A HEDONIC ANALYSIS OF CATTLE PRICES IN NICARAGUA

A Thesis

by

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ABSTRACT

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Growing at an annual rate of 3.7%, the Latin American livestock sector has surpassed the average global livestock growth rate of 2.1% and has become the leading region for beef and poultry exports worldwide (Food and Agriculture Organization [FAO], 2020a). In this investigation, a case study of cattle prices in Nicaragua, the leading meat-producing country in Central America, is conducted. Nicaragua's cattle production is non-intensive and exhibited a growth rate of 24% between 2017 and 2018 (Nicaraguan Central Bank [NCB], 2018). Using data on futures on feeder cattle prices from the Chicago Mercantile Exchange Group (CME) supplemented with data on 2,520 sales transactions from 99 auctions from 2017 to 2018 from the Nicaraguan Cattle Auction (NCA), this study conducts a hedonic price analysis for cattle auctioned in Nicaragua. While in a previous study, we used cash price as the independent variable, following Trapp and Eilrich (1991), we used a basis approach in the present study to further improve the regression model. A basis model has been found to be a better risk management tool as variations between cash prices and futures prices are reduced. In particular, the study empirically identifies factors affecting price differentials for cattle. The estimation results show that weight, lot size, and sex are among statistically significant factors impacting cattle auction prices. The results of the study are of importance to buyers and sellers of cattle in their decision-making process and help them understand information from the futures market to predict price differences and reduce price risk and uncertainty.

Keywords: hedonic analysis, feeder cattle, futures market, livestock auction data, Nicaragua

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INTRODUCTION

1.1 Latin America

In Latin America, which includes Spanish America and Brazil or all the Americas South of the U.S. (Merriam-Webster, 2020), the livestock industry is very important in terms of food security, cultural traditions, and ecosystems' preservation. It is estimated that the average household in this region spends around one-fifth of its food budget on meat and dairy products and 46% of the agricultural Gross Domestic Product (GDP) of the region is derived from the livestock sector (Food and Agriculture Organization (FAO), 2020a). Moreover, cultural heritage and traditional values are preserved through livestock passed on with pride from past to future generations. The possession of livestock is important to this region as it also reaffirms current generations' ties to ancestral lands (Raish and McSweeney, 2003). In terms of biodiversity preservation, livestock contributes to ecosystem services by converting grass into milk or meat, by grazing and producing dung and urine and by moving around, responding to fluctuations in resource availability (FAO, 2020b).

Growing at an annual rate of 3.7%, the Latin American livestock sector has surpassed the average global livestock growth rate which is 2.1% (FAO, 2020a). As a result, they have become the leading region for beef and poultry exports worldwide (FAO, 2020a). Together, Latin America and the Caribbean account for 13.5% of the world population but produce 21.4% of poultry and 23% of beef and buffalo meat globally (FAO, 2020a).

Despite the progress in the livestock sector in Latin America, the region faces several challenges. One of them is the high costs of animal feed, which represents between 60 and 70% of total production costs under an intensive production model (TechnoServe-USDA, 2016).

Moreover, productivity is restrained as a consequence of limited quality forage supply and inefficient use of available food resources mainly related to low production density. For instance, Nicaragua has the lowest production density in the region (2.82 cows per acre) despite being the leading country in beef exports in Central America (TechnoServe-USDA, 2016). Also, due to the steady trading of live animals, there is an increasing risk of transboundary pests and diseases spread throughout the Central American region. Another factor that also tends to offset the growth of this agricultural sector is climate change along with its negative effects on production (FAO, 2020a).

1.2 Central America

1.2.1 Beef Production, Consumption, and Trade in Central America

For the period 2014-2019, beef production increased by 5.3% in El Salvador (from 19 to 20 thousand of Metric Tons Carcass Weight Equivalent (MT CWE)), followed by Honduras (from 63 to 65 thousand of MT CWE or 3.2%), Nicaragua (from 161 to 165 thousand of MT CWE or 2.5%) and Guatemala (from 72 to 73 thousand of 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 of MT CWE) and 1.1% (from 88 to 87 thousand of MT CWE), respectively (United States Department of Agriculture [USDA] – Foreign Agricultural Service [FAS], 2020).

Over the last five years (2014-2019), Central America[1] witnessed an increase of 4% in beef consumption (from 335 to 347 thousand of MT CWE[2]), mainly because of a sharp increase in consumption from Honduras and El Salvador (Central America Data, 2020). However, for the same period, beef consumption fell sharply in Nicaragua (from 34 to 17 thousand of MT CWE or

[1] Honduras, Nicaragua, El Salvador, Guatemala, Costa Rica and Panama.
[2] Carcass Weight Equivalent, i.e., the animal weight after slaughtering and processing.

50%). This is explained by the sharp increase in beef price in Nicaragua, where demand for meat is elastic as a vast majority of people live with less than one dollar per day in income. Beef price per pound rose from $2.46 to $2.68[3] between 2014 and 2019 (NCB, 2018). As a result, consumption per capita dropped from 12.04 to 5.73 pounds during the same period. Additionally, the decrease in beef consumption led to an increase in chicken consumption (126.2 to 145.15 thousand of MT CWE; NCB, 2018).

In terms of beef consumption, Guatemala is the leading country in the region (93 thousand of MT CWE) followed by Panama and Costa Rica, each of them with 71 thousand of MT CWE as of 2019. In El Salvador, for the period 2014-2019, beef consumption increased by 65% (from 40 to 66 thousand of MT CWE) followed by Guatemala (from 76 to 93 thousand of MT CWE or 22.4%) and Honduras (from 60 to 63 thousand of MT CWE or 5%). However, beef consumption in Nicaragua plunged by 50% compared to Panama and Costa Rica where it only dropped by 14% (from 82.2 to 71 thousand of MT CWE) and 4.1% (from 74 to 71 thousand of MT CWE), respectively (USDA-FAS, 2020; Economic Commission for Latin America and the Caribbean [ECLAC], 2020a).

For the same period, as a result of an increasingly growing demand for beef unmet by domestic production, beef imports skyrocketed in Guatemala by 177.8% (from 9 to 25 thousand of MT CWE) followed by El Salvador (from 21 to 46 thousand of MT CWE or 119%), Costa Rica (from 8 to 15 thousand of MT CWE or 87.5%) and Honduras (from 2 to 3 thousand of MT CWE or 50%). Meanwhile, beef imports in Nicaragua remained low and steady (1,000 MT CWE) and plummeted by 73% (from 1.5 to 0.4 thousand of MT CWE) in Panama (USDA-FAS, 2020; Economic Commission for Latin America and the Caribbean, 2020a). On the other hand,

[3] This is before inflation which was 27.59% over the same period. The numbers have been deflated using the CPI provided by the Nicaraguan Central Bank.

for the same period, Costa Rican and Nicaraguan beef exports grew by 40.9% (from 22 to 31 thousand of MT CWE) and 16.4% (from 128 to 149 thousand of MT CWE), respectively. For Guatemala and Honduras, beef exports remained low and steady at 5 thousand of MT CWE each (USDA-FAS, 2020). El Salvador and Panama in their case registered less than one-tenth of a metric ton meaning that they are mainly importers in this industry. Figure 1 provides a broad overview of the beef industry in Central America in 2019.

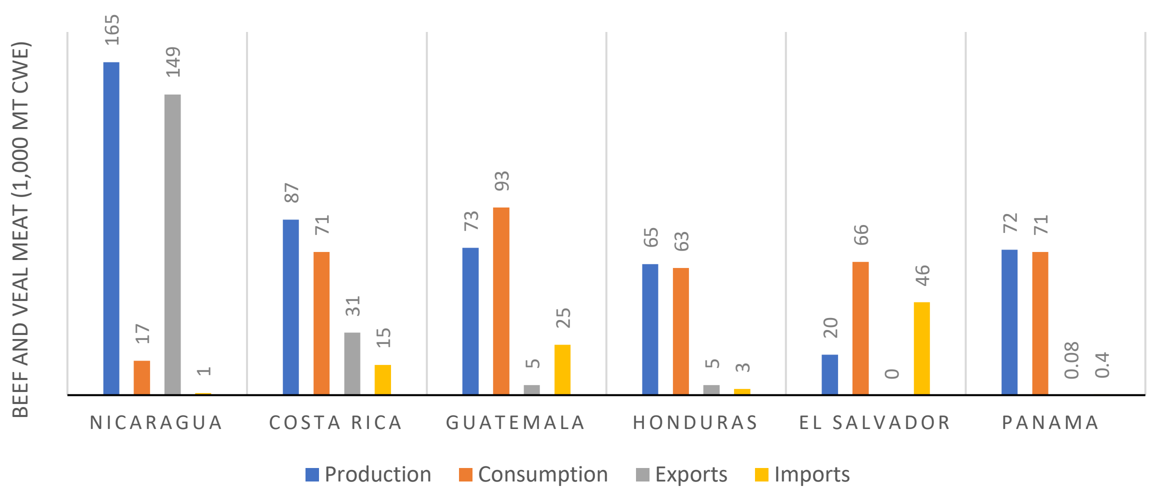

Figure 1. Beef and veal production, consumption, exports and imports by country in Central America in 2019.

Source: USDA-FAS, ECLAC and NCB Online Databases, computed by author.

