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A Hedonic Analysis of Cattle Prices in Nicaragua

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ABSTRACT

The annual growth rate of Latin American livestock production is estimated to be above the world average, and the region has become prominent for beef and poultry exports worldwide. In 2018, Nicaragua led beef production and exports in Central America with growth rates of 24% and 16.4%, respectively. Using data on feeder cattle futures prices and on 2,520 sales transactions from 99 cattle auctions in Nicaragua from 2017 to 2018, this study conducts a hedonic price analysis using a basis approach, which can be used as a risk management tool for cattle prices. The study found that weight, lot size, and class are statistically significant factors impacting cattle auction prices. The results are relevant to Nicaraguan cattle buyers and sellers and help understand how the futures market can be used to predict price differences and reduce price risk and uncertainty.

KEYWORDS: hedonic analysis, feeder cattle, futures market, livestock auction, Nicaragua

INTRODUCTION

The Latin American livestock industry is a major contributor to global food security. For the period 1997/99-2015, Latin American livestock production was projected to grow at an annual rate of 2.4% surpassing the World annual growth rate of 1.7% (FAO 2003). "Latin America and the Caribbean account for 28% of the world's cattle population, beef production, and milk production. Additionally, the region represents 44% of global beef exports and 42% of chicken production, playing a crucial role in global food and nutritional security" (FAO 2024).

Livestock systems are main contributors to the economy of Latin America and the Caribbean (FAO 2024). However, the region faces several challenges, including high costs of animal feed, which for the period 2012-2016 represented between 60% and 70% of total production costs under an intensive production model; low productivity; and an increasing risk of transboundary pests and disease spread (TechnoServe-USDA 2016). Climate change also offsets the growth of the industry and negatively affects agricultural production.

Beef, Chicken, and Swine Meat Production in Central America. In Central America, for the period 2014-2019, beef production increased by 5.3% in El Salvador (from 19 to 20 thousand metric tons of carcass weight equivalent (MT CWE)), followed by Honduras (from 63 to 65 thousand MT CWE, or 3.2%), Nicaragua (from 161 to 165 thousand MT CWE, or 2.5%), and Guatemala (from 72 to 73 thousand MT CWE, or 1.4%). Panama and Costa Rica were the only countries in the region that saw their production decrease by 13% (from 83 to 72 thousand MT CWE) and 1.1% (from 88 to 87 thousand MT CWE), respectively (USDA 2020).

In terms of chicken production, for the period 2014-2019, production increased for all the countries in the Central American region as a result of a growing population and increasing prices of substitute meats. Honduras, Panama and El Salvador experienced the highest increase in chicken production with 30.2% (from 156.14 to 203.33 thousand MT CWE), 28.2% (from 169.45 to 217.2 thousand MT CWE) and 26.2% (from 117.7 to 148.5 MT CWE), respectively (Avicolatina 2020). Nicaragua, Costa Rica and Guatemala faced a relatively slower growth in chicken production with 14.8% (from 126.9 to 145.7 thousand MT CWE), 12.5% (from 123.7 to 139.2 thousand MT CWE) and 6% (from 215 to 228 thousand MT CWE), respectively (USDA 2020; Avicolatina 2020). Guatemala is the leading chicken producer in the region.

In terms of swine meat, for the period 2014-2019, production remained steady in Guatemala (62 thousand MT CWE). Panama experienced an unprecedented increase of 35.3% (from 34 to 46 thousand MT CWE), followed by Nicaragua (from 10 to 12 thousand MT CWE or 20%) and Costa Rica (from 55 to 63 thousand MT CWE or 14.5%). Honduras and El Salvador have seen their production collapsed by 23.1% (from 13 to 10 thousand MT CWE) and

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22.2% (from 9 to 7 thousand MT CWE), respectively. Together, in 2019, Costa Rica, Guatemala, and Panama had an average volume share of 85.5% of the total production in Central America (FAOSTAT 2020a; USDA 2020). Figure 1 summarizes beef, chicken, and swine meat production in Central America in 2019.

