear quality ranking value of $11.24 with the rank of "9," which represents "Supreme." Quite a significant difference in price impact! This new high is followed by "Premium/Supreme" at $115.63 and "Premium" at $112.05. Overall, these results display interesting impacts, where Teff Grass, Orchard Grass, and Timothy each had more value than the reference crop Alfalfa at $20.11, $47.34, and $16.60, respectively. This tells us that these 3 types of grass would demand these higher values on average if sourced from the same state, packaged in the same bale size, grown from the same seed type, transported using the same shipping type, possessing the same quality, and purchased the same year as alfalfa. Another interesting category is the location. Every state demands a higher price than a similar product sourced within the reference state of WY, with CA demanding the highest price premium based on location alone.

After this final Regression model was generated, a contrasting model was also employed to find the marginal effect of each variable and to make statistical inferences across all attributes. The summary of the contrasted marginal effects is contained within Table 4.

Table 4: Contrasting Model Output

Category	Margin	Std. err.	Unadjusted groups
Location			
TX	166.9573	4.762654	CD
CA	168.6221	5.124512	D
CO	123.6866	5.019092	
ID	146.1706	5.609413	B
MT	160.1697	6.08251	CD
NM	138.8997	5.029742	A
OR	139.034	5.006848	AB
WA	160.8873	5.624331	C
WY	98.91259	5.078347	
Crop			
Alfalfa	182.4489	3.066197	G
Timothy	199.0456	4.839355	H
Bermuda	129.4895	3.869341	BC
Millet	147.3092	7.839293	DE
Rye Grass	157.0321	7.685518	EF
Oat	131.1644	5.975886	BCD
Prairie Grass	171.5528	5.158113	F
Triticale	123.1287	4.757375	B
Barley	145.7983	5.651436	E
Wheat	126.0106	5.062213	B
Orchard	229.7899	4.703938	I
Sorghum	126.5932	6.376847	B
Sudan Grass	124.3681	4.764152	B
Teff	202.5557	11.02213	GH
Bluegrass	16.65121	49.86561	A
Brome Grass	179.384	26.15741	CDEFGHI
Klein Grass	69.54185	12.03009	A
Quality Rank			
Utility	76.32079	7.73418	
Utility/Fair	107.9506	6.073405	A
Fair	112.8807	4.879596	A
Fair/good	120.6377	5.122499	
Good	148.0698	4.700344	
Good/premium	159.0762	4.925567	
Premium	187.11	4.741011	B
Premium/supreme	189.6286	5.010697	B
Supreme	201.6654	4.828067	
Bale Size			
2 tie	168.1792	4.792629	A
3 tie	197.19	5.406762	
3x3	167.8496	5.202534	A
3x4	135.7704	4.843267	
4x4	128.2261	4.793906	
round	71.67788	4.929354	
Shipping			
F.O.B.	130.7284	4.727364	
Delivered	158.9027	4.781652	

For the most part, the individual variables each had their own effect, save for a few states, crop types, and qualities having similar effects at the 5% level. Variables with the same letter grouping within Table 4 are estimated to have statistically similar (P=0.05) effects on the price. As an example, Utility/Fair and Fair are estimated to have similar marginal effects (letter grouping "A"), which is unsurprising as both are very low on the USDA quality chart and sell for low quality feeder prices. The same case was found in the Premium and Premium/Supreme categories at the higher end of that quality rankings. The states with similar effects were interesting, noting how diverse the C and D groupings were. Not many similarities can be found within CA, TX, WA, and MT, as each has its own climate, water situation, elevation, and cost of living. Yet their marginal impact on hay prices is found to be statistically similar within the C and D groupings at the 5% level. Overall, this chart displays that bale size and quality rank variables are the most distinct, with only a few variables within these categories having statistically similar effects on the price of a hay transaction. Interestingly, though, many crop types had similar effects. After analyzing the results, annual grain-style hays, such as wheat, oats, triticale, etc., are grouped together, as well as some grasses that are typically aimed at horse owners such as Timothy, Brome, and Teff. (Staff, 2020)

Post-estimation, a check for multicollinearity among variables was performed through the calculation of a correlation matrix (see Appendix Figure A9). Using |.60| as the benchmark for checking correlation levels, most were well under and displayed weak or no correlation. Only three calculations were over |.60|, bermuda and alfalfa with -.61, real price and year at .62, and 4x4 and 2 tie at .62. Even these numbers do not indicate a very strong correlation, being just outside the check value. An interaction term model was also generated, interacting multiple variable combinations such as Bale Size x Quality, Location x Quality, etc. All these interaction combinations did not yield results that added any significant findings and, in turn, added unnecessary complication. This led to the decision that the non-interacted model was a better overall model for explaining the effects generated by each variable.

The economic principle of the law of one price, grounded in the assumption that prices in distinct markets do not significantly deviate beyond transportation and transaction costs (Tomek and Robinson, 1990), is generally acknowledged in agricultural commodity markets. However, the applicability of this law to the hay market is nuanced due to the heterogeneous nature of hay compared to more uniform commodity crops. This study delves into the diverse factors influencing hay prices, revealing variations across the hay sold. As illustrated in Table 4, states such as California, Texas, and Washington are anticipated to exhibit higher average hay prices compared to many other western states in the study. The elevated prices in these states may be attributed, in part, to their proximity to export markets, where demand from international exports, particularly to China, Japan, and South Korea, can drive prices upward. On the contrary, states like Colorado and Wyoming face logistical challenges, with large mountain ranges hindering westward shipping, leading to comparatively lower marginal values (Table 4). Despite these regional disparities, these states benefit from robust domestic hay markets, with major feedlots in eastern Colorado, midwestern dairies, prominent feed retailers, and sports arenas contributing to regional demand. While certain aspects of the law of one price are evident in the hay industry, the regression results for location values, including the lower value for Oregon sourced hay, underscore that factors beyond shipping costs play a significant role in determining hay prices across states.

One thing to consider for those who are producing hay is the quality vs. quantity tradeoff. Our results demonstrate that higher quality products demand premiums with every increase in quality rank. However, quality and yield are known to be inversely correlated (Kaatz, 2022). The potential lower yield output when targeting higher quality levels exposes growers to risks associated with harvest timing and post-harvest weather patterns. Growers could cut hay at the appropriate time to capture more nutrients and minimize the ADF and NDF values in the crop but then lose leaves due to dry baling conditions, rain damage in the windrow, or sun fade damage from letting the windrows or bales sit too long in the field. Also, there is no assurance that the hay quality will be maintained once it has been removed and stacked. Degradation of quality is made worse when not stored in a barn or tarped sufficiently for the elements. For some operations maximizing profit, the best method might entail letting the hay grow to a higher yield and lower quality, effectively maximizing the total tonnage produced at a lower relative quality.