1.2.2 Poultry Production, Consumption, and Trade in Central America

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 other types of meat relative to chicken. Honduras, Panama and El Salvador experienced the highest increase in chicken production with 30.2% (from 156.14 to 203.33 thousand of MT

CWE), 28.2% (from 169.45 to 217.2 thousand of MT CWE) and 26.2% (from 117.7 to 148.5 MT CWE), respectively (Asociación Latinoamericana de Avicultura [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 of MT CWE), 12.5% (from 123.7 to 139.2 thousand of MT CWE) and 6% (from 215 to 228 thousand of MT CWE), respectively (Avicolatina, 2020; USDA-FAS, 2020). It should be pointed out that Guatemala is the leading chicken producer in the region.

Poultry is the most consumed meat in Central America, as of 2019, with an average volume of 64% (1,241 thousand of MT CWE) followed by beef (381 thousand of MT CWE or 20%) and swine (323 thousand of MT CWE or 17%) (Avicolatina, 2020; United Nations [UN] COMTRADE Database, 2020). For the period 2014-2019, domestic consumption of poultry grew in all of the countries in Central America with Honduras exhibiting the highest percent increase (from 165 to 215 thousand of MT CWE or 30.3%) followed by Panama (from 176 to 223 thousand of MT CWE or 26.7%) and El Salvador (from 123 to 154 thousand of MT CWE or 25.2%) (Avicolatina, 2020; UN COMTRADE Database, 2020). For the same period, respective consumption growth rates in Costa Rica, Guatemala and Nicaragua were 19.4% (from 124 to 148 thousand of MT CWE), 19.3% (from 295 to 352 thousand of MT CWE) and 12.9% (from 132 to 149 thousand of MT CWE), respectively. Guatemala is the largest producer, importer, exporter (22^{nd} place worldwide) and consumer of poultry in the region as of 2019 (Avicolatina, 2020; UN COMTRADE Database, 2020).

For the period 2014-2019, chicken meat exports decreased in several countries of Central America as the production failed to meet the increasing domestic consumption. Costa Rica exhibited the highest decrease (from 1.9 to 0.87 thousand of MT CWE or 54.2%), followed by

El Salvador (from 2.3 to 1.3 thousand of MT CWE or 43.5%) and Honduras (from 2.5 to 1.5 thousand of MT CWE or 40%) (UN COMTRADE Database, 2020). Surprisingly, chicken exports skyrocketed by 700% (from 0.05 to 0.4 thousand of MT CWE) in Panama (UN COMTRADE Database, 2020). Guatemala, in turn, witnessed an increase of 14.3% (from 7 to 8 thousand of MT CWE) (USDA-FAS, 2010).

On the other hand, for the same period, demand for chicken meat increased in all of the countries of Central America. With an expansion of 1400% (from 0.05 to 0.75 thousand of MT CWE), Panama exhibited the largest chicken import growth rate followed by Costa Rica (from 5.1 to 12.4 thousand of MT CWE or 143.1%), Guatemala (from 87 to 132 thousand of MT CWE or 51.7%), El Salvador (from 11.2 to 14.8 thousand of MT CWE or 32.1%), Honduras (from 11.4 to 14 thousand of MT CWE or 22.8%) and finally Nicaragua (from 4.8 to 5.7 thousand of MT CWE or 18.8%) (ECLAC, 2020a; USDA-FAS, 2020).

Also, as of 2019, poultry was the most imported meat in the region in terms of total meat imports with an average volume of 46% (179.65 thousand of MT CWE) followed by swine (124 thousand of MT CWE or 32%) and beef (90 thousand of MT CWE or 23%). Figure 2 provides a broad overview of the poultry industry in Central America in 2019.

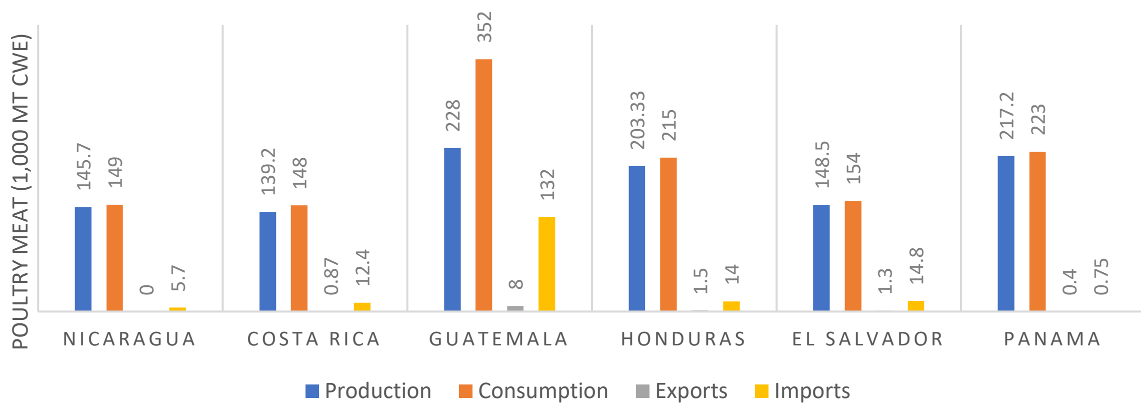

Figure 2. Poultry production, consumption, exports and imports by country in Central America in 2019.

Source: USDA-FAS, ECLAC and NCB Online Databases, computed by author.

1.2.3 Swine Production, Consumption, and Trade in Central America

In terms of swine meat or pork, for the period 2014-2019, production remained steady in Guatemala (62 thousand of MT CWE). Panama experienced an unprecedented increase of 35.3% (from 34 to 46 thousand of MT CWE), followed by Nicaragua (from 10 to 12 thousand of MT CWE or 20%) and Costa Rica (from 55 to 63 thousand of MT CWE or 14.5%). Honduras and El Salvador have seen their production collapsed by 23.1% (from 13 to 10 thousand of MT CWE) and 22.2% (from 9 to 7 thousand of MT CWE), respectively. Together, in 2019, Costa Rica, Guatemala and Panama had an average volume of 85.5% of the total production in Central America (FAOSTAT, 2020a; USDA-FAS, 2020).

Although pork is the least consumed meat in Central America compared to beef and poultry, over the last 6 years (2014-2019), consumption has grown surprisingly by 40.4% (from 242 to 323 thousand of MT CWE) (UN COMTRADE Database, 2020; USDA-FAS, 2020). Such rapid growth has been boosted primarily by domestic consumption in Honduras (from 32 to 55 thousand of MT CWE or 71.9%) followed by Nicaragua (from 12 to 19 thousand of MT CWE or 58.3%) and Panama (from 48 to 70 thousand of MT CWE or 45.8%) (UN COMTRADE Database, 2020; USDA-FAS, 2020). For the same period, domestic consumption has grown at a relatively lower rate in El Salvador (from 14 to 18 thousand of MT CWE or 28.6%), Costa Rica (from 60 to 74 thousand of MT CWE or 23.3%) and Guatemala (from 76 to 87 thousand of MT CWE or 14.5%) (UN COMTRADE Database, 2020; USDA-FAS, 2020).

As a result of the high increase in demand for swine meat in Central America, for the period 2014-2019, total imports have climbed at unprecedented rates. Four out of the 6 countries in Central America have doubled their swine imports. Starting with Nicaragua with a massive increase of 250% (from 2 to 7 thousand of MT CWE) followed by Honduras (from 19 to 45 thousand of MT CWE or 136.8%), Costa Rica (from 5 to 11 thousand of MT CWE or 120%) and El Salvador (from 5 to 11 thousand of MT CWE or 120%) (UN COMTRADE Database, 2020; USDA-FAS, 2020). With respective rates of 73.3% (from 15 to 26 thousand of MT CWE) and 71.4% (from 14 to 24 thousand of MT CWE), Guatemala and Panama swine imports lagged behind (UN COMTRADE Database, 2020; USDA-FAS, 2020). Unfortunately, Central America is not at a level to compete with other regions in the world in terms of swine exports. For the period 2014-2019, exports have decreased by 20% (from 1.42 to 1.13 thousand of MT CWE). Guatemala by itself exports only 1,000 MT CWE of pork which represents 88% of total swine exports in the region (UN COMTRADE Database, 2020; USDA-FAS, 2020). It has to be emphasized that Honduras, El Salvador and Panama did not export any swine meat for the same period (UN COMTRADE Database, 2020; USDA-FAS, 2020). Figure 3 provides a broad overview of the swine industry in Central America.