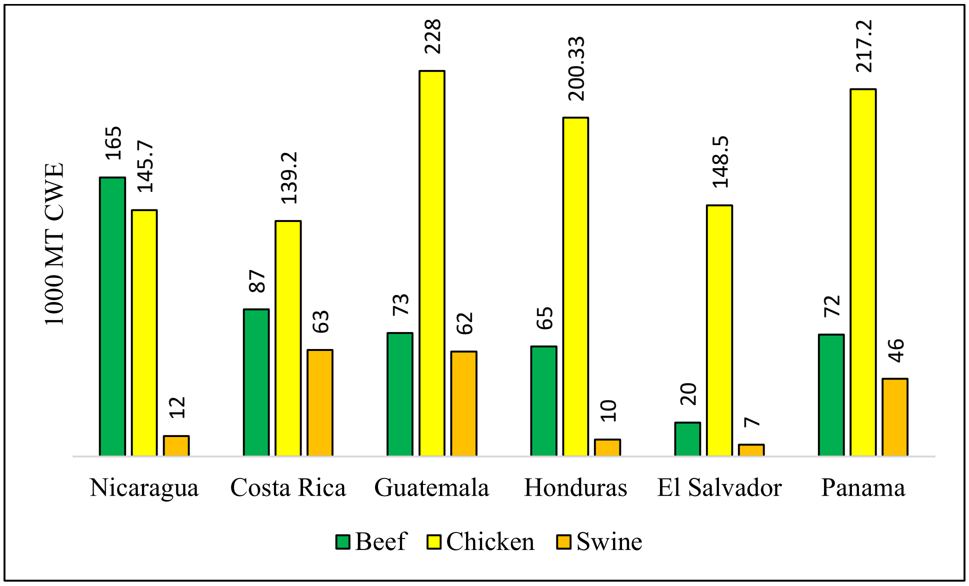

Figure 1. Beef, Chicken, and Swine Meat Production in Central America in 2019.
Source: Beef production from USDA (2020). Chicken production from Avicolatina (2020) and USDA (2020). Swine production from FAOSTAT (2020a) and USDA (2020).

Beef, Chicken, and Swine Meat Exports in Central America. For the period 2014-2019, Costa Rica and Nicaragua beef exports grew by 40.9% (from 22 to 31 thousand MT CWE) and 16.4% (from 128 to 149 thousand MT CWE), respectively. For Guatemala and Honduras, beef exports remained low and steady at 5 thousand MT CWE each (USDA 2020); while El Salvador and Panama registered less than one-tenth of a metric ton in beef exports.

For the period 2014-2019, chicken meat exports decreased in several countries of Central America. Costa Rica exhibited the highest decrease (from 1.9 to 0.87 thousand MT CWE or 54.2%), followed by El Salvador (from 2.3 to 1.3 thousand MT CWE or 43.5%) and Honduras (from 2.5 to 1.5 thousand MT CWE or 40%) (UN-COMTRADE 2020). Surprisingly, chicken exports skyrocketed by 700% (from 0.05 to 0.4 thousand MT CWE) in Panama (UN-COMTRADE 2020). Guatemala, in turn, witnessed an increase of 14.3% (from 7 to 8 thousand MT CWE) (USDA 2020).

Unfortunately, Central America is not at a level to compete with other regions in the world in terms of swine meat exports. For the period 2014-2019, exports decreased by 20% (from 1.42 to 1.13 thousand MT CWE). Guatemala by itself exported 1000 MT CWE of swine meat, which represents 88% of total swine exports in the region (UN-COMTRADE 2020; USDA 2020); while Honduras, El Salvador and Panama did not export any swine meat at all (0 MT CWE) for the same period (UN-COMTRADE 2020; USDA 2020). Figure 2 summarizes beef, chicken, and swine exports in Central America in 2019.

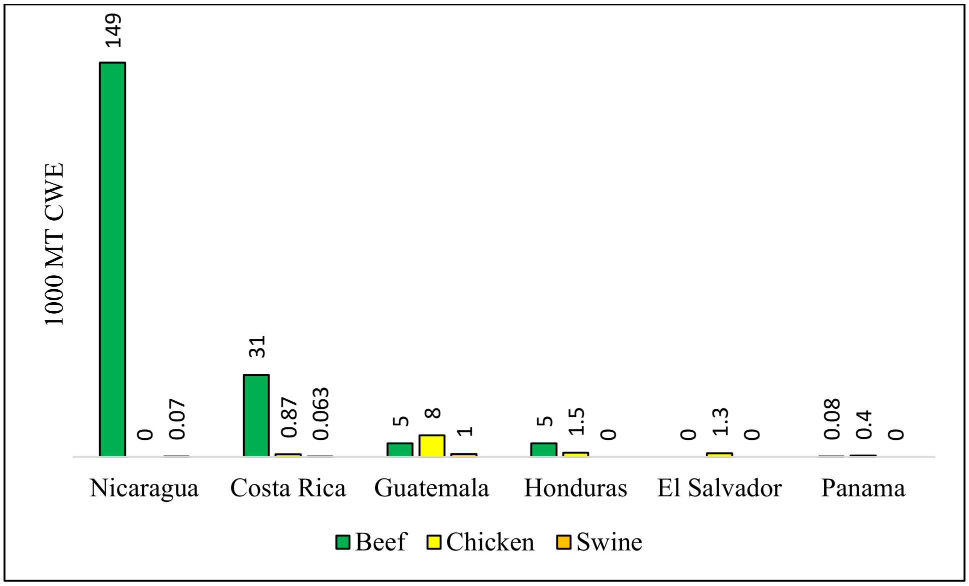

Figure 2. Beef, Chicken, and Swine Meat Exports in Central America in 2019
Source: Beef exports from USDA (2020). Chicken exports from UN-COMTRADE (2020) and USDA (2010). Swine exports from UN-COMTRADE (2020) and USDA (2020).

Beef and Cattle Production in Nicaragua. Nicaragua leads beef production and exports in Central America (Figures 1 and 2). The cattle industry is a key element in improving the Nicaraguan economy, as the production is almost 10 times more than the domestic consumption (Figure 3). Their top three export markets for meat and edible meat offal are the United States followed by Venezuela and El Salvador (UN-COMTRADE 2020).