CONCLUSION

In summary, this study utilized hedonic regression analysis to discern the influential factors shaping hay prices, ranking from most to least impactful: Quality, Location, Bale Size, Crop Type, Seed Type, Shipping, and Year. This differs slightly from the original hypothesis of Year, Location, Quality, Crop type, Bale size, Seed Type, Shipping. While these insights contribute to our understanding of the hay market, it is crucial to acknowledge and address the limitations inherent in the study.

Foremost among these limitations is the incomplete dataset, marked by the absence of Western hay-producing states—Utah, Arizona, and Nevada. Given these states' role in hay production and trade, their exclusion introduces a gap in regional variations, affecting the overall generalizability of the findings. Additionally, this study is limited by the absence of tons sold for each individual transaction, as past research has demonstrated the significance of lot tonnage within hedonic hay pricing models. While many of the transactions included a recorded tonnage variable, there were also numerous transactions that did not have this field filled in. As the data was cleaned in preparation for this analysis, 25,802 of the 29,984 observations used were identified as not having tonnage recorded. Without this included variable, we don't know the volume of hay products sold in each bale type, crop type, etc. While a state's percentage of transactions in certain bale size categories could be high, the actual volume (tonnage) of hay sold could be relatively low. As in the case of Texas having a higher percentage of 2-tie bales sold, the tonnage sold of this size could in fact be comparatively lower than the other bale sizes (Appendix A3).

Furthermore, the intentional focus on the Western United States limits the generalizability of the results to this region. Careful consideration is needed when interpreting and generalizing the findings, and future research should aim for a more comprehensive dataset. Extending the timeframe by incorporating data from earlier years and capturing more recent transactions in the fall and early winter could enhance the timeliness and relevance of the results. These limitations demonstrate the need for future endeavors to expand the dataset, incorporating additional states and years to create a more accurate and complete model.

In reflection, while this study provides valuable insights, it serves as a foundation for exploration of the factors influencing hay prices in the Western United States. Successive research should address these limitations to build a stronger analysis, increase confidence in the results, and create a deeper understanding of the hay industry.

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APPENDICES

Figure A1

USDA

Hay Quality Designation Guidelines
Agricultural Marketing Service
Livestock, Poultry, and Grain Market News

Alfalfa Guidelines (domestic livestock use and not more than 10% grass)

Quality	ADF	NDF	RFV	TDN-100%	TDN-90%	CP
Supreme	<27	<34	>185	>62	>55.9	>22
Premium	27-29	34-36	170-185	60.5-62	54.5-55.9	20-22
Good	29-32	36-40	150-170	58-60	52.5-54.5	18-20
Fair	32-35	40-44	130-150	56-58	50.5-52.5	16-18
Utility	>35	>44	<130	<56	<50.5	<16

Grass Hay Guidelines

Quality	Crude Protein Percent
Premium	Over 13
Good	9-13
Fair	5-9
Utility	Under 5

Figure A1: USDA Hay Quality Designation Guidelines

Source: Hay Quality Guidelines - Agricultural Marketing Service. (n.d.).

Figure A2

YEAR	CPI	% Change
2000	172.2	3.40%
2001	177.1	2.80%
2002	179.9	1.60%
2003	184	2.30%
2004	188.9	2.70%
2005	195.3	3.40%
2006	201.6	3.20%
2007	207.3	2.90%
2008	215.3	3.80%
2009	214.5	-0.40%
2010	218.1	1.60%
2011	224.9	3.20%
2012	229.6	2.10%
2013	233	1.50%
2014	236.7	1.60%
2015	237	0.10%
2016	240	1.30%
2017	245.1	2.10%
2018	251.1	2.40%
2019	255.7	1.80%
2020	258.8	1.20%
2021	271	4.70%
2022	292.7	8.00%
2023*	304.3	4.00%

Figure A2: CPI Chart for real price conversion

Figure A3.1

Wyoming

Crop		Quality	
Alfalfa	89.38%	Utility	1.06%
Timothy	1.06%	Utility/Fair	1.91%
Bermuda	0.00%	Fair	5.31%
Millet	0.00%	Fair/Good	7.64%
Rye Grass	0.85%	Good	34.61%
Oat	0.00%	Good/Premium	5.52%
Prairie	0.42%	Premium	40.76%
Triticale	0.21%	Premium/Supreme	0.64%
Barley	3.18%	Supreme	2.55%
Wheat	0.00%		
Orchard	3.40%	**Bale Size**	
Sorghum	0.00%	2 tie	21.66%
Sudan	0.00%	3 tie	15.50%
Teff	1.49%	3x3	4.03%
Bluegrass	0.00%	3x4	52.44%
Brome grass	0.00%	4x4	5.31%
Klein Grass	0.00%	Round	1.06%
Seed Type		**Shipping**	
Organic	0.0%	F.O.B	99.00%
Conventional	100.0%	Delivered	1.00%

California

Crop		Quality	
Alfalfa	75.98%	Utility	0.67%
Timothy	0.34%	Utility/Fair	3.43%
Bermuda	8.28%	Fair	3.57%
Millet	0.07%	Fair/Good	8.88%
Rye Grass	0.07%	Good	18.91%
Oat	1.08%	Good/Premium	10.57%
Prairie	1.21%	Premium	36.14%
Triticale	0.13%	Premium/Supreme	7.07%
Barley	0.07%	Supreme	11.00%
Wheat	2.22%		
Orchard	3.63%	**Bale Size**	
Sorghum	0.00%	2 tie	8.08%
Sudan	2.76%	3 tie	40.58%
Teff	1.82%	3x3	0.13%
Bluegrass	0.07%	3x4	49.13%
Brome grass	0.07%	4x4	2.09%
Klein Grass	2.22%	Round	0.00%
Seed Type		**Shipping**	
Organic	0.0%	F.O.B	84.59%
Conventional	100.0%	Delivered	15.41%

Texas

Crop		Quality	
Alfalfa	92.54%	Utility	0.07%
Timothy	0.00%	Utility/Fair	0.00%
Bermuda	5.41%	Fair	6.37%
Millet	0.14%	Fair/Good	1.43%
Rye Grass	0.12%	Good	25.59%
Oat	0.06%	Good/Premium	3.05%
Prairie	0.06%	Premium	36.36%
Triticale	0.17%	Premium/Supreme	1.39%
Barley	0.00%	Supreme	25.74%
Wheat	1.01%		
Orchard	0.00%	**Bale Size**	
Sorghum	0.50%	2 tie	50.27%
Sudan	0.00%	3 tie	0.00%
Teff	0.00%	3x3	0.01%
Bluegrass	0.00%	3x4	2.01%
Brome grass	0.00%	4x4	42.28%
Klein Grass	0.00%	Round	5.43%
Seed Type		**Shipping**	
Organic	0.0%	F.O.B	38.68%
Conventional	100.0%	Delivered	61.32%