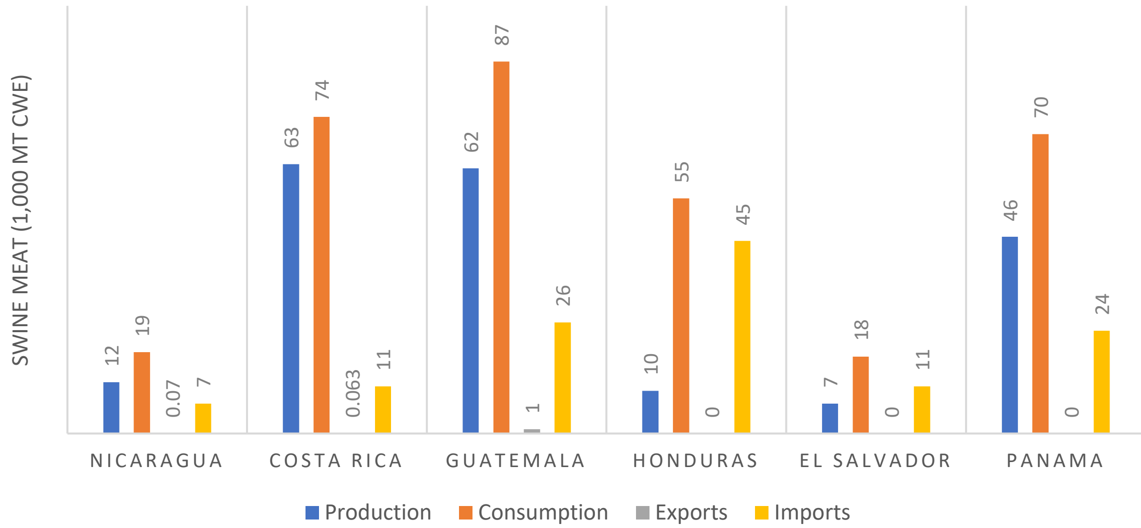

Figure 3. Swine production, consumption, exports and imports by country in Central America in 2019.

Source: USDA-FAS, ECLAC and NCB Online Databases, computed by author.

1.3 Nicaragua

As of 2016, Nicaragua had approximately 135,000 cattle ranchers with 90% of them being small-sized producers (TechnoServe-USDA, 2016). On 3.26 million hectares[4] of land, they raise nearly 5 million head which puts them in first place in Central America in terms of total number of head (TechnoServe-USDA, 2016). It needs to be noted that the vast majority of Nicaraguan cattle ranchers run dual-purpose businesses which means they are milk sellers on a daily basis and meat or live cattle sellers intermittently (TechnoServe-USDA, 2016).

According to the Nicaraguan Central Bank (2018), the number of cattle slaughtered in 2017 increased by 23.7% (from 695,230 to 860,000 head), followed by pigs (from 223,800 to 240,000 head or 7.2%) and chicken (from 66.92 to 69.6 million head or 4%). In terms of meat,

[4] A hectare is equal to 2.471 acre in the British Imperial System.

beef production grew up by 24% (from 118.89 to 147.42 thousand of MT CWE), followed by swine (from 11.43 to 12.56 thousand of MT CWE or 9.9%) and poultry (from 138.94 to 140.75 thousand of MT CWE or 1.3%) (NCB, 2018).

Nicaragua consumes only 10.7% (15.88 thousand of MT CWE) of the total beef it produces which makes it self-sufficient and an exporter in this industry as of 2017 (NCB, 2018). The remaining production consisting of 129.55 thousand of MT CWE (annual increase of 10.5%) of beef and offal was exported earning the economy a total of $500 million. Additionally, it exported 35,000 head of live cattle which represented an increase of 28.10% (NCB, 2018). Hence, Nicaragua is the leading country in Central America in terms of beef exports and occupies the thirteenth place worldwide. It exports approximately five times more beef than its next competitor, Costa Rica, and 3.6 times more beef than all the countries of Central America combined in 2019 (USDA-FAS, 2020).

In 2017, pork (swine meat) consumption increased by 3% in Nicaragua (from 18.19 to 18.73 thousand of MT CWE; NCB, 2018), while domestic pork consumption is nearly 50% higher than national production. As a result, total pork imports amounted to 6.58 thousand of MT CWE.

Similarly, regarding poultry consumption, the country is not self-sufficient but will be over time according to trends in production. The total poultry imports in 2017 were 4.4 thousand of MT CWE which represents the 3% surplus in poultry consumption compared to poultry production (145.15 versus 140.75 thousand of MT CWE; NCB, 2018).

As you can see in Figure 4, the cattle industry is a key element in improving the Nicaraguan economy as the production is almost 10 times more than the domestic consumption. Their top three import markets for meat and edible meat offal are the US followed by Costa Rica and Honduras whereas the top three export markets for the same commodities are the United States followed by Venezuela and El Salvador (UN COMTRADE Database, 2020).

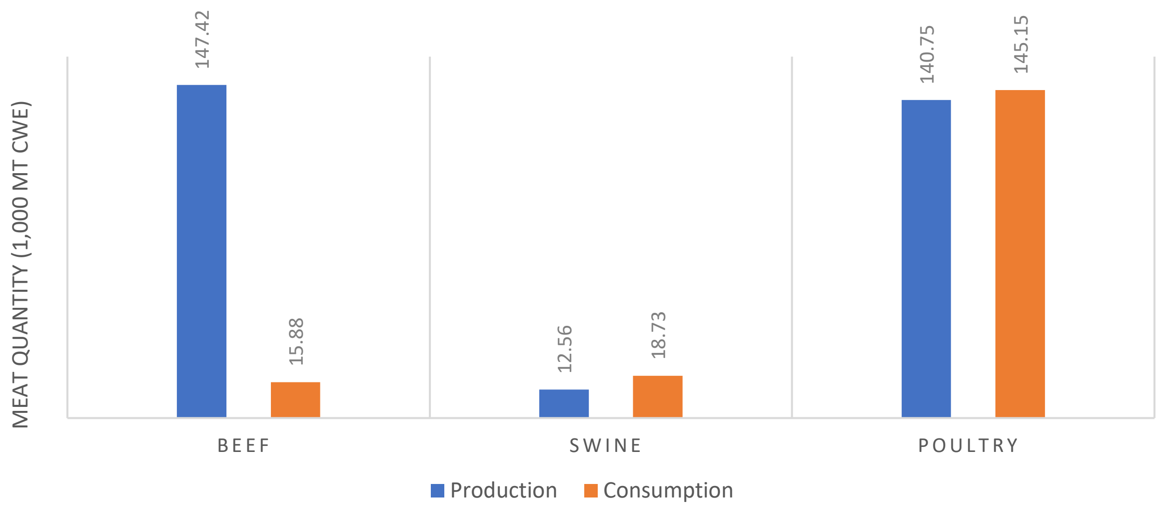

Figure 4. Meat production and consumption in Nicaragua in 2017.

Source: USDA-FAS, ECLAC and NCB Online Databases, computed by author.

According to ECLAC (2020b), 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 (Central Intelligence Agency, 2020). As of 2017, 31.1% of the workforce was employed in agriculture, which represented a total of nearly one million jobs (FAOSTAT, 2020b).

1.4 Statement of the Problem

The cattle industry in Nicaragua faces multiple challenges despite its relevance to the national economy. First, land for cattle production in Nicaragua is underutilized as the country sets records for having the lowest cattle production density in Central America (2.82 cows per acre) which is mainly a result of a lack of investment in this sector (TechnoServe-USDA, 2016). Second, over 35% of all lands in Nicaragua is subject to conflicting claims (Landlinks-USDA, 2020). A series of ongoing property right disputes for farmlands across the country decreases confidence to invest in farms and negatively affects agricultural productivity overall. Nicaraguan cattle producers have adopted mainly an extensive cattle production model which is characterized by a low productivity per animal and per area. As such, cattle herd expansion is highly correlated with increases in land use. Given the growth trends in cattle production, it may eventually spread over protected lands rich in arable soil as the country is struck by more and more severe drought seasons (Central America Data, 2021). As the sustainability of the cattle industry in Nicaragua is at risk, in order to remain in business, cattle producers need to start the shift towards the adoption of a more intensified cattle production model. However, since land expansion is limited, such an intensification implies an increase in investments in the cattle industry. As such, in order to maximize their return on investment, it is crucial for Nicaraguan cattle ranchers to know and understand the extent of the premiums that cattle buyers are willing to pay for physical and lot characteristics.

This study examines how cattle prices in Nicaragua are affected by cattle physical and lot characteristics. By using basis (cash prices minus futures prices) as a powerful predictive tool accounting for volatility, this study also analyzes the extent to which Nicaraguan cattle ranchers could benefit from a better understanding of the relationship between cash and futures prices to manage risk. The study may 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.

1.5 Purpose of the Study

The purpose of the study is to empirically identify the factors affecting cattle auction price differentials using data from Nicaragua Cattle Auction (NCA) and data on cattle closing prices from the Chicago Mercantile Exchange (CME) Group. Several factors influence cattle auction prices from NCA, including feeder cattle futures price, weight, number of head sold, and the sex of feeder cattle. This study will analyze the value of individual traits and characteristics of cattle from NCA and its relationship with the futures market. 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. Specifically, a hedonic analysis allows for a better understanding of the most important animal characteristics.

1.6 Objectives

The general objective of this study is to identify and empirically quantify both intrinsic and extrinsic factors that determine cattle prices in auction sales in Nicaragua. The specific objectives are to:

1. Examine the literature on cattle price differential to develop an appropriate econometric model for analyzing NCA sales;
2. Conduct a hedonic regression analysis to adequately identify inherent market value for feeder cattle lot and physical characteristics;
3. Determine factors that affect prices of cattle from NCA using regression analysis;
4. Estimate price premiums or discounts associated with specific physical attributes of feeder cattle; and

5. Analyze the extent to which futures prices of the CME affect the basis resulting from cash prices given at cattle auction houses in Nicaragua.

1.7 Hypotheses

The following are two of the hypotheses that will be examined in this study:

1. Chicago Mercantile Exchange (CME) Futures markets have an effect on Nicaraguan Cattle Auction (NCA) cash markets.
2. Auctions prices depend on cattle physical and lot characteristics.