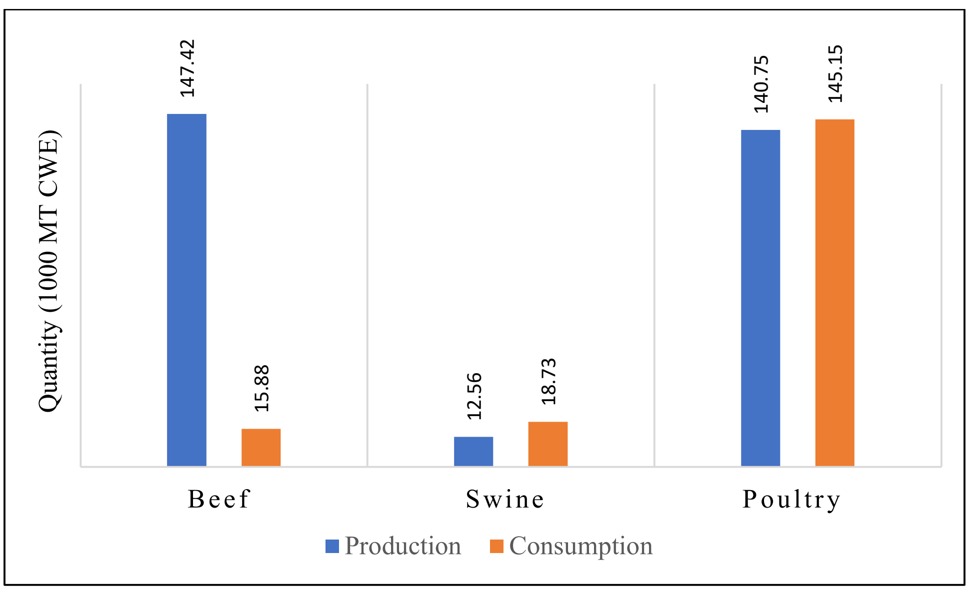

Figure 3. Meat Production and Consumption in Nicaragua in 2017.
Source: USDA (2020)

According to ECLAC (2020), the Nicaraguan cattle industry accounts for 10.4% of the total exports of all products in general in 2018. It was only surpassed by the industry of knitted garments (14.6%) and insulated wire and cable (11.4%). In terms of contribution to the Gross Domestic Product, Agriculture and related activities hold the third place with a share of 15.5% behind services (60%) and industry (24.4%) in 2017 (CIA 2020). As of 2017, 31.1% of the workforce was employed in agriculture, which represented nearly one million jobs (FAOSTAT 2020b).

As of 2016, Nicaragua had approximately 135,000 cattle ranchers with 90% of them being small-sized producers (TechnoServe-USDA 2016). Nicaragua raises nearly 5 million heads on 3.26 million hectares of land, which puts them in first place in Central America in terms of total number of heads (TechnoServe-USDA 2016). However, the vast majority of Nicaraguan cattle ranchers run dual-purpose businesses as milk sellers on a daily basis and meat or live cattle sellers intermittently (TechnoServe-USDA 2016).

According to the Nicaraguan Central Bank (NCB 2017), the number of cattle slaughtered in 2017 increased by 23.7% (from 695,230 to 860,000), followed by pigs (from 223,800 to 240,000 or 7.2%) and chicken (from 66.92 to 69.6 million or 4%). In terms of meat, beef production grew up by 24% (from 118.89 to 147.42 thousand MT CWE), followed by swine (from 11.43 to 12.56 thousand MT CWE or 9.9%) and poultry (from 138.94 to 140.75 thousand MT CWE or 1.3%) (NCB 2017).

This study analyzes cattle prices in Nicaragua. The general objectives of the study are to analyze how cattle prices are affected by cattle physical and lot characteristics, to examine the relationship between cash and futures prices, and to assess how basis (cash prices minus futures prices) can be used as a predictive tool for price volatility. The specific objectives of the study are to develop a suitable econometric model for analyzing Nicaragua cattle auction sales; to estimate price premiums or discounts associated with specific physical attributes of feeder cattle; and to analyze the extent to which futures prices of the CME and cash prices from cattle auction houses in Nicaragua can be used to manage price risk and market uncertainty.

The study is beneficial in several ways. Nicaraguan cattle ranchers could benefit from a better understanding of the relationship between cash and futures prices to manage risk. The study may also assist Nicaraguan buyers and sellers in their decision-making process when bidding at cattle auctions and may help them better understand information from the futures market to predict price differences and reduce price risk and market uncertainty. Likewise, the study has the potential to benefit Latin American producers by helping them understand the importance of risk management tools and best management practices when buying feeder cattle at auctions. Last, while there are many studies on feeder cattle prices based on quality attributes in the United States, this study is unique in that there have not been similar studies for Nicaragua nor any country in Central America.