Colorado

Crop		Quality	
Alfalfa	61.35%	Utility	1.05%
Timothy	8.27%	Utility/Fair	0.93%
Bermuda	0.00%	Fair	1.75%
Millet	0.12%	Fair/Good	3.96%
Rye Grass	0.00%	Good	12.92%
Oat	0.70%	Good/Premium	15.02%
Prairie	12.69%	Premium	47.96%
Triticale	1.75%	Premium/Supreme	13.27%
Barley	0.00%	Supreme	3.14%
Wheat	0.23%		
Orchard	10.13%	**Bale Size**	
Sorghum	1.16%	2 tie	34.34%
Sudan	2.10%	3 tie	6.75%
Teff	0.93%	3x3	22.93%
Bluegrass	0.00%	3x4	24.91%
Brome grass	0.58%	4x4	6.75%
Klein Grass	0.00%	Round	4.31%
Seed Type		**Shipping**	
Organic	1.51%	F.O.B	88.59%
Conventional	98.49%	Delivered	11.41%

Figure A3.1 Summary of Variables by State (continued)

Figure A3.2.

Idaho

Crop		Quality	
Alfalfa	89.11%	Utility	4.19%
Timothy	4.47%	Utility/Fair	24.02%
Bermuda	0.00%	Fair	2.23%
Millet	0.00%	Fair/Good	27.65%
Rye Grass	0.00%	Good	3.91%
Oat	1.40%	Good/Premium	15.92%
Prairie	1.40%	Premium	6.42%
Triticale	0.28%	Premium/Supreme	8.66%
Barley	0.00%	Supreme	6.98%
Wheat	0.00%		
Orchard	2.79%	**Bale Size**	
Sorghum	0.00%	2 tie	1.68%
Sudan	0.00%	3 tie	1.12%
Teff	0.00%	3x3	0.28%
Bluegrass	0.00%	3x4	90.50%
Brome grass	0.56%	4x4	4.75%
Klein Grass	0.00%	Round	1.68%
Seed Type		**Shipping**	
Organic	1.12%	F.O.B	90.78%
Conventional	98.88%	Delivered	9.22%

New Mexico

Crop		Quality	
Alfalfa	84.41%	Utility	0.00%
Timothy	0.00%	Utility/Fair	1.00%
Bermuda	1.99%	Fair	1.24%
Millet	0.00%	Fair/Good	8.58%
Rye Grass	0.00%	Good	1.41%
Oat	2.53%	Good/Premium	17.50%
Prairie	0.00%	Premium	13.23%
Triticale	1.37%	Premium/Supreme	57.05%
Barley	0.54%	Supreme	0.00%
Wheat	1.58%		
Orchard	0.00%	**Bale Size**	
Sorghum	0.04%	2 tie	28.69%
Sudan	7.55%	3 tie	4.52%
Teff	0.00%	3x3	22.76%
Bluegrass	0.00%	3x4	28.15%
Brome grass	0.00%	4x4	14.18%
Klein Grass	0.00%	Round	1.70%
Seed Type		**Shipping**	
Organic	5.31%	F.O.B	86.98%
Conventional	94.69%	Delivered	13.02%

Montana

Crop		Quality	
Alfalfa	83.99%	Utility	4.27%
Timothy	12.46%	Utility/Fair	2.14%
Bermuda	0.00%	Fair	14.59%
Millet	0.00%	Fair/Good	9.61%
Rye Grass	0.00%	Good	5.34%
Oat	0.00%	Good/Premium	38.08%
Prairie	0.71%	Premium	19.57%
Triticale	0.00%	Premium/Supreme	4.27%
Barley	0.00%	Supreme	2.14%
Wheat	1.07%		
Orchard	1.78%	**Bale Size**	
Sorghum	0.00%	2 tie	19.93%
Sudan	0.00%	3 tie	0.00%
Teff	0.00%	3x3	3.20%
Bluegrass	0.00%	3x4	58.72%
Brome grass	0.00%	4x4	2.49%
Klein Grass	0.00%	Round	15.66%
Seed Type		**Shipping**	
Organic	0.0%	F.O.B	100.0%
Conventional	100.0%	Delivered	0.0%

Oregon

Crop		Quality	
Alfalfa	57.66%	Utility	0.00%
Timothy	5.86%	Utility/Fair	0.00%
Bermuda	0.00%	Fair	4.31%
Millet	0.00%	Fair/Good	3.95%
Rye Grass	0.24%	Good	18.90%
Oat	1.79%	Good/Premium	11.12%
Prairie	1.44%	Premium	51.67%
Triticale	7.89%	Premium/Supreme	5.14%
Barley	1.44%	Supreme	4.90%
Wheat	1.32%		
Orchard	22.13%	**Bale Size**	
Sorghum	0.00%	2 tie	28.35%
Sudan	0.00%	3 tie	21.77%
Teff	0.24%	3x3	1.08%
Bluegrass	0.00%	3x4	48.09%
Brome grass	0.00%	4x4	0.60%
Klein Grass	0.00%	Round	0.12%
Seed Type		**Shipping**	
Organic	9.69%	F.O.B	99.64%
Conventional	90.31%	Delivered	0.36%

Figure A3.2 Summary of Variables by State (continued)
Figure A3.3

Washington			
Crop		**Quality**	
Alfalfa	70.33%	Utility	3.05%
Timothy	19.31%	Utility/Fair	18.70%
Bermuda	0.00%	Fair	1.83%
Millet	0.00%	Fair/Good	29.27%
Rye Grass	0.00%	Good	6.50%
Oat	0.61%	Good/Premium	14.84%
Prairie	0.81%	Premium	21.54%
Triticale	0.41%	Premium/Supreme	2.03%
Barley	0.00%	Supreme	2.24%
Wheat	0.00%		
Orchard	6.10%	**Bale Size**	
Sorghum	0.00%	2 tie	20.12%
Sudan	0.61%	3 tie	17.07%
Teff	1.42%	3x3	0.81%
Bluegrass	0.41%	3x4	60.16%
Brome grass	0.00%	4x4	1.83%
Klein Grass	0.00%	Round	0.00%
Seed Type		**Shipping**	
Organic	0.41%	F.O.B	87.20%
Conventional	99.59%	Delivered	12.80%