1.8 Limitations and Delimitations

The study uses data only from the major auction house in Nicaragua. The study could be improved by adding additional auction houses from Nicaragua or Central America. However, very few auction houses are willing to share price information for research purposes.

Moreover, 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.

1.9 Organization of Thesis Chapters

Chapter 1 provides an introduction and sets a background on Latin America livestock production, consumption, exports and imports by country with an emphasis on Nicaragua. Chapter 2 provides the literature review of similar studies and underlines their major findings. This chapter examines what other studies have done and will also be used to compare and contrast the findings from this study. Chapter 3 specifies the procedures and the model used to conduct the analysis and describes the data. Chapter 4 presents the estimation results from the model used. Finally, Chapter 5 provides the summary and conclusions, along with the recommendations for future research.

Chapter 2

REVIEW OF THE LITERATURE

Since the earlier 1900s, economists started using hedonic pricing models to estimate prices of commodities based on specific quality attributes. As of today, there are many studies in agricultural economics literature regarding their use. This study examines the different factors that have an impact on feeder cattle prices. The analysis of premiums and discounts is crucial for determining whether or not a particular characteristic justifies the increase or decrease in production costs. According to Waugh (1928), individual farmers cannot control the competition, but can control, to some extent, the quality of the commodities they produce. This proves how insightful hedonic pricing studies are to commodity farmers given their exposure to a very competitive market environment.

Compared to other agricultural sectors such as corn production where the whole production process occurs on a single farm, the beef industry, due to the difficulties of vertical integration, is divided into 4 different subsectors (cow-calf operations, stocker operations, feedlot operations, and slaughtering and packaging operations), each having its challenges and opportunities (Burdine, 2011). The cow-calf operators produce weaned calves and sell them to the stocker operators. These in turn, add weight to the calves and sell feeder cattle to feedlot operators that are in charge of marketing cattle ready for slaughter to beef packers. This last segment finally sells the processed meat to wholesalers and retailers. The final value of cattle in each of the subsectors deeply relies on the characteristics acquired in the last stage of production. This explains why, in the case of feeder cattle, it is necessary that stocker operators know the cattle traits feedlot operators are willing to pay a premium for. Feeder cattle are usually sold through auction markets where prices are set based on genetic, management, market, and marketing factors. As a result, hedonic price models are extremely useful to feeder cattle producers as they provide a solid correlation between price determination and the futures market.

Previous studies on this topic analyzed feeder cattle auction prices under two different approaches: the basis approach and the bid price approach (Burdine, 2011). The former is a result of cash prices minus future prices. When it is negative, it means that local prices are below the future prices and vice versa (Mintert et al., 2002). Compared to bid prices which are absolute price levels, basis is a more robust indicator as it implies less variation (Trapp and Eilrich, 1991; Bailey, Gray, and Rawls, 2002). Nevertheless, basis predictability reduces as we move further away from contract specifications (Dhuyvetter et al., 2008).

Factors affecting cash prices can be grouped into two categories: intrinsic or extrinsic (Mathews, 2007; Zimmerman, 2010; Burdine, 2011). The former refers to factors over which ranchers have control to some extent while the latter refers to factors that go beyond their control (also referred to in the literature as exogenous factors). Intrinsic factors comprise lot (size, commingling state,[5] uniformity, etc.), genetics (sex, breed influence, frame score,[6] color, frame size, horn presence, muscling, etc.), management (horn status, gonad status, health, condition score, nutrition program, vaccination program, parasite management practices, implant status,[7] etc.) and marketing (weight uniformity, sale date, delivery date, fill,[8] market location, source verification,[9] age-verification status, etc.) variables. Extrinsic factors, on the other hand, include market variables (diesel price, corn futures price, slaughter cattle price, etc.), seasonality and environment (snow, relative humidity, temperature, rain, mud, etc.).

[5] Practice that consists of mixing cattle from different operations.
[6] A numeric description of cattle skeletal size.
[7] Pellet placed under the animal skin to stimulate growth.
[8] Injection of liquid into the animal cavities to correct defects.
[9] Ability to trace cattle back to the farm where they were born.

Williamson, Carter, and Gaines (1961) used a five-year sales data of the Virginia auction market representing 9,481 lots of cattle to quantify the effect of sale size, average weight, lot size, grade and breed on the cash prices given for steers and heifers. According to their findings, the optimal weight range of feeder cattle was between 400 and 500 pounds and the optimal lot size for steers was between 21 to 30 head. Lopez, Bankole, and Wahrmund (2017) analyzed sales of pre-conditioned calves from 22 auctions in Northeast Texas to determine the prediction power of physical attributes with respect to price differentials (premiums and discounts) in feeder cattle. Weight, sex, lot size and breed, alongside feeder cattle futures prices, were among the variables that were found to be statistically different.

Generally speaking, corn price is one of the most significant, if not the primary driver, of feeder cattle prices, especially in countries where the growing cattle industry requires intensive production. This is because cattle are mainly corn-fed in their finishing phase. Using a breakeven simulation, Buccola (1980) estimated the effect of corn price on feeder cattle prices. He found that an increase in corn price leads to a decrease of breakeven price for feeder cattle. Similarly, Burdine (2011) found that a $1/bushel increase in corn price leads to a $2.97/ hundredweight (cwt) decrease in cattle prices. In spite of the negative effects of corn price on feeder cattle prices found in these previous studies, Schulz et al. (2010) did not find a significant effect of corn prices on feeder cattle price and hence, did not include it in their model.

Faminow and Gum (1986), using sales data for 368 lots of feeder cattle, found that the economic value of heifers was reduced after passing a 615-pound weight level. Additionally, they concluded that the lot weight that maximizes profit was 32,000 pounds which is close to truck capacity for transportation (40,000 pounds). However, they also acknowledge that optimal lot size may vary depending on the region and the season of the year. Moreover, according to the same study, light heifers received a premium compared to heavier ones. Schulz, Boetel and Dhuyvetter (2018) evaluated price-weight relationships for feeder cattle and concluded that lightweight cattle received premiums compared to heavyweight cattle. Consistent with Burdine (2011) and Faminow and Gum (1986), they also found an inverse relationship between cattle weight and prices.

Brown (1992), in contrast to Faminow and Gum (1986) , found that crossbred calves are more in demand than straightbred calves, especially straight Hereford or Brahman. According to the findings, calves with high percentages (over 25%) of dairy, Brahman and Hereford were subject to discounts compared to other crossbred calves. Mathews (2007) and Schulz et al. (2010) also found discounts in dairy-influenced breeds. It also should be pointed out that color description is a clue into the calf's breeding as they are highly correlated. Black and black-and-white cattle received a premium over red cattle (Schulz et al., 2010; Zimmerman, 2010; Burdine, 2011). Additionally, Mathews (2007) found a premium of $1.84/cwt in entirely black calves. However, compared to other characteristics, breed-related premiums are relatively small because, although related to tenderness, it does not guarantee it considered alone (Koohmaraie et al., 1996). Burdine (2011) highlighted that one of the challenges of price differentials related to breed is that some of them are more popular in certain areas, which may bias the final choice of bidders.

Feeder cattle demand is derived from fed cattle demand as feedlot operators are the last actors in the production chain. Schroeder et al. (1997) investigated the problems related to value-based fed cattle pricing, which indicated that the future market share of the beef industry relies on two important pillars: improved price discovery and vertical coordination. Moreover, a positive relationship was established between feeder cattle prices and fed cattle prices in a large number of studies (Dhuyvetter and Schroeder, 2000). In other words, these two variables move together. For instance, Mathews (2007) concluded that a $1/cwt increase in fed cattle futures prices is associated with a $1.15/cwt increase in feeder cattle prices.

According to Dunkel (2000), commingling can reduce sale time by approximately 30%, which benefits all of the parties involved. Moreover, they estimated that this practice is related to a premium of $7 to $8 per cwt per lot in comparison with non-commingled lots. Contrarily, Mathews (2007) analyzed the effects of explanatory variables on sale price using ordinary least squares regression hedonic model and found the following as significant: seasonality, cyclical effects, type of sale, lot size, sex, breed type, weight, corn price, commingling and fed cattle futures price. The results showed that, for lot size below 17 head, non-commingled lots of feeder cattle received a premium in comparison with commingled lots.

Mathews (2007) used sales data gathered over six years at Joplin Regional Stockyards to measure the value-added characteristics in feeder cattle. The empirical results from the study showed that feeder cattle sold through value-added programs received a premium compared to those sold through regular sales. Another interesting finding in her study was that commingled lots received a discount compared to non-commingled lots; however, the negative effect could be offset when lot size is at least 17 head. Williams et al. (2012) estimated the value of weaning, verification, certification, vaccinating and phenotypic traits at Oklahoma auctions, and they reported that vaccination programs and weaning lead to premiums of $1.44/cwt and $2.05/cwt, respectively.

Zimmerman (2010) conducted research using 14-year sales data from the Superior Livestock Auction (SLA) video market to determine the effect of value-added production on feeder calf prices. His study confirmed that premiums are received when health and genetic claims are verified. He also emphasized the importance of vertical coordination through the beef industry as it allows each of the sectors to capture better premiums as they focus their interests on what the final customer is willing to pay for. Furthermore, similar to Burdine (2011), he found premiums related to age and source verification (ASV). Burdine (2011) used Kentucky internet auctions and Certified Preconditioned for Health sales to examine factors affecting feeder cattle basis. He found premiums of $1.35 per cwt for age and source verification alone and $2.18 for natural designation alone. He also concluded that cattle certified as natural are 57% more likely to be age and source-verified. He also suggested that production costs have to be analyzed in the case of natural cattle, as opposed to age and source verification where only additional time is invested, because it implies a low gain in weight compared to other types of cattle production where growth hormones are used. That is, production costs in natural cattle are more expensive; therefore, a lower weight gain is observed relative to non-natural cattle.