MATERIALS AND METHODS

Data. Nicaraguan cattle auction data were obtained from Comergasa, a livestock auction house established and located in Managua, Nicaragua. Comergasa is second to Suganar, the largest auction house located in Managua, in terms of animals sold. The main bidders are slaughterhouses' representatives, local butchers, intermediaries and independent producers. Auction sales are held on a biweekly basis, Wednesdays and Fridays. In winter, on average, 5,000 head are generally sold per month at the Comergasa auction. Comergasa charges a sale commission of 3% per animal sold, a percentage similar to the other two cattle auction houses in the country, Suganar and La Chontaleña.

Data were provided on auction dates along with feeder cattle characteristics related to sex, weight, lot size, and cash price for the period 2015-2019. One of the limitations of the data is that color and breed were not reported. Monthly data for the years 2017 and 2018 exhibited seasonal patterns. However, several months for the years 2015, 2016, and 2019 were missing observations. Due to the seasonal patterns in the data for the years 2017 and 2018, and missing observations for the years 2015, 2016, and 2019, these latter years were discarded due to the data being not representative; leaving us with 2,520 out of the initial 3,214 observations.

The 2,520 transactions for the period 2017-2018 represented 2,520 different lots encompassing a total of 34,408 cattle heads. Steers and cows accounted for the highest frequencies, 57.38% and 33.22%, respectively. In turn, bulls represented 6.86%, oxen 2.11%, and calved cows 0.43%. Calved cows were removed from the analysis given the low and non-represented percentage, while bulls and oxen were grouped in one category, similar to Schulz et al. (2010). Last, prices were converted from Córdobas (Nicaragua national currency) to US dollars, then from nominal prices to real prices using the consumer price index (CPI) provided by the Nicaraguan Central Bank, and finally from prices per kilogram (kg) to prices per hundredweight (cwt).

Overall, the summary statistics in Table 1 show a mean lot of 51.57 animals per lot, ranging widely from 1 to 179 heads. The mean weight per head across all lots was 611.42 pounds and ranged from 55.12 to 2039.27 pounds. Cash prices across lots averaged \$66.63/cwt and ranged from \$13.07/cwt to \$153.03/cwt. Table 2 reports the descriptive statistics of select variables by sex. On average, steers weigh 171.98 pounds less than heifers, but are priced \$16.18/cwt higher than heifers.

Table 1. Summary Statistics from Comergasa Sales and CME Future Prices, 2017-2018.

Variable	Mean	Std. Dev.	Min.	Max.
Lot size (head)	51.57	35.82	1.00	179.00
Weight (lbs)	611.42	274.39	55.12	2039.27
Price ($/cwt)	66.63	11.92	13.07	153.03
January Futures ($/cwt)	141.24	7.10	131.00	149.38
February Futures ($/cwt)	134.74	12.90	121.70	150.93
March Futures ($/cwt)	132.98	6.53	124.23	143.68
April Futures ($/cwt)	138.33	2.66	135.33	141.38
May Futures ($/cwt)	142.16	5.23	134.90	152.58
August Futures ($/cwt)	150.00	4.73	144.65	158.73
September Futures ($/cwt)	150.71	3.12	145.03	154.28
October Futures ($/cwt)	149.51	3.37	140.50	152.85
November Futures ($/cwt)	155.48	1.83	152.96	157.43
Steers ($/cwt)	154.67	1.35	152.10	157.78
Heifers ($/cwt)	153.33	4.59	147.83	160.88
Bulls ($/cwt)	151.17	5.12	146.00	157.78

Table 2. Summary Statistics by Sex from Comergasa Sales, 2017-2018.

	Steers			
Variable	Mean	Std. Dev.	Min	Max
Cash price ($/cwt)	71.71	10.37	13.07	153.03
Lot size (head)	47.06	28.77	1.00	137.00
Weight (lbs)	512.54	238.48	55.12	1818.81
	Heifers			
Variable	Mean	Std. Dev.	Min	Max
Cash price ($/cwt)	55.53	6.17	21.57	92.80
Lot size (head)	68.86	40.28	1.00	179.00
Weight (lbs)	684.52	194.41	55.12	1818.81
	Bulls			
Variable	Mean	Std. Dev.	Min	Max
Cash price ($/cwt)	76.06	6.12	42.19	101.31
Lot size (head)	7.18	4.49	1.00	21.00
Weight (lbs)	1121.56	215.57	385.81	2039.27

Closing daily feeder cattle futures prices were also obtained from the Chicago Mercantile Exchange (CME 2020) website for the period 2017-2018. Conventionally, the CME website provides future contract prices available for purchase for the following eight months of the year: January, March, April, May, August, September, October, and November. The average prices by month for the period 2017-2018 are reported in Table 1. Similar to Burdine (2011), Zimmerman (2010), and Feuz et al. (2008), the value of the closing price of the feeder cattle futures contract on the auction date or closest to it was used.