Figure A3.3 Summary of Variables by State (continued)

Figure A4

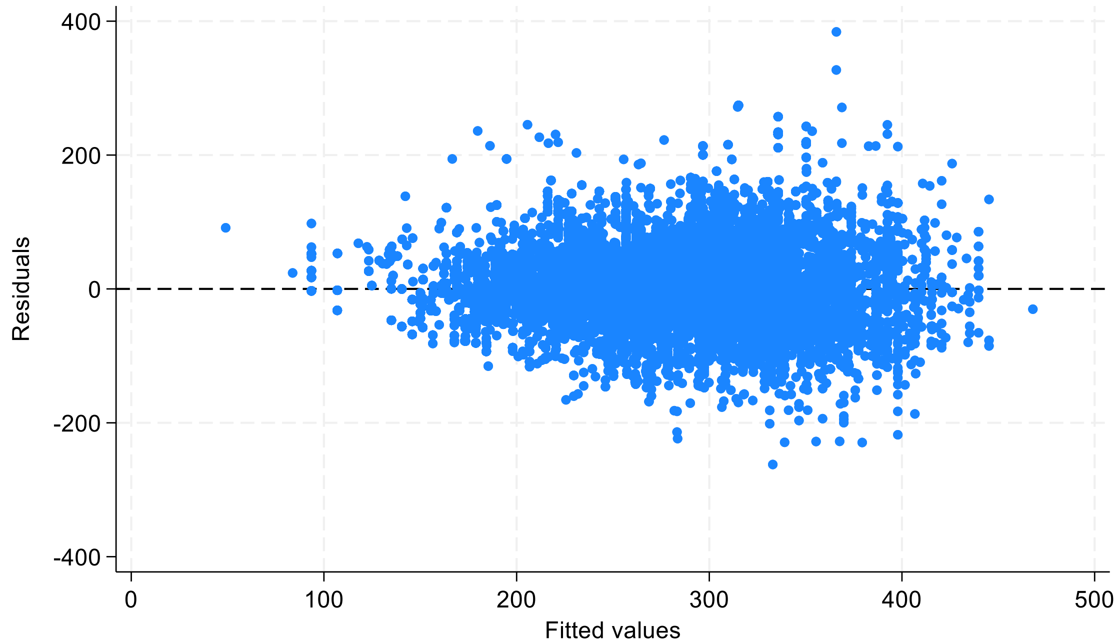

Figure A4: Heteroskedasticity scatter plot

Figure A5

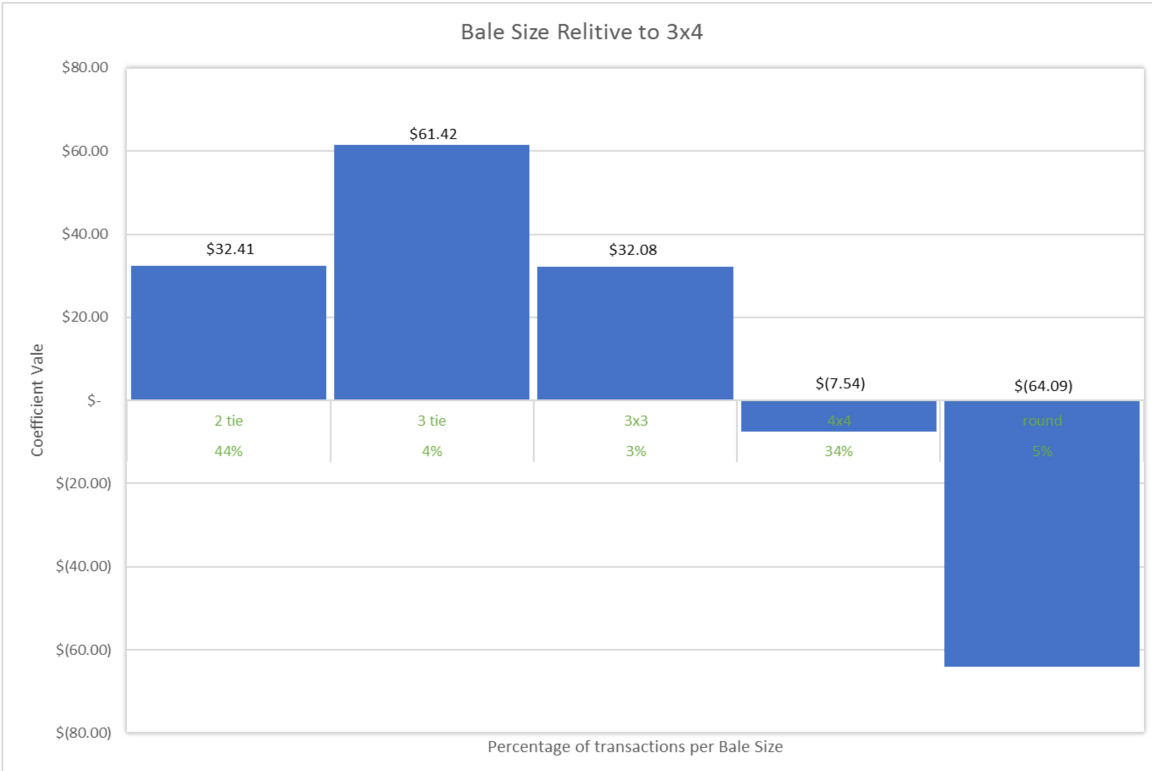

Figure A5: Chart of bale size coefficients

Figure A6

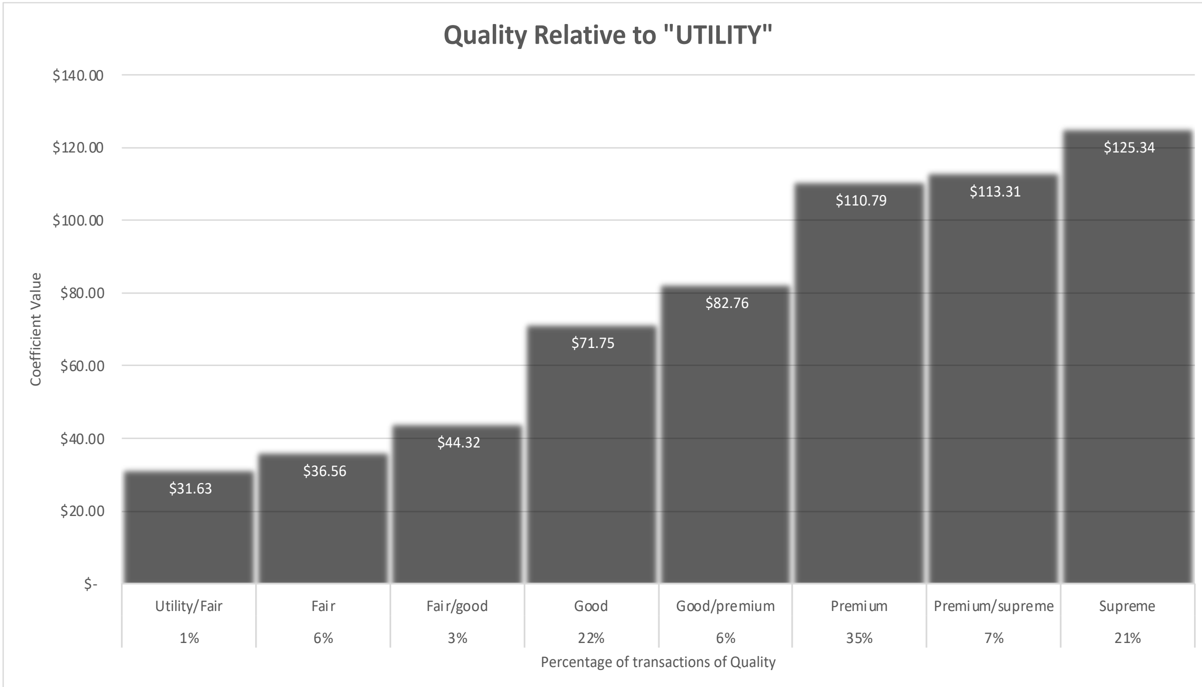

Figure A6: Chart of quality coefficients

Figure A7

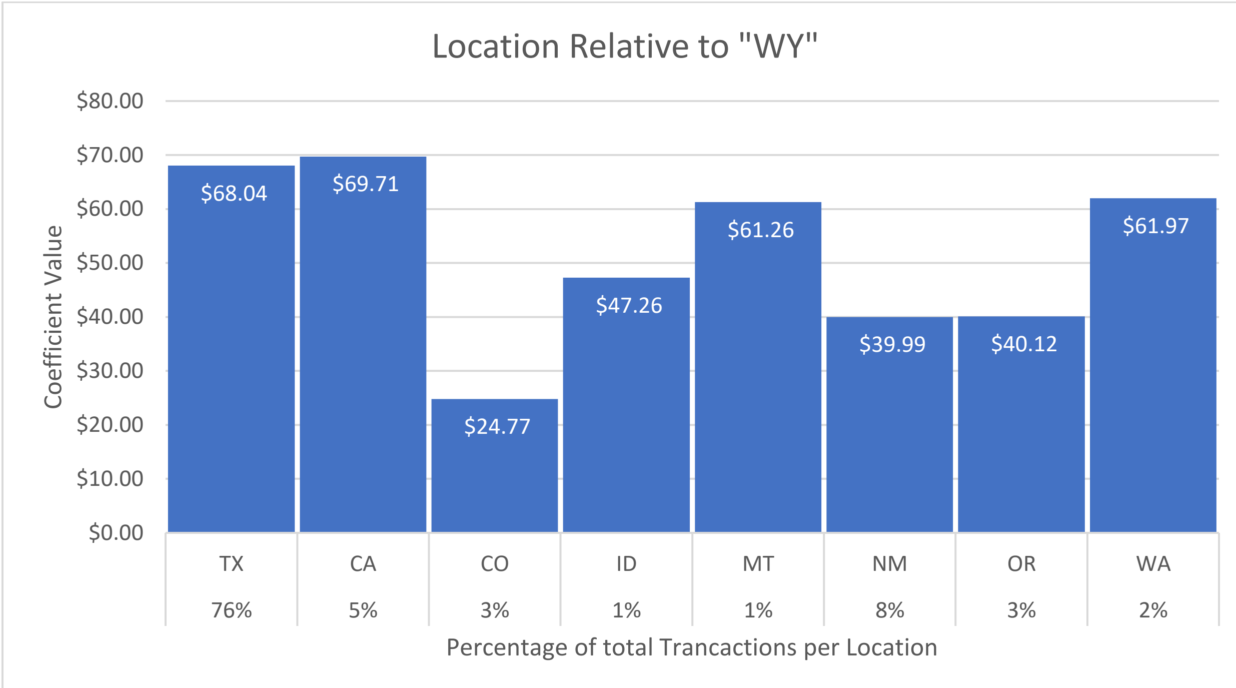

Figure A7: Chart of location coefficients

Figure A8

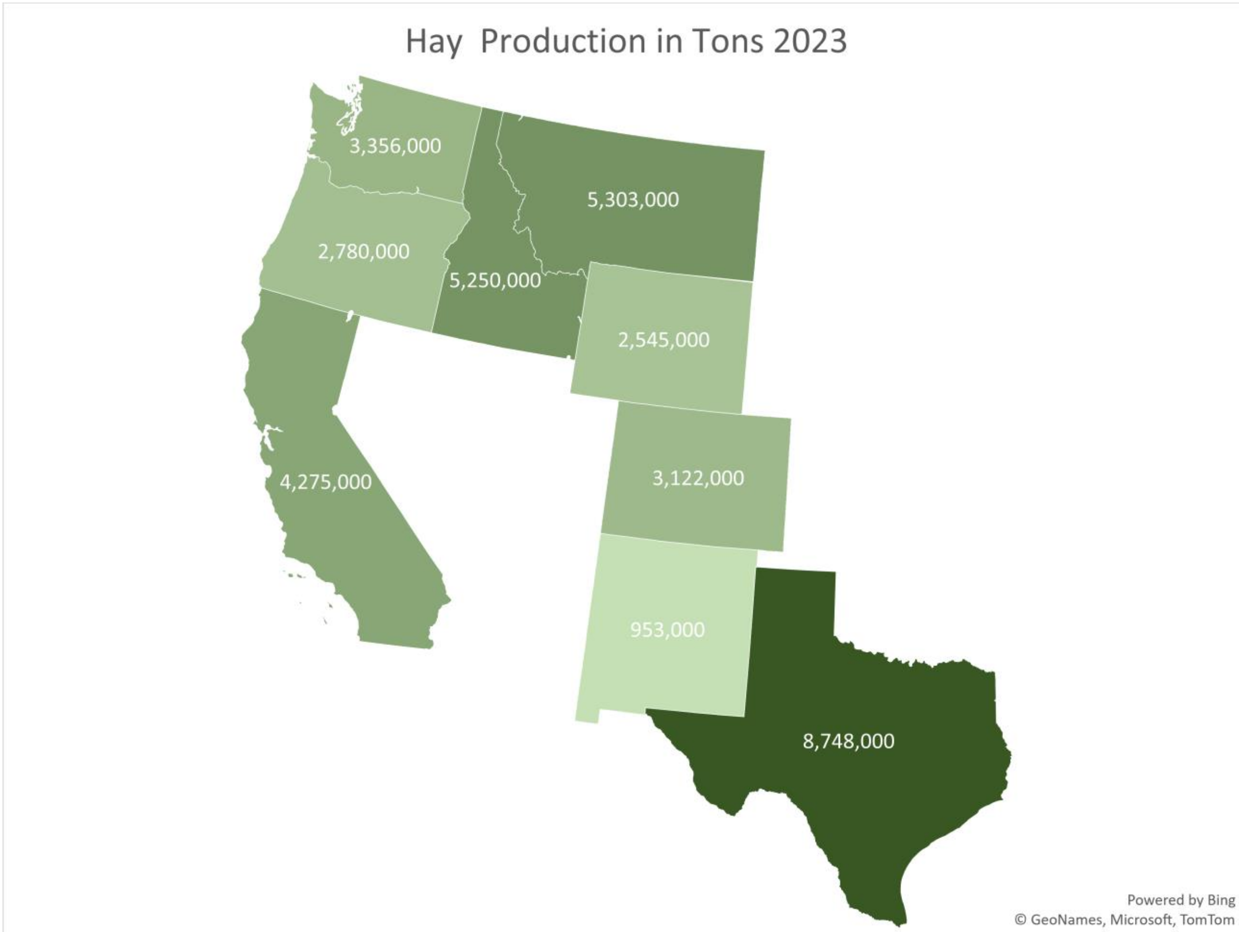

Figure A8: Map of 2023 hay production

Figure A9.1

		LOCATION								
	YEAR	TX	CA	CO	ID	MT	NM	OR	WA	WY
YEAR	1									
TX	-0.6725	1								
CA	0.2743	-0.4064	1							
CO	0.2061	-0.3056	-0.0392	1						
ID	0.1322	-0.1956	-0.0251	-0.0189	1					
MT	0.1166	-0.1731	-0.0222	-0.0167	-0.0107	1				
NM	0.3512	-0.5264	-0.0675	-0.0508	-0.0325	-0.0288	1			
OR	0.2046	-0.3014	-0.0387	-0.0291	-0.0186	-0.0165	-0.0501	1		
WA	0.1546	-0.2299	-0.0295	-0.0222	-0.0142	-0.0126	-0.0382	-0.0219	1	
WY	0.1517	-0.2248	-0.0288	-0.0217	-0.0139	-0.0123	-0.0374	-0.0214	-0.0163	1
Organic	0.1064	-0.1572	-0.0131	0.0145	0.0043	-0.0086	0.153	0.1723	-0.0054	-0.0112
Conventior	-0.1064	0.1572	0.0131	-0.0145	-0.0043	0.0086	-0.153	-0.1723	0.0054	0.0112
Alfalfa	-0.4135	0.2176	-0.0914	-0.148	0.0015	-0.0144	-0.0397	-0.1656	-0.0747	0.0029
Timothy	0.1136	-0.1715	-0.014	0.1321	0.0408	0.1175	-0.0285	0.0876	0.2487	0.0019