Chapter 3

DATA AND ESTIMATION PROCEDURES

3.1 Model

3.1.1 Hedonic Pricing Model

Our hedonic model relies on the structure introduced by Ladd and Martin (1976), in which the hedonic price theory advocates that the value of a good is based on its physical characteristics. Hedonic prices represent the prices for individual attributes of a commodity as opposed to the price of the commodity itself (Rosen, 1974). Thus, the price of a commodity is the sum of the monetary values of its characteristics or features (Lancaster, 1966; Ladd and Martin, 1976). Rosen (1974) found that the value of such attributes was susceptible to market forces and characteristics. Adjoining the attributes of Rosen's (1974) market value susceptibility as well as Ladd and Martin's (1976) hedonic price theory allowed us to apply the base hedonic model used in this study as a function of the cattle physical characteristics (C) and the market forces (M) at the time of the sale (Buccola, 1980). Schroeder et al. (1988) formulated this relationship as follows:

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

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 and ε_t is the error term. The underlying assumption of this model is that, when supply is given, demand for feeder cattle relies on physical traits (Faminow and Gum, 1986).

Based on select variables recorded in the data, an ordinary least squares (OLS) regression is used to estimate the model, using SAS (Statistical Analysis Software) 9.4. The basis model proposed is expressed as:

$$Basis_{it} = \beta_0 + \beta_1 Lot_{it} + \beta_2 Lot_{it}^2 + \beta_3 Weight_{it} + \beta_4 Weight_{it}^2 + \beta_5 Heifer_{it} + \beta_6 Bull_{it} + \beta_7 February + \beta_8 March + \beta_9 April + \beta_{10} May + \beta_{11} June + \beta_{12} July + \beta_{13} August + \beta_{14} September + \beta_{15} October + \beta_{16} November + \beta_{17} December + \varepsilon_t \qquad (2)$$

where $Basis_{it}$ is the difference between cash price ($/cwt) given for the lot and corresponding futures prices from the CME for lot i in time period t, *Lot* is the number of head in the lot in question, Lot^2 is the lot size squared, *Weight* is the mean weight of cattle lot in pounds, $Weight^2$ is the mean weight squared, *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, βs are the parameters to be estimated and ε_t is the error term for each observation.

3.1.2 Expected Signs of Parameter Estimates

Lotsize is expected to have a positive effect on basis as exhibited in Table 1. In other words, basis increases as lot size increases. However, this relationship is non-linear as it reverses at a certain point (Burdine, 2011). Williamson, Carter, and Gaines (1961) found the optimal lot size to be between 21 and 30 head. This is why $Lotsize^2$ is also used as explanatory variable. It is expected to have a negative impact on basis as a result of diminishing marginal returns.

Weight is another predictor variable and 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). That is, there is an inverse relationship between feeder cattle weight and basis. The reason is that heavier cattle are less likely to gain weight. Similar to

Lotsize, the quadratic term is used for weight to capture its non-linear relationship with basis (Faminow and Gum, 1986), and therefore *Weight*^{2} is expected to have a positive sign.

Heifer is a dummy variable which takes on 1 when cattle is heifer and 0 otherwise (for steer). It has been found consistently in literature that heifers are discounted compared to their male counterparts (Mathews, 2007; Zimmerman, 2010; Burdine, 2011). As such, heifer is expected to have a negative coefficient.

Bull is another binomial predictor variable. It takes on 1 only when the animal is found to be a bull and 0 otherwise. Its parameter estimate is expected to have a negative sign since bulls are usually discounted relative to steers (Schulz et al., 2010; Williams et al., 2012).

Month is a variable that has been included in the study to account for seasonality. It is used as a dummy variable with January being the base month. It equals 1 for all of the months of the year except for January where it is 0. As a result of cattle supply closely related to feed availability and costs, feeder cattle prices tend to be higher during the dry season and lower during the rainy season as large sales volume leads to weaker prices. Based on that, the months of the rainy season are expected to have a negative coefficient.

Table 1. *Expected signs of coefficients based on prior studies.*

Variable Name	Sign	Prior Studies
Lot	+	Mathews (2007), Burdine (2011)
Lot^2	-	Faminow and Gum (1986), Burdine (2011)
Weight	-	Zimmerman (2010), Schulz et al. (2018)
Weight^2	+	Zimmerman (2010), Burdine (2011)
Heifer	-	Eldridge (2005), Mathews (2007)

Table 1 (continued)

Variable Name	Sign	Prior Studies
Bull	-	Schulz et al. (2010),Williams et al., (2012)
February	+	*
March	+	*
April	+	*
May	+	*
June	-	*
July	-	*
August	-	*
September	-	*
October	-	*
November	-	*
December	+	*

Note: *Sign is based on whether the season is dry or rainy and January is the base month.

3.1.3 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 whether the three aforementioned assumptions were violated.

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 when two or more explanatory variables move together given their nature. Looking at the correlation coefficients between pairwise variables is a preliminary way of determining 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 using the following formula:

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

where R_j^2 is the R-squared obtained after regressing the j^{th} independent variable on the remaining predictors. As a general rule of thumb, VIFs close to or higher than 10 reveals the presence of multicollinearity. The variables *Lotsize*, $Lotsize^2$, *Weight* and $Weight^2$ were found to have VIFs between 9 and 20. However, similar to Burdine (2011), these variables were included in the model since they are crucial to understanding the effects of cattle characteristics on basis.

Autocorrelation is another possible violation of the OLS assumptions that is usually common in time-series data. Autocorrelation measures the degree to which a set of current values of a variable is correlated to the same values recorded at different points in time. A very common test used in literature to detect and assess the level of correlation in datasets is the Durbin-Watson statistic. Its results range between zero and four with two indicating the absence of autocorrelation, less than two positive autocorrelation and more than two negative correlation. 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 1.072 which suggests the presence of a positive autocorrelation. The first order autocorrelation detected was corrected with the PROC AUTOREG in SAS 9.4.

Last, heteroscedasticity is also a possible violation of the OLS regression models' assumptions. Heteroscedasticity occurs when variances across individual observations of a sample are not constant and is also common in time-series data. The ARCHTEST option was used with the PROC AUTOREG in SAS 9.4 to test for heteroscedasticity. This test reported p-values for lags ranging from 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 specified within the PROC AUTOREG to eliminate the effects of heteroscedasticity.

3.2 Data

3.2.1 Nicaraguan Cattle Auction Houses

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. 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 that is similar in the other two cattle auction houses in the country, Suganar and La Chontaleña. The requirements for sellers to feature their animals are quite simple compared to developed countries such as the United States. According to Comergasa's manager, it is required for every animal to possess their traceability ear tags and that the sellers demonstrate ownership by presenting their legal documents. 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 were provided for the years 2017 and 2018; however, only several months were obtained for the years 2015, 2016, and 2019. Since the 2017 and 2018 data exhibited seasonal patterns, the years 2015, 2016 and 2019 were discarded due to being incomplete and not representative, leaving us with 2,520 out of the initial 3214 observations. The cattle sold are delivered on the same day and check payments from buyers are received previous to the auction date. Refunds are made or additional check payments requested depending on whether the actual purchase amount was above or below the initial payment issued. The main bidders are slaughterhouses' representatives, local butchers, intermediaries and independent producers.

3.2.2 Comergasa Cattle Auction Data

The 2,520 transactions for the period 2017-2018 represented 2,520 different lots encompassing a total of 34,408 head of cattle. Steers and heifers accounted for the highest frequencies, 57.38% and 33.22%, respectively (Figure 5). In turn, bulls represented 6.86%, oxen 2.11% and cow/calf pairs[10] lagged behind with 0.43%. Given this low percentage of cow/calf pairs and the fact that their number is not representative, they were removed from the analysis. Bulls and oxen were grouped under one category, which is similar to Schulz et al. (2010), and therefore all oxen were treated as bulls in our hedonic model as they account for almost 10% of the data.

[10] By cow/calf pairs, we refer to cows exhibited with their recently borne calves.

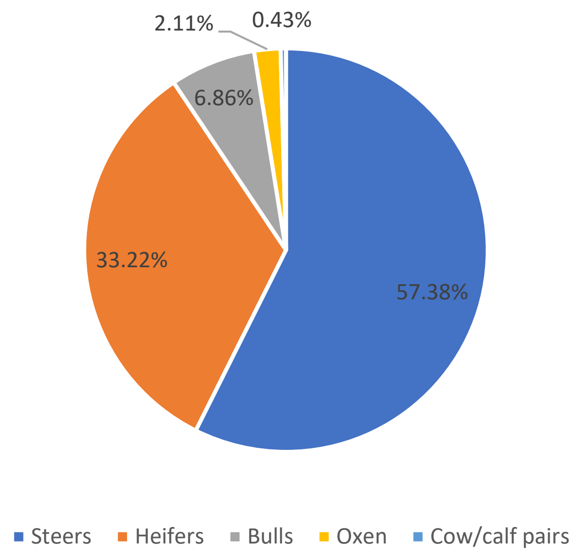

Figure 5. Distribution of cattle categories reported in the data (2017-2018).