Model. The hedonic model used in this study is widely recognized in the literature and rooted on earlier studies (Schulz et al. 2018; Dhuyvetter and Schroeder 2000; Lee and Brorsen 1994; Schroeder et al. 1988; Marsh 1985; Buccola 1980; Ladd and Martin 1976; Rosen 1974; Lancaster 1966). It states that the price of a commodity is a function of cattle's physical characteristics and market forces. That is,

(1) $\text{Price}_{it} = \Sigma\, \text{V}_{\text{ikt}} C_{ikt} + \Sigma\, \text{R}_{\text{ht}} M_{ht} + \varepsilon_t,$

where *Price* is the cash price given, *i* is the specific lot, *t* is the auction date, V represents the value of a specific attribute, *k* is the animal trait, C is the specific characteristic of the animal, R is the effect of market forces on price at the time of the sale, *h* is the market influence, M is the specific market force, and ε_t is the error term. The underlying assumption of this model is when supply is given, demand for feeder cattle relies on physical traits (Faminow and Gum 1986).

The following basis model was estimated in SAS (Statistical Analysis Software) 9.4 using an autoregressive error model (AUTOREG) to correct for autocorrelation and a generalized autoregressive conditional heteroscedasticity (GARCH) model to correct for heteroscedasticity due to the presence of these as explained below.

(2) $Basis_{it} = \beta_0 + \beta_1 Lotsize_{it} + \beta_2 WeightINV_{it} + \beta_3 Heifer_{it} + \beta_4 Bull_{it} + \beta_5 February + \beta_6 March + \beta_7 April + \beta_8 May + \beta_9 June + \beta_{10} July + \beta_{11} August + \beta_{12} September + \beta_{13} October + \beta_{14} November + \beta_{15} December + \varepsilon_t,$

or

$$Basis_t = \mathbf{x}_t'\beta + \varepsilon_t$$

where $Basis_{it}$ is the difference between the cash price ($/cwt) and the corresponding futures prices for lot *i* in time period *t*, *Lotsize* is lot size or number of heads, *WeightINV* is the reciprocal or inverse of the weight of the cattle lot in pounds (lbs), *Heifer* is a dummy variable that equals 1 if heifer and 0 otherwise, *Bull* is a dummy variable that equals 1 if bull and 0 otherwise, *Month* is the month of the sale, the βs are the parameters to be estimated, and ε_t is the error term for each observation.

The variable *Weight* represents the average weight of the entire lot sold. It is expected to have a negative coefficient, as concluded by Schulz et al. (2018) and others (Mathews 2007; Zimmerman 2010). The reason heavier cattle are discounted is because they are less likely to gain weight. The reciprocal or inverse transformation is used for weight (*WeightINV*) to capture any possible non-linear relationship with basis (Faminow and Gum 1986). If the coefficient associated with *WeightINV* is negative, then the relationship between the dependent variable *Basis* and the independent variable *Weight* increases at a decreasing rate while the relation between *Basis* and *WeightINV* is linear with a negative slope (Mirrer 1995). However, if the coefficient as associated with *WeightINV* is positive, then the relationship between *Basis* and *Weight* decreases at a decreasing rate while the relation between *Basis* and *WeightINV* is linear with a positive slope (Mirrer 1995).

Heifer is a dummy variable that takes on the value of 1 when cattle is a heifer and 0 otherwise (for steer). It has been found consistently in the literature that heifers are discounted compared to their male counterparts (Mathews 2007; Zimmerman 2010; Burdine 2011). *Bull* is another binomial predictor variable. It takes on 1 only when the animal is found to be a bull and 0 otherwise. Bulls are usually discounted relative to steers (Williams et al. 2012; Schulz et al. 2010).

Month is a variable that has been included in the study to account for seasonality. Each month variable is a dummy variable, with January being the base or excluded month. Each month variable equals 1 for the corresponding month of the year and 0 otherwise. Since the cattle supply is affected by feed availability and costs, feeder cattle prices tend to be higher during the dry season (November to April) and lower during the rainy season (May to October) as large sales volume leads to weaker prices. Therefore, in general, months corresponding to the rainy season are expected to have a negative coefficient compared to January.

Model diagnostics. In order for the Ordinary Least-Squares (OLS) regression model to be the best linear unbiased estimator (BLUE), it has to meet certain underlying assumptions. Among these are the absence of multicollinearity, autocorrelation, and heteroscedasticity. Such assumptions are evaluated through the use of regression diagnostics. The model validity is improved when any violations of the assumptions are correctly addressed (Burdine 2011). SAS 9.4 was used to assess the three aforementioned assumptions.

Multicollinearity occurs when a high correlation is found between two or more independent variables. As such, it becomes challenging to determine the individual effect, if any, of each of these variables on the response variable and quantify it. An intuitive way to detect multicollinearity is to assess whether two or more explanatory variables are associated. The correlation coefficients between pairwise variables are a preliminary way to determine which sets are highly correlated. However, this method is limited since it does not account for dependence among three or more variables. Therefore, the study uses variance of inflation factors (VIF) to test for multicollinearity. The VIF of each independent variable in the model was computed as follows:

(3) $VIF_j = \frac{1}{1-R_j^2}$

where R_j^2 is the *R*-squared obtained after regressing the j^{th} independent variable on the remaining independent variables. As a general rule of thumb, VIFs close to or higher than 10 reveal the presence of multicollinearity. The model used a reciprocal or inverse specification for variable weight to capture any possible non-linear relationship with basis and alleviate the presence of multicollinearity. Variance inflection factors ranged from 1.17 and 2.70, suggesting absence of multicollinearity.