Bermuda	0.2516	0.0613	0.0389	-0.038	-0.0244	-0.0215	-0.0377	-0.0375	-0.0286	-0.028
Millet	0.0394	0.0143	-0.0031	0.0002	-0.0037	-0.0033	-0.01	-0.0057	-0.0044	-0.0043
RyeGrass	0.0372	0.0027	-0.0031	-0.0058	-0.0037	-0.0033	-0.01	0.0063	-0.0044	0.0276
Oat	0.0739	-0.0955	0.0245	0.0081	0.0173	-0.0062	0.0997	0.0374	0.0043	-0.008
Prairie	0.0882	-0.1187	0.0204	0.2818	0.0126	0.0021	-0.022	0.0203	0.0046	-0.0021
Triticale	0.0859	-0.0885	-0.0124	0.0289	-0.0038	-0.0071	0.0344	0.1723	-0.0021	-0.0055
Barley	0.0416	-0.0659	-0.0043	-0.0064	-0.0041	-0.0036	0.0322	0.0595	-0.0048	0.1042
Wheat	0.1155	-0.0083	0.026	-0.0138	-0.0114	0.0001	0.015	0.0043	-0.0134	-0.0131
Orchard	0.1378	-0.2035	0.0474	0.1345	0.0146	0.0042	-0.0338	0.3127	0.055	0.0236
Sorghum	0.0765	0.023	-0.0148	0.0199	-0.0071	-0.0063	-0.0172	-0.011	-0.0084	-0.0082
Sudan	0.105	-0.1612	0.0494	0.0245	-0.01	-0.0088	0.2216	-0.0153	-0.0029	-0.0114
Teff	0.0503	-0.0735	0.0913	0.0317	-0.0045	-0.004	-0.0122	0.0028	0.0393	0.0403
Bluegrass	0.0124	-0.0178	0.0131	-0.0017	-0.0011	-0.001	-0.003	-0.0017	0.0512	-0.0013
Bromegras	0.0206	-0.0291	0.0057	0.0584	0.0358	-0.0016	-0.0048	-0.0028	-0.0021	-0.0021
KleinGrass	0.0403	-0.0591	0.1454	-0.0057	-0.0036	-0.0032	-0.0098	-0.0056	-0.0043	-0.0042
Utility	0.0639	-0.0685	0.0172	0.0252	0.0819	0.0739	-0.0156	-0.0089	0.0681	0.0189
UtilityFair	0.1144	-0.1715	0.0601	0.0002	0.2659	0.0124	0.0023	-0.0163	0.2405	0.0131