Overall, the summary statistics in Table 2 show a mean lot of 16.02 animals per lot, ranging widely from 1 to 179 head. The mean weight per head across all lots was 849.61 lb and ranged from 55.13 to 2,039.27 lb. Cash prices across lots averaged $70.79[11] per cwt and ranged from $13.07 to $153.03. Figure 6 exhibits the average price ($/cwt) per category per auction ID for the period 2017-2018. Cash prices tend to increase from the beginning of the year up to July and tend to decrease for the remaining months of the year. Table 3 reports the descriptive statistics of select variables by sex. The difference between the price means is $14.22 per hundredweight and the difference between the average weights is 205.91 pounds with heifers having the lowest averages in both cases.

[11] Prices were converted from Córdobas (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 per kilogram to per hundredweight.

Table 2. *Summary statistics from Comergasa sales and CME future prices, 2017-2018.*

Variable	Mean	Std. Dev.	Min.	Max.
Lot size (head)	16.02	23.87	1.00	179.00
Live weight (lb)	849.61	417.21	55.12	2039.27
Cash price ($/cwt)	70.79	11.72	13.07	153.03
January Futures	136.31	10.95	110.85	161.53
March Futures	134.93	10.32	109.25	158.35
April Futures	135.07	10.66	109.18	158.33
May Futures	135.15	10.95	108.90	157.60
August Futures	140.73	12.36	109.90	160.10
September Futures	142.21	12.44	109.53	159.35
October Futures	143.39	12.00	111.75	159.18
November Futures	144.35	11.30	116.40	160.88
Steers' prices ($/cwt)	72.11	11.63	13.07	153.03
Heifers' prices ($/cwt)	59.63	9.21	21.57	92.80
Bulls' prices ($/cwt)	76.21	6.80	42.19	101.31

Table 3. *Summary statistics by sex from Comergasa sales for the period 2017-2018.*

	Male bovine (Steers and Bulls)				Female bovine (Heifers)			
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Cash price ($/cwt)	73.85	10.08	13.07	153.03	59.63	9.21	21.57	92.80
Lot size (head)	16.47	21.49	21.49	137.00	30.64	34.26	1.00	179.00
Live weight (lb)	831.81	418.97	55.12	2039.27	625.90	356.00	55.12	1818.81

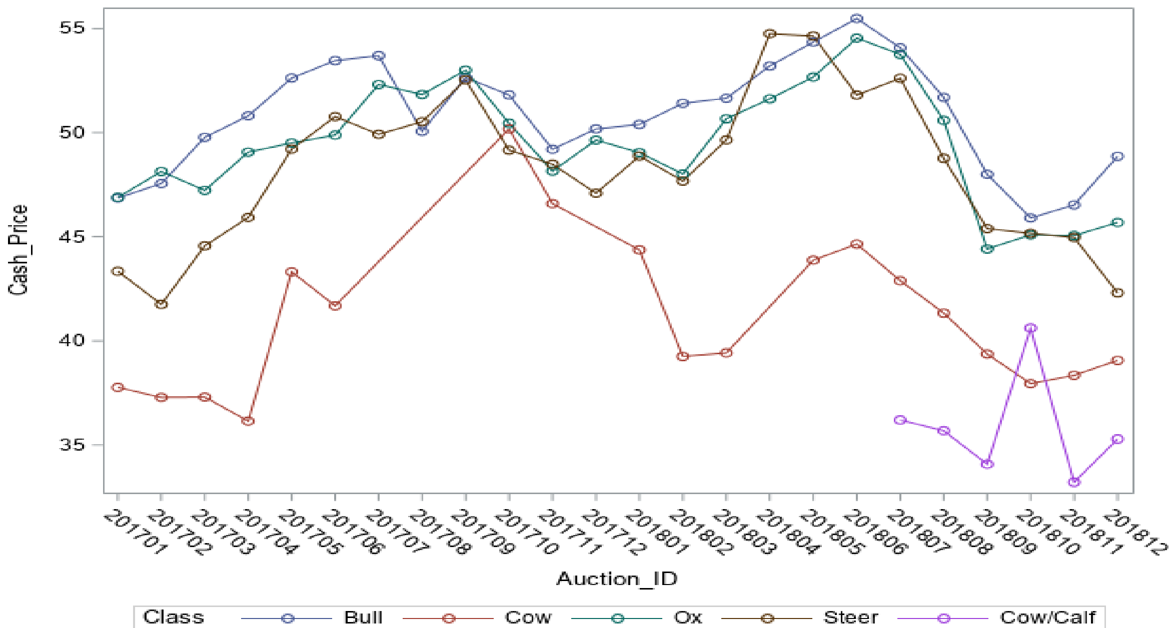

Figure 6. Average price per hundredweight (cwt) per category per auction ID for the period 2017-2018.

3.2.3 Futures Feeder Cattle Data

Closing daily feeder cattle futures prices were 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 price per cwt for each of these months for the period 2017-2018 are reported in Table 2 and Figure 7, and reflects the monthly trend of futures prices for the same period. As can be seen, futures prices for the second half of the year are greater compared to the first half of the year. 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. Descriptive statistics from CME futures for the period 2017-2018 are reported in Table 2.

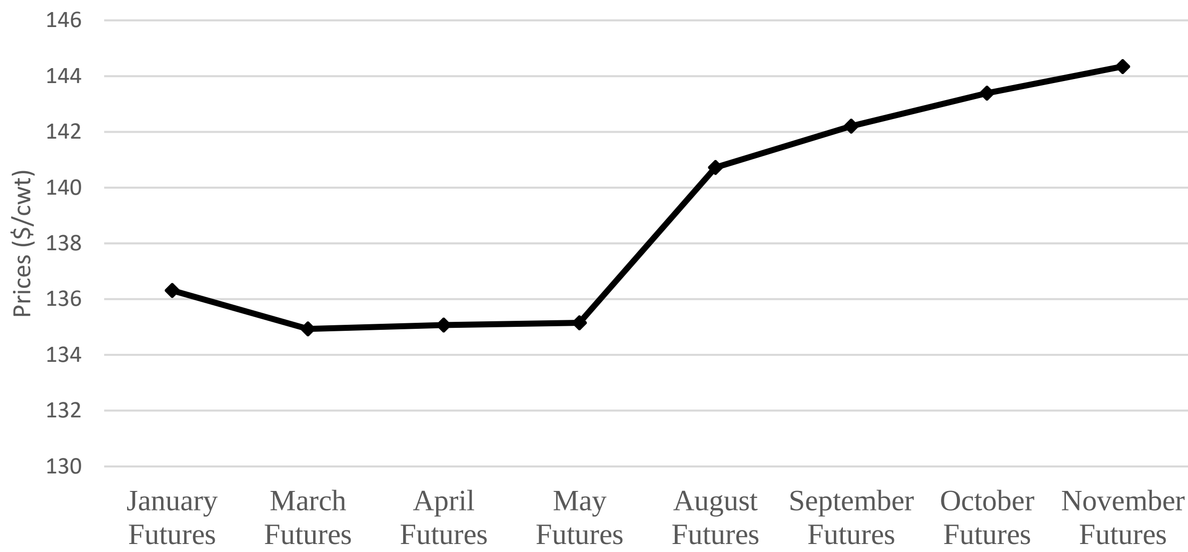

Figure 7. Average feeder cattle futures prices ($/cwt) per month for the period 2017-2018.

Chapter 4

PRESENTATION OF FINDINGS

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. The PROC REG procedure of the 9.4 version of Statistical Analysis System (SAS) was utilized to estimate the regression model. Moreover, in order to account for lot size, the keyword WEIGHT was included in the PROC REG. This is an important step because the sale of a lot is recorded as a single observation, regardless of the number of animals in the lot. Table 4 reports the coefficients of the explanatory variables used in the OLS regression model, along with their associated standard errors, *t* values and *p*-values. The *F*-statistic and the *R* squared are also provided in Table 4. The values of the coefficients for each of the variables, excluding the monthly dummy variables, indicate the extent of the premiums or discounts related to that variable. Stated differently, they can be interpreted as an increase or decrease in basis ($/cwt) when the explanatory variable value goes up by 1 unit, everything else being held constant. The *F*-statistic of over 260 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. As such, 63.86% of the variation in the dependent variable (i.e., basis) is explained by the model.

Table 4. *Ordinary Least Squares parameter estimates from livestock auction house Comergasa in Nicaragua, 2017-2018.*

Variable	Parameter Estimate	Standard Error	*t* statistic	*p*-value
Intercept	-67.0143**	1.1380	-58.8900	<0.0001
Lotsize	0.1106**	0.0244	4.5300	<0.0001
Lotsize^2	-0.0011**	0.0002	-4.8300	<0.0001
Weight	-0.0139**	0.0028	-5.0200	<0.0001
Weight^2	0.0000**	0.0000	5.6800	<0.0001
Heifer	-13.9002**	0.4616	-30.1100	<0.0001
Bull	0.8246	0.9656	0.8500	0.3932
February	4.8232**	0.9997	4.8200	<0.0001
March	9.5711**	0.9633	9.9400	<0.0001
April	7.2353**	1.5958	4.5300	<0.0001
May	6.1927**	1.0309	6.0100	<0.0001
June	-2.1101*	1.1116	-1.9000	0.0578
July	-3.6563**	0.9003	-4.0600	<0.0001
August	-9.0474**	0.8703	-10.4000	<0.0001
September	-17.4197**	0.9466	-18.4000	<0.0001
October	-15.1161**	0.9003	-16.7900	<0.0001
November	-13.6121**	0.8971	-15.1700	<0.0001
December	-10.9129**	0.9828	-11.1000	<0.0001
R^2	0.6386			
F-statistic	260.04			<0.0001

Note: * and ** denote statistical significance at the 0.1 and 0.01 levels, respectively.