Autocorrelation is another possible violation of the OLS assumptions that is usually common in time-series data. Autocorrelation measures the degree to which a variable's recent values correlate to past values of the same variable. A common test to detect and assess the level of autocorrelation in a variable is the Durbin-Watson statistic. Its results range between zero and four, two indicating the absence of autocorrelation, less than two positive autocorrelation, and more than two negative correlations. The DWPROB keyword was used as an option in the PROC REG procedure to detect autocorrelation. The result of the Durbin-Watson statistic obtained was 1.066 which suggests the presence of a positive autocorrelation. The first-order autocorrelation detected was corrected with the PROC AUTOREG, which implements regression models that use time series data where the errors are autocorrelated.

Last, heteroscedasticity is also a possible violation of the OLS regression models' assumptions. Heteroscedasticity occurs when variances across individual sample observations are not constant and is also common in time-series data. The ARCHTEST option was used with the PROC AUTOREG to test for heteroscedasticity. This test reported p-values for lags in order one through 12. The data were highly heteroscedastic since all the p-values were less than 0.0001 for all the lags. The GARCH (generalized autoregressive conditional heteroscedasticity) option was used with PROC AUTOREG to eliminate the effects of heteroscedasticity.

In general, the GARCH regression model with autoregressive errors is:

$$(4) \quad Basis_t = \mathbf{x}_t'\beta + v_t$$
$$v_t = \varepsilon_t - \varphi_1 v_{t-1} - \ldots - \varphi_m v_{t-m}$$
$$\varepsilon_t = \sqrt{h_t} e_t$$
$$h_t = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-1}^2 + \sum_{j=1}^{p} \gamma_j h_{t-j}$$
$$e_t \sim \mathrm{IN}(0,1)$$

where the residuals follow a distribution where the values fall between (or are bounded within) 0 and 1; that is, $e_t \sim \mathrm{IN}(0,1)$. This model combines the m^{th}-order autoregressive error model with the GARCH(p, q) variance model. It is denoted as the AR(m)-GARCH(p, q) regression model.

RESULTS

A total of 2,520 observations were used to estimate the coefficients of the hedonic regression model in equation (2). Basis, which is the difference between cattle cash prices from the Comergasa auction and the futures prices from the CME, represents the response variable and is modeled as a function of the intrinsic variables related to cattle and the extrinsic variables related to the market characteristics. Statistical Analysis System (SAS), Version 9.4, was utilized to estimate the regression model. Table 3 reports the coefficients of the explanatory variables used in the regression model, along with their associated standard errors, *t* values, and *p*-values. The *F*-statistic and the *R* squared are also reported in Table 3. The *F*-statistic of over 280 is strong evidence that all the independent variables are jointly statistically significant. The *R* squared is a measure of the goodness of fit of the hedonic model and assesses whether the variables used have good explanatory power. It indicates that 63.35% of the variation in the dependent variable (i.e., basis) is explained by the model.

The value of the intercept is -68.55, which means that cattle futures prices from the CME are higher than local cattle cash prices given at the Comergasa auction over the period analyzed. Stated differently, on average, futures prices are $68.55/cwt higher than local cash prices when all the remaining coefficients of the independent variables equal zero, holding everything else constant. The coefficients associated with the lot variable (i.e, *Lotsize*) and the physical characteristic variables *WeightINV* and *Heifer* obtained their expected negative signs (Table 3). Overall, all the sixteen parameter estimates were statistically significant at the 0.001 probability level.

Table 3. Basis Model Parameter Estimates from Livestock Auction House Comergasa in Nicaragua, 2017-2018.

Variable	Parameter Estimate	Standard Error	t statistic	p-value
Intercept	-68.5555*	0.4049	-169.30	<0.0001
Lotsize	-0.0310*	0.0111	-2.78	0.0054
WeightINV	-704.2701*	52.3253	-13.46	<0.0001
Heifer	-9.3817*	0.5577	-16.82	<0.0001
Bull	3.0145*	0.6441	4.68	<0.0001
February	9.8068*	0.8328	11.78	<0.0001
March	11.2683*	0.6328	17.81	<0.0001
April	5.6055*	1.5536	3.61	0.0003
May	4.6546*	0.6792	6.85	<0.0001
June	-2.0522*	0.7057	-2.91	0.0036
July	-4.6737*	0.4695	-9.95	<0.0001
August	-10.9775*	0.7565	-14.51	<0.0001
September	-20.6564*	0.7590	-27.22	<0.0001
October	-18.9019*	0.5864	-32.23	<0.0001
November	-15.9501*	0.7197	-22.16	<0.0001
December	-13.0972*	0.7009	-18.69	<0.0001
R^2	0.6335			
F-statistic	288.52			<0.0001

Note: Asterisk (*) denotes statistical significance at the 0.01 level, respectively.