Fair	-0.0798	0.0625	-0.0199	-0.0286	-0.016	0.0383	-0.0558	-0.0093	-0.0211	-0.0014
FairGood	0.2252	-0.1979	0.0678	0.0047	0.1456	0.0327	0.0829	0.0045	0.1824	0.0289
Good	-0.2144	0.1477	-0.0178	-0.0381	-0.0483	-0.0394	-0.1477	-0.0132	-0.0486	0.0379
GoodPremi	0.2905	-0.2132	0.0456	0.0668	0.047	0.1333	0.1463	0.0379	0.0493	-0.0019
Premium	-0.0928	0.0674	0.0076	0.0484	-0.065	-0.0307	-0.1327	0.0609	-0.0354	0.0165
PremiumSu	0.3153	-0.3784	0.0033	0.0451	0.0086	-0.0095	0.5954	-0.0106	-0.0241	-0.0306
Supreme	-0.1265	0.2308	-0.0551	-0.0738	-0.0368	-0.0442	-0.1502	-0.0654	-0.0584	-0.0562
two_tie	-0.1727	0.2406	-0.1634	-0.0319	-0.0929	-0.0464	-0.0887	-0.052	-0.0611	-0.0558
three_tie	0.2373	-0.3494	0.4453	0.0276	-0.0151	-0.0191	0.0126	0.1618	0.0913	0.0788
three_thre	0.1953	-0.2919	-0.0357	0.2171	-0.0162	0.0034	0.3708	-0.0166	-0.0147	0.0109
three_four	0.4358	-0.5372	0.2654	0.0704	0.2692	0.1421	0.151	0.1914	0.1944	0.1599
four_four	-0.346	0.3198	-0.153	-0.0981	-0.0675	-0.0643	-0.1226	-0.1188	-0.0873	-0.0761
round	0.1573	0.0729	-0.05	-0.0022	-0.0152	0.0516	-0.0407	-0.0361	-0.0283	-0.0212
FOB	0.3353	-0.4354	0.1539	0.1295	0.0877	0.0955	0.2134	0.1651	0.0938	0.1214
Delivered	-0.3353	0.4354	-0.1539	-0.1295	-0.0877	-0.0955	-0.2134	-0.1651	-0.0938	-0.1214
Price	0.622	-0.4397	0.2488	0.1228	0.0399	0.0562	0.2244	0.1574	0.101	0.0304