The value of the intercept is minus 67.01 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 $67.01/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 variables (i.e, *Lotsize*, $Lotsize^2$) and the physical characteristic variables (i.e., *Weight*, $Weight^2$, *Heifer*, and *Bull*) had their respective expected signs (Tables 1 and 4), except for the *Bull* coefficient. Overall, all the seventeen parameter estimates of the variables of the hedonic model used were statistically significant at the 0.001 probability level, including the seasonal dummy variables (i.e., the included dummy variables for the months of February to December), except for the variables *Bull* and the dummy variable of *June*.

The variable *Lotsize* has a positive and statistically significant coefficient as expected (p-value < 0.0001). With respect to the coefficient of the quadratic version of the variable *Lotsize*, it was found to be negative and statistically significant also (p-value < 0.0001). The respective signs of the *Lotsize* and $Lotsize^2$ variables suggest a non-linear relationship between *Lotsize* and basis. Basis starts increasing at a decreasing rate as *Lotsize* increases but eventually reaches a maximum point and gradually decreases (Figure 8). In fact, an increase of *Lotsize* in one additional head induces basis to go up by $0.07/cwt, *ceteris paribus*. Such results are consistent with Mathews (2007) and Burdine (2011) studies. Similar to the calculations done by Mathews (2007) and Burdine (2011), the optimal lot size is 48 head of cattle after which the premium received gradually decreased (Figure 8). Optimal lot sizes obtained in Missouri and Kentucky by Mathews (2007) and Burdine (2011) were 133 and 328 animals per lot, respectively. One of the factors that have a direct impact on optimal lot size is transportation capacity, as moving cattle from one spot to another implies considerable expenses. According to Mintert (2001), buyers strongly prefer lot sizes that will fit in a single truckload. At Comergasa, the most common cattle transportation means are trucks that can be filled up to 6,500 kilograms. Considering the average weight of cattle head implied by the data (385 kg), maximum truck capacity is attained between 16 and 17 head of cattle. The optimal lot size obtained in the analysis (48 head of cattle) is a sign that bidders try to optimize transportation costs by buying lot sizes that are multiples of truck capacity.

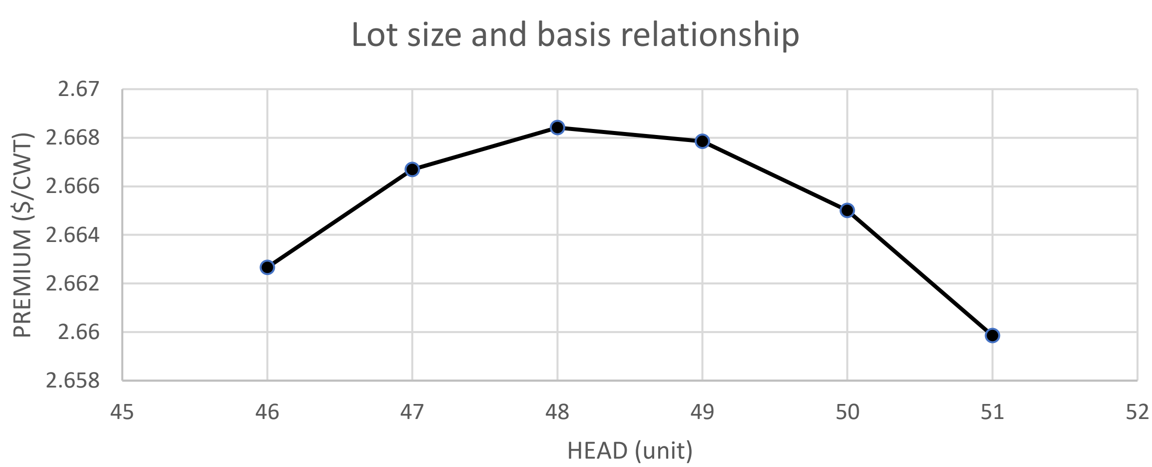

Figure 8. Visual representation of the maximum premium given for lot size at Comergasa using a basis model, 2017-2018.

The variable *Weight* has the expected negative sign and the variable *Weight*^{2} has the expected positive sign (Tables 1 and 4). Both of them were found to be statistically significant at the 0.001 probability level. Unlike the variable *Lotsize*, the relationship between *Weight* and *Basis* is statistically significant, but very low (parameter estimate < 0.0001). Any possible nonlinear relationship is captured by the negative coefficient of the quadratic version of the

Weight variable. Since the *Weight*^{2} variable is practically insignificant, the -0.014 coefficient of the *Weight* variable suggests that for every additional weight gain of one pound, basis goes down by $0.005/cwt, everything else being held constant. A discount ($0.025/cwt) was found by Burdine (2011) for a one-pound increase in feeder cattle weight in Kentucky from 2008 through 2011. The very low value of the *Weight*^{2} coefficient (0.00001128) means that the change in slope (change in basis over change in weight) of the curve is very minimal for each additional weight gain of one pound. 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). In short, the lighter the animal, the higher 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. Moreover, in the case of Nicaragua, cattle nutrition and health records are unavailable most of the time. As a result, this lack of animal records triggers cattle buyers' uncertainty regarding the acquisition of heavy cattle. The results from the analysis of the *Weight* and *Weight*^{2} variables revealed that the highest discount related to weight is given at 613 lb (Figure 9). From this point onward, such penalty decreases and eventually gets close to zero.

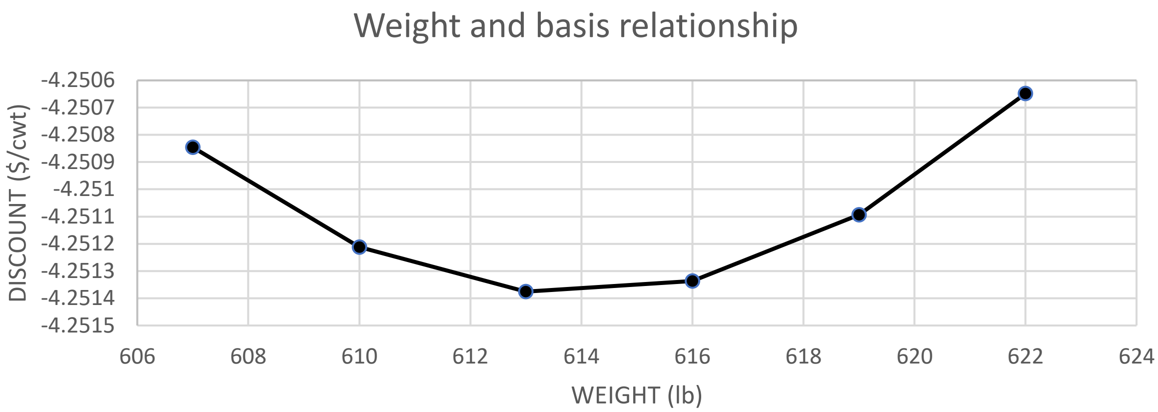

Figure 9. Visual representation of the maximum discount given for weight at Comergasa using a basis model, 2017-2018.

The coefficient of *Heifer* was negative and statistically significant (*p*-value < 0.001) as expected (Tables 1 and 4). Compared to steers, heifers were penalized with a $13.90/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). Furthermore, heifers are more likely to grow slower since they have a lower feed-conversion rate compared to steers which are genetically predisposed to put on more muscle than fat. 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 2010 data from the Oklahoma Quality Beef Network program, Williams et al. (2012) found a similar discount of $11.78/cwt between heifers and steers. As a final note, it needs to be distinguished that the magnitude of the differentials between steers and heifers decreases as weight increases.

Contrary to our expectations, the variable *Bull* has a positive coefficient of 0.82 (Tables 1 and 4). However, this was not statistically significant (*p*-value = 0.39). Compared to steers, bulls usually received a discount since there’s not much room to put weight on them. Nevertheless, 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 1,169.14 lb which is way over the threshold indicating that they are ready for slaughter. Although not significant, the positive sign of the *Bull* variable is a clue that bulls are more likely to receive a slight premium rather than a discount.

In order to account for seasonality, monthly dummy variables were used for all the months of the year except January which was used the base month. It is worth mentioning that in Nicaragua, two seasons are observed throughout a year: the rainy and dry seasons. This is in contrast to the United States' climate where all four seasons are normally observed. Table 5 reports the descriptive statistics for cattle weight (lb) and prices ($/cwt) per month and per season. The rainy season goes from June to November and is characterized by greater grass availability and better grass quality. As a result, more cattle and also heavier cattle are supplied in the auctions which leads to a drop in cattle cash prices and consequently a reduction in basis. Such a claim is supported by the results shown in Table 5, where cattle mean weight for the rainy season is 7.55 lb more compared to the dry season (853.67 lb versus 846.12 lb) although during the rainy season on average cattle received $2.33/cwt less than during the dry season ($69.73/cwt versus $72.06/cwt).