The coefficient corresponding to the variable *Lotsize* is statistically significant (p-value < 0.0001). If *Lotsize* increases by one head, basis is expected to slightly decrease by $0.03/cwt, ceteris paribus. The variable *WeightINV* obtained negative sign and is statistically significant at the 0.001 probability level (Table 3), suggesting the relation between *Basis* and *Weight* increases at a decreasing rate. That is, heavier animals are discounted, but as weight increases the discount slowly decreases. Heavier animals tend to be penalized compared to lighter ones since bidders prefer smaller animals as it is easier to put weight on them and thus make a profit (Zimmerman 2010). Burdine (2011) even reported a discount of $0.025/cwt for a one-pound increase in feeder cattle weight in Kentucky from 2008 through 2011. In short, the lighter the animal, the higher the premium they tend to receive, with the opposite being also true. Lighter animals are more likely to gain weight, which makes it easier for buyers to fatten them and sell them for a better price at the next production stage. In Nicaragua, cattle nutrition and health records are often unavailable; as a result, the lack of animal records triggers cattle buyers' uncertainty regarding the acquisition of heavy cattle.

The coefficient of *Heifer* is negative and statistically significant (p-value < 0.001) as expected (Table 3). Compared to their male counterparts, heifers were penalized with a 9.38/cwt discount, ceteris paribus. According to Eldridge (2005), one of the reasons for this is the risk associated with heifers regarding their likelihood of death or physical injury related to calving difficulties (dystocia). Moreover, heifers are more likely to grow slower since they have a lower feed-conversion rate compared to steers. As such, fattening a steer instead of a heifer implies that a reduced window time between the purchase and the sale can be attained and perhaps at a lower cost. Based on a 2010 data from the Oklahoma Quality Beef Network program, Williams et al. (2012) found a similar discount of $11.78/cwt. However, the magnitude of the differentials between steers and heifers decreases as weight increases.

The coefficient associated with the variable *Bull* is positive and statistically significant (p-value < 0.001), Table 3. Compared to steers, bulls at Comergasa received a premium of $3.02/cwt. Bulls usually receive a discount compared to steers since there is not much room to put weight on them, but this may not hold true for the Comergasa auction, given the presence of butchers and slaughterhouse representatives among the bidders. Such buyers intend to slaughter the animals and sell the meat as opposed to fattening them. In fact, the average mean weight of the bulls sold was 1,121.56 pounds (Table 2) which is over the 800 pounds threshold indicating that they are ready for slaughter.

In order to account for seasonality, monthly dummy variables were used for each of the months of the year, except for January, which was excluded to avoid perfect multicollinearity. Nicaragua has two seasons throughout the year: the rainy and dry seasons. Table 4 reports the descriptive statistics for cattle weight (lbs) and prices ($/cwt) per month and season. The rainy season goes from May to October and is characterized by greater grass availability and better grass quality. As a result, more cattle and heavier cattle are supplied in the auctions, which leads to a drop in cattle's cash prices and consequently a reduction in basis. Such a claim is supported by the results shown in Table 4, where cattle mean weight for the rainy season is 13.54 pounds more compared to the dry season (617.18 pounds versus 603.64 pounds), although during the rainy season, on average, cattle received $1.04/cwt less than during the dry season ($66.19/cwt versus $67.22/cwt).

Table 4. Descriptive Statistics for Months and Seasons with Respect to Weight and Prices, 2017-2018.

	Weight (lbs)		Price ($/cwt)	
	Mean	Std. Dev.	Mean	Std. Dev.
Rainy season	617.18	262.57	66.19	12.74
Dry season	603.64	289.42	67.22	10.69
January	601.88	293.39	68.30	8.06
February	563.86	285.85	68.25	8.80
March	596.25	295.32	69.82	8.70
April	552.29	318.37	74.37	11.90
May	569.20	265.20	72.82	12.97
June	613.04	269.52	72.18	10.97
July	621.68	266.75	70.70	13.49
August	635.50	261.31	63.41	10.73
September	623.44	247.75	60.12	10.69
October	611.68	263.78	63.70	12.15
November	608.80	267.47	64.61	11.84
December	652.33	300.91	65.05	12.33

From June through December, all the coefficients reported were negative and statistically significant at the 0.01 probability level (Table 3). As such, cattle received discounts that ranged from -$2.05/cwt to -$20.66/cwt, with the lowest point attained in September, ceteris paribus. Conversely, compared to January, from February to May, cattle received premiums ranging from $4.65/cwt to $11.27/cwt, with March being the peak, ceteris paribus. In other words, given January as the base month, the best month to sell cattle at Comergasa is March, while the worst month is September from the producer's perspective. The seasonal pattern of premiums and discounts received for cattle at Comergasa for the period 2017-2018 is exhibited in Figure 4.