Figure A9.1: Correlation Matrix

Figure A9.2

	Seed Type		Crop							
	Organic	Conven~l	Alfalfa	Timothy	Bermuda	Millet	RyeGrass	Oat	Prairie	Tritic~e
Organic	1									
Conventior	-1	1								
Alfalfa	-0.0645	0.0645	1							
Timothy	-0.0085	0.0085	-0.2696	1						
Bermuda	-0.0196	0.0196	-0.6196	-0.0214	1					
Millet	-0.003	0.003	-0.0942	-0.0032	-0.0075	1				
RyeGrass	-0.003	0.003	-0.0942	-0.0032	-0.0075	-0.0011	1			
Oat	0.0788	-0.0788	-0.1773	-0.0061	-0.014	-0.0021	-0.0021	1		
Prairie	0.0089	-0.0089	-0.208	-0.0072	-0.0165	-0.0025	-0.0025	-0.0047	1	
Triticale	0.0356	-0.0356	-0.2036	-0.007	-0.0161	-0.0025	-0.0025	-0.0046	-0.0054	1
Barley	-0.0033	0.0033	-0.1035	-0.0036	-0.0082	-0.0012	-0.0012	-0.0023	-0.0028	-0.0027
Wheat	0.0355	-0.0355	-0.2891	-0.01	-0.0229	-0.0035	-0.0035	-0.0066	-0.0077	-0.0075
Orchard	-0.0067	0.0067	-0.3198	-0.011	-0.0253	-0.0039	-0.0039	-0.0072	-0.0085	-0.0083
Sorghum	-0.0057	0.0057	-0.181	-0.0062	-0.0143	-0.0022	-0.0022	-0.0041	-0.0048	-0.0047
Sudan	0.1699	-0.1699	-0.2533	-0.0087	-0.0201	-0.0031	-0.0031	-0.0057	-0.0067	-0.0066
Teff	-0.0036	0.0036	-0.1154	-0.004	-0.0091	-0.0014	-0.0014	-0.0026	-0.0031	-0.003
Bluegrass	-0.0009	0.0009	-0.028	-0.001	-0.0022	-0.0003	-0.0003	-0.0006	-0.0007	-0.0007
Bromegrass	-0.0014	0.0014	-0.0457	-0.0016	-0.0036	-0.0006	-0.0006	-0.001	-0.0012	-0.0012
KleinGrass	-0.0029	0.0029	-0.0928	-0.0032	-0.0074	-0.0011	-0.0011	-0.0021	-0.0025	-0.0024
Utility	-0.0047	0.0047	-0.0272	0.0282	0.0394	-0.0018	-0.0018	-0.0033	-0.0039	-0.0038
UtilityFair	-0.0085	0.0085	-0.0052	0.0748	-0.0214	-0.0032	0.0071	-0.0006	0.0212	-0.0022
Fair	-0.0032	0.0032	0.0607	-0.0082	-0.0531	-0.0082	0.0653	-0.0154	-0.0102	-0.0016
FairGood	0.002	-0.002	-0.2069	0.0448	0.2338	-0.001	0.0207	0.0169	0.0303	0.0165
Good	-0.0049	0.0049	0.0197	-0.0363	-0.0352	0.0584	0.0083	0.0171	-0.0104	0.0388
GoodPremi	0.0492	-0.0492	-0.3381	0.0264	0.3202	-0.0084	-0.0084	0.0808	-0.0032	0.0328
Premium	-0.0154	0.0154	0.0048	0.0416	-0.0654	-0.0224	-0.0245	-0.0172	0.0426	-0.0132
PremiumSu	0.0661	-0.0661	0.0879	-0.0244	-0.0588	-0.009	-0.009	-0.017	-0.0199	-0.0195
Supreme	-0.043	0.043	0.1805	-0.0489	-0.1125	-0.0171	-0.0171	-0.0322	-0.0378	-0.037
two_tie	-0.0039	0.0039	0.0426	-0.0079	0.021	-0.0296	-0.0296	-0.0291	0.0201	-0.0547
three_tie	-0.0153	0.0153	-0.1435	0.079	0.0567	-0.0014	-0.0066	0.0099	0.0188	0.0149
three_three	0.0637	-0.0637	-0.0558	0.0429	-0.0365	-0.0056	-0.0056	0.0225	0.0299	0.0454
three_four	0.0873	-0.0873	-0.0315	0.055	-0.0626	-0.0092	0.0093	0.0771	0.0051	0.0651
four_four	-0.0623	0.0623	0.2487	-0.0674	-0.1579	-0.0241	-0.0241	-0.043	-0.0531	-0.0442
round	-0.0193	0.0193	-0.443	-0.0178	0.3809	0.1444	0.1207	0.0215	0.0247	0.0811
FOB	0.0715	-0.0715	-0.2482	0.087	0.1727	0.0014	-0.0204	0.0422	0.0577	0.0171
Delivered	-0.0715	0.0715	0.2482	-0.087	-0.1727	-0.0014	0.0204	-0.0422	-0.0577	-0.0171
Price	0.0763	-0.0763	-0.1007	0.097	0.0036	-0.0087	-0.0144	0.0037	0.0456	-0.0083