Table 5. *Descriptive statistics for months and seasons with respect to weight and prices, 2017-2018.*

	Live Cattle Weight (lb)		Cash Price ($/cwt)	
	Mean	Std. Dev.	Mean	Std. Dev.
Rainy season	853.67	411.65	69.73	12.53
Dry season	846.12	423.01	72.06	10.54
January	880.88	425.67	70.91	8.86
February	815.54	430.82	70.84	10.00
March	847.29	413.40	72.16	9.54
April	858.68	425.29	75.08	9.51
May	762.81	405.18	76.02	11.04
June	822.97	433.92	75.98	9.89
July	868.92	421.56	75.30	13.07
August	864.84	395.20	68.07	10.99
September	816.48	412.15	63.29	12.28
October	861.10	401.42	67.94	12.49
November	865.86	414.47	68.04	11.74
December	931.39	428.97	68.68	12.36

The previous information is key to understanding the coefficients of the monthly dummy variables in Table 4. From June through December, all the coefficients reported were negative and statistically significant at the 0.001 probability level except for June which had a *p*-value of 0.058. As such, cattle received discounts that ranged from -$2.11/cwt to -$17.42/cwt with the lowest point attained in September, *ceteris paribus*. Conversely, compared to January, from February to May, cattle received premiums ranging from $4.82/cwt to $9.57/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 perspective. The seasonal pattern of premiums and discounts received for cattle at Comergasa for the period 2017-2018 is exhibited in Figure 10.

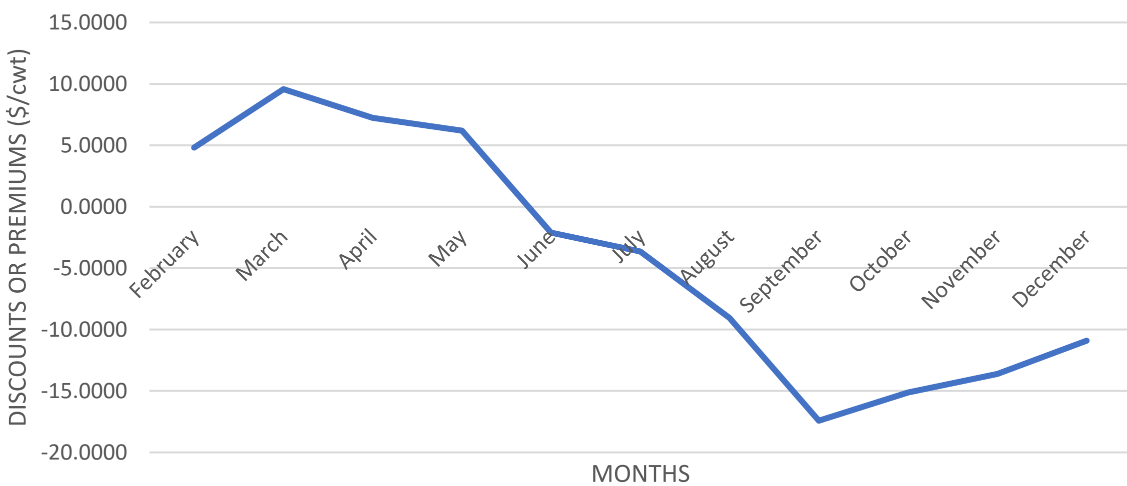

*Figure 10***.** Seasonal pattern of premiums and discounts for cattle ($/cwt) given at Comergasa, 2017-2018.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

According to the USDA-FAS (2020), Nicaragua’s beef exports surpassed the total beef exports of the remaining countries of Central America combined by 3.6 times in 2019. Also in the same year, 89.3% of the national total beef produced was destined for exports (USDA-FAS, 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 exports (USDA-FAS, 2020) providing evidence that the cattle industry is crucial to the Nicaraguan economy. In fact, it represents more than 10% of the national total exports and is classified as the third major component of its Gross Domestic Product (ECLAC, 2020b). As the least developed country in Central America, it is a must for Nicaragua to harness the potential of its cattle industry and further improve its economy. But what are the major challenges that prevent the country from doing so? To begin with, despite being the leading cattle meat production country in the Central America region, Nicaragua’s cattle production is non-intensive and yet is experiencing rapid growth. Between 2017 and 2018, cattle production grew by approximately 24% (NCB, 2018). An extensive production model implies an increase in the use of resources such as lands compared to an intensive production model and thus is less efficient in terms of a cost-benefit approach unless marketed properly. Such issues are worsened by the property right disputes for farmlands that restrict cattle producers from using all their lands due to a lack of peace of mind. In order to efficiently raise cattle and maximize the return of investment, Nicaraguan cattle ranchers need to be aware of the physical and lot characteristics cattle buyers are willing to pay premiums for.

The main objective of this study was to empirically quantify intrinsic and extrinsic factors that shape cattle prices at livestock auction sales in Nicaragua.

Cattle data including auction ID, transaction date, animal class, animal weight, lot size and cash prices were provided by Comergasa livestock auction for the period 2015-2019. Preliminary analysis of the data suggested the existence of seasonality. As such, only the period 2017-2018 was used to conduct the analysis since the data was incomplete for the remaining years. Overall, the data for 2017-2018 featured 99 auctions for a total of 2520 transactions. In addition, feeder cattle futures prices were obtained from the Chicago Mercantile Exchange (CME) for the period 2017-2018. These prices were used to calculate basis which in turn was used as dependent variable.

A hedonic regression model was used and estimated using SAS 9.4 to capture the effect of the explanatory variables on the dependent variable basis. The *F*-statistic indicated that all the coefficients of the OLS model are jointly statistically significant (p-value < 0.001). Moreover, according to the coefficient of determination (R^2) obtained, 63.86 % of the variation in basis is explained by the independent variables of the regression model. This goodness of fit measurement is higher than the one obtained in our previous study on cattle prices in Nicaragua using a cash price model instead of a basis 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. The underlying philosophy of basis is that it reduces the variations between local cash prices and futures prices.

Out of the 17 independent variables, only *Bull* and *June* were found not significant at the 0.001 probability level. The remaining physical and lot characteristics, including the monthly dummy variables, were significant (p-value < 0.001). Particularly, the *Lotsize* variable had a positive nonlinear (parabolic curve) effect on basis with the maximum premium being attained at 48 cattle head per lot. Similar to the variable *Lotsize*, the statistical effect of weight on basis was nonlinear except that it was negative at the beginning of the curve (inverted parabolic curve). The diminishing marginal rate of the variable *Weight* is indicated by the positive sign of its quadratic form ($Weight^2$). Heifers were discounted compared to steers, everything else being held constant. The variable *Bull* was found not statistically significant, but its positive sign indicated that, compared to steers, bulls were more likely to receive a slight premium. Finally, the coefficients of the monthly dummy variables confirmed the seasonal pattern detected after the preliminary analysis of the data. Compared to the month of January, cattle received discounts from June through December and premiums from February through May.

5.1 Recommendations for Further Research

One of the constraints of this present study is that animal breed was not included in the hedonic regression model since it was not reported in the sales datasheets. However, we reached out to one of the Managers of La Chontaleña, the third largest auction house in Nicaragua, in order to have preliminary information regarding the breeds more valued by cattle buyers at auction sales. Based on the information gathered, generally, cattle buyers are willing to pay more for Brahman, Guzerat,[12] Simbra,[13] and any cross that includes Brahman whereas dairy cattle and dairy-related-breed of cattle are discounted. Future research can account for the variable breed to support the aforementioned claim and reveal the extent to which such breed-related premiums and discounts are garnered.

Additionally, premiums and discounts do not automatically translate to profits and losses since the volume of operation and the specific management practices of each cattle producer are

[12] Guzerat are gray cattle originated from Northern India and characterized by long, lyre-shaped horns.
[13] Simbra is a mix of Simmental and Brahman.

different. As such, net premiums and discounts will be undoubtedly different on a producer-to-producer basis. Consequently, in order to better forecast profitability, the net utility rather than the mere cash price may be a preferable tool to assist practitioners in their decision-making process. Future studies can use net benefit per lot instead of cash prices when determining basis. These cost-benefit analyses will certainly reveal the worthiness of investing in specific animal breeds or management practices based on their return on investment.

Although women actively participate in cattle production in Nicaragua, they have been excluded from training programs aiming to revamp the domestic cattle industry (TechnoServe-USDA, 2016), which can be an important barrier preventing the success of these programs. Future training programs must aim to actively engage all genders throughout their activities. Moreover, a gender-inclusive approach must be adopted not only in terms of training but also in terms of access to credit and other sources of support that may hinder women's ability to thrive in their cattle businesses.

Finally, value-added programs will help Nicaraguan cattle ranchers create additional value through improved management practices such as better record-keeping systems, source verification and grazing style. There is a tremendous potential for these programs in Nicaragua and it bears clarifying that such programs will allow cattle ranchers to lock in better prices for their cattle and thus improve their net returns. However, at the same time, marketers have a lot to bring to the table in terms of communicating the value of such programs to every shareholder in the value chain from producers to bidders and consumers. Although the return on investment of these programs may not outweigh their participation cost at the beginning, they will provide great support to small and independent producers and standardize the quality of beef produced in Nicaragua.

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