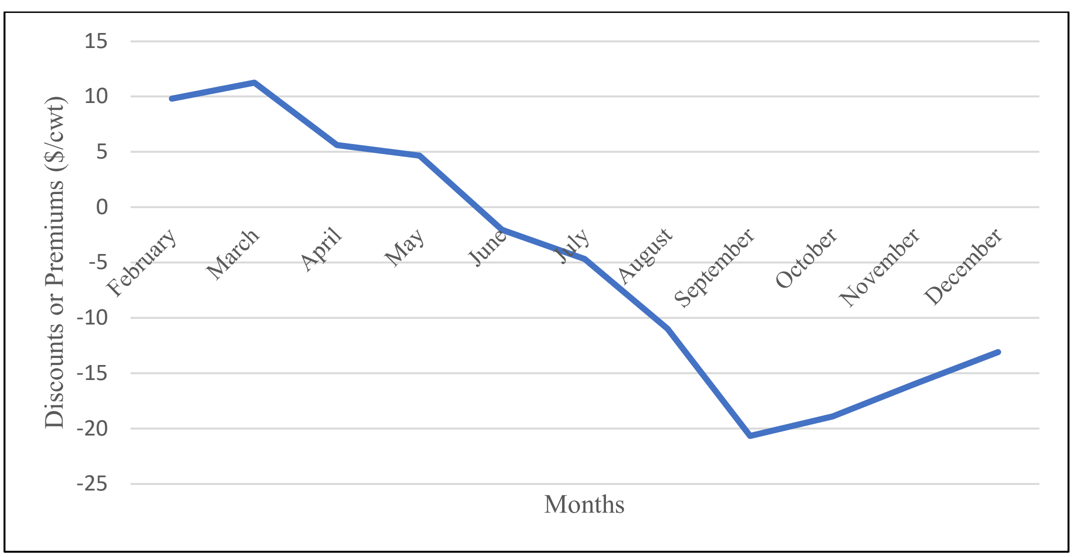

Figure 4. Seasonal Pattern of Premiums and Discounts for Cattle ($/cwt) Given at Comergasa, 2017-2018.

CONCLUSION

According to USDA (2020), Nicaragua's beef exports surpassed the total beef exports of the remaining countries of Central America combined by 3.5 times in 2019. For the same year, 89.3% of the national total beef produced was exported (USDA 2020). These astounding production and export records put Nicaragua at the top of the list as the leading country in Central America in terms of beef production and exports (USDA 2020), providing evidence that the cattle industry is crucial to the Nicaraguan economy. In fact, beef exports represent more than 10.4% of the national total exports and are classified as the third major component of its gross domestic product (ECLAC 2020). As the least developed country in Central America, Nicaragua must harness the potential of its cattle industry and further improve its economy. However, Nicaragua faces some major challenges that prevent the country from doing so. First, Nicaragua's cattle production is non-intensive but rapidly growing, approximately 24% from 2017 to 2018 (NCB 2017). Second, property rights disputes make it harder for cattle producers to acquire or lease new farmland.

This study may assist Nicaragua cattle ranchers to maximize their return on investment by helping them being aware of the physical and lot characteristics cattle buyers are willing to pay premiums for. The study empirically quantified intrinsic and extrinsic factors that shape cattle prices at livestock auction sales in Nicaragua.

A hedonic regression model was estimated to capture the effect of the explanatory variables on the dependent variable basis. The *F*-statistic indicated that all the coefficients of the model are jointly statistically significant (p-value < 0.001), while the coefficient of determination (R^2) indicated that 63.35 % of the total variation in basis is explained by the independent variables of the regression model. This supports the claim of Trapp and Eilrich (1991) stating that the use of a basis model may further improve the results of the hedonic regression model in terms of variations between local cash prices and futures prices and potential endogeneity issues associated with these two variables.

All 15 independent variables were found statistically significant at the 0.01 probability level. The *Lotsize* variable had a slight negative effect on basis. The *WeightINV* variable suggested the relation between *Basis* and *Weight* increases at a decreasing rate. That is, heavier animals are discounted, but as weight increases the discount slowly decreases. Heifers were discounted compared to steers, everything else being held constant. Finally, the coefficients of the monthly dummy variables confirmed the suspected seasonal pattern. Compared to the month of January, cattle received discounts from June through December and premiums from February through May. This indicates periods where Nicaraguan cattle ranchers are susceptible or resilient to taxation or potential agricultural policies.

Recommendations for Further Research. Animal breed was not included in the hedonic regression model because it was not reported in the sales datasheets. Future research can examine breed-related premiums and discounts. Additionally, premiums or discounts do not necessarily lead to profits or losses since the volume of operation and the specific management practices vary for each cattle producer. A cost-benefit analysis may provide insight into assessing the profitability of specific quality attributes of cattle. Third, although women actively participate in cattle production in Nicaragua, they have yet to be excluded from training programs aiming to revamp the domestic cattle industry (TechnoServe-USDA 2016), which limits the success of these programs. A gender-inclusive approach is recommended for training, access to credit, and any other source of support that may hinder women's ability to thrive in the cattle business. Finally, value-added programs may help Nicaraguan cattle ranchers create additional value through improved management practices such as better record-keeping systems, source verification, and grazing style. These programs may allow cattle ranchers in Nicaragua to secure better cattle prices and increase their profits.

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