Figure A9.2: Correlation Matrix (Continued)

Figure A9.3

	Crop								
	Barley	Wheat	Orchard	Sorghum	Sudan	Teff	Bluegr~s	Bromeg~s	KleinG~s
Barley	1								
Wheat	-0.0038	1							
Orchard	-0.0042	-0.0118	1						
Sorghum	-0.0024	-0.0067	-0.0074	1					
Sudan	-0.0034	-0.0094	-0.0104	-0.0059	1				
Teff	-0.0015	-0.0043	-0.0047	-0.0027	-0.0037	1			
Bluegrass	-0.0004	-0.001	-0.0011	-0.0006	-0.0009	-0.0004	1		
Bromegrass	-0.0006	-0.0017	-0.0019	-0.0011	-0.0015	-0.0007	-0.0002	1	
KleinGrass	-0.0012	-0.0034	-0.0038	-0.0021	-0.003	-0.0014	-0.0003	-0.0005	1
Utility	-0.0019	-0.0054	-0.006	-0.0034	-0.0048	-0.0022	0.0629	-0.0009	-0.0017
UtilityFair	-0.0036	-0.0065	-0.0079	-0.0062	-0.0087	-0.004	0.034	0.0198	-0.0032
Fair	-0.005	-0.0208	-0.0252	-0.0157	-0.0171	0.0147	-0.0024	-0.004	-0.0037
FairGood	-0.0021	0.0143	0.0172	-0.0122	0.0397	0.0099	-0.0019	0.0081	0.0047
Good	0.0324	-0.0072	-0.0496	0.1101	-0.026	-0.0084	0.0027	-0.0087	0.0041
GoodPremi	0.0407	0.0796	0.028	0.0037	0.189	0.0035	-0.0025	0.0133	0.0003
Premium	-0.0231	0.0325	0.0996	-0.047	-0.0362	0.0194	-0.0073	0.0053	0.0161
PremiumSu	-0.0099	-0.0277	-0.0295	-0.0173	-0.0005	-0.0111	-0.0027	-0.0044	-0.0089
Supreme	-0.0188	-0.0525	-0.0551	-0.0329	-0.046	-0.021	-0.0051	-0.0083	-0.0169
two_tie	-0.0088	-0.0593	0.0223	-0.0568	-0.0302	0.0111	-0.0088	-0.002	-0.0292
three_tie	-0.0025	-0.003	0.1995	-0.0127	-0.0139	0.0732	0.0157	-0.0032	-0.0012
three_three	-0.0061	-0.0048	0.0106	-0.0074	0.1609	-0.0018	-0.0016	0.0355	-0.0055
three_four	0.0623	0.011	-0.0233	-0.022	0.0662	-0.01	0.0171	0.0004	0.0879
four_four	-0.0264	-0.0656	-0.0804	-0.0462	-0.0631	-0.0295	-0.0071	-0.0074	-0.0237
round	-0.0081	0.2787	-0.0236	0.2906	0.0015	-0.009	-0.0022	-0.0036	-0.0073
FOB	0.0345	0.0258	0.104	0.0138	0.0763	0.0389	0.0098	0.016	0.0306
Delivered	-0.0345	-0.0258	-0.104	-0.0138	-0.0763	-0.0389	-0.0098	-0.016	-0.0306
Price	-0.0055	-0.0138	0.1866	-0.036	0.0058	0.0549	-0.0133	0.0126	-0.0094

Figure A9.3: Correlation Matrix (Continued)

Figure A9.4

	Quality Rank								
	Utility	Utilit~r	Fair	FairGood	Good	GoodPr~m	Premium	Premiu~e	Supreme
Utility	1								
UtilityFair	-0.0051	1							
Fair	-0.0128	-0.0234	1						
FairGood	-0.01	-0.0182	-0.046	1					
Good	-0.0281	-0.0514	-0.1295	-0.1009	1				
GoodPremi	-0.0132	-0.0241	-0.0606	-0.0473	-0.1332	1			
Premium	-0.0383	-0.07	-0.1764	-0.1376	-0.3876	-0.1815	1		
PremiumSu	-0.0141	-0.0258	-0.0651	-0.0507	-0.1429	-0.0669	-0.1948	1	
Supreme	-0.0268	-0.0489	-0.1233	-0.0961	-0.2708	-0.1268	-0.3691	-0.1361	1
two_tie	-0.0437	-0.0762	-0.1678	-0.064	-0.0339	-0.0969	0.1527	-0.0763	0.1067
three_tie	-0.0003	-0.0005	-0.0292	0.015	-0.0478	0.0433	0.1125	-0.0131	-0.0905
three_three	-0.0087	0.0102	-0.0328	0.0405	-0.0704	0.0968	-0.045	0.2401	-0.0806
three_four	0.0913	0.208	-0.0293	0.1681	-0.0603	0.1418	-0.1365	0.2049	-0.1073
four_four	-0.0323	-0.0578	0.2221	-0.1198	0.1006	-0.1616	-0.0557	-0.1145	0.0731
round	0.0432	-0.0161	-0.0079	0.1193	0.0429	0.2639	-0.0933	-0.0478	-0.1096
FOB	0.0479	0.0583	-0.0942	0.1581	-0.1356	0.1635	0.0229	0.1659	-0.1237
Delivered	-0.0479	-0.0583	0.0942	-0.1581	0.1356	-0.1635	-0.0229	-0.1659	0.1237
Price	-0.0272	0.0141	-0.1775	0.0096	-0.2601	0.0836	0.0727	0.2734	0.0605

Figure A9.4: Correlation Matrix (Continued)

Figure A9.5

	Bale Size						Shipping		
	two_tie	three~ie	three~ee	three_~r	four_f~r	round	FOB	Delive~d	Price
two_tie	1								
three_tie	-0.1725	1							
three_three	-0.1448	-0.0324	1						
three_four	-0.3202	-0.0716	-0.0601	1					
four_four	-0.6275	-0.1402	-0.1177	-0.2603	1				
round	-0.1923	-0.043	-0.0361	-0.0798	-0.1563	1			
FOB	0.0585	0.1702	0.151	0.1873	-0.3345	0.0601	1		
Delivered	-0.0585	-0.1702	-0.151	-0.1873	0.3345	-0.0601	-1	1	
Price	0.0021	0.281	0.14	0.2191	-0.2444	-0.1508	0.1006	-0.1006	1

Figure A9.5: Correlation Matrix (Continued)