Determinants of the Choice-Select Spread

By

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Abstract

The Choice-Select (C-S) spread is the difference between the Choice and Select carcass cut-out values and is an important market indicator for feedlots and producers within the United States. It presents the direct discount for Select grading cattle carcasses. Over the past several decades the Choice-Select spread has generated extensive seasonality, which can cause financial stress on feedlots and cattle producers due to fluctuating prices. The goal of this research is to quantify the determinants of the Choice-Select spread. Results from partial adjustment econometric models suggests the percentage quantity of Choice graded beef (i.e. relative supply of Choice beef) was the most influential determinant for the Choice-Select spread; that is, a 1% increase in quantity resulted ($P = 0.058$) in a \$21-24/cwt decrease in the spread. The estimation also found that \$1 change in consumer demand driven wholesale boxed beef prices lead ($P < 0.01$) to a \$0.069-0.072/cwt increase in the spread. The model also identified a statistically significant ($P = 0.037$) seasonal effect of roughly \$0.684-0.80/cwt on the spread during the months of April to August (the grilling season).

Acknowledgements

I would first like to thank Dr. Jared Carlberg, who has freely offered his time and energy to help me graduate in a timely manner. He has been extremely helpful, motivating, and knowledgeable throughout my entire degree. There is no way that I would have been able to finish on time without all your help; thank you. Secondly, I would like to thank my committee advisors Dr. Jon Biermacher, and Dr. Derrell Peel, who have both given their time and guidance, providing plenty of insights into the mechanisms within the beef industry. Lastly, I would like to thank the Livestock Marketing Information Center (LMIC), for granting me access to their historical data sets, without which this thesis could never have been completed.

Dedication

I dedicate my thesis to my partner Laura Wall, who has been with me throughout this entire process and supported me every step of the way. She has compassion for every person she meets and has helped me be a better person. To Laura, I love you.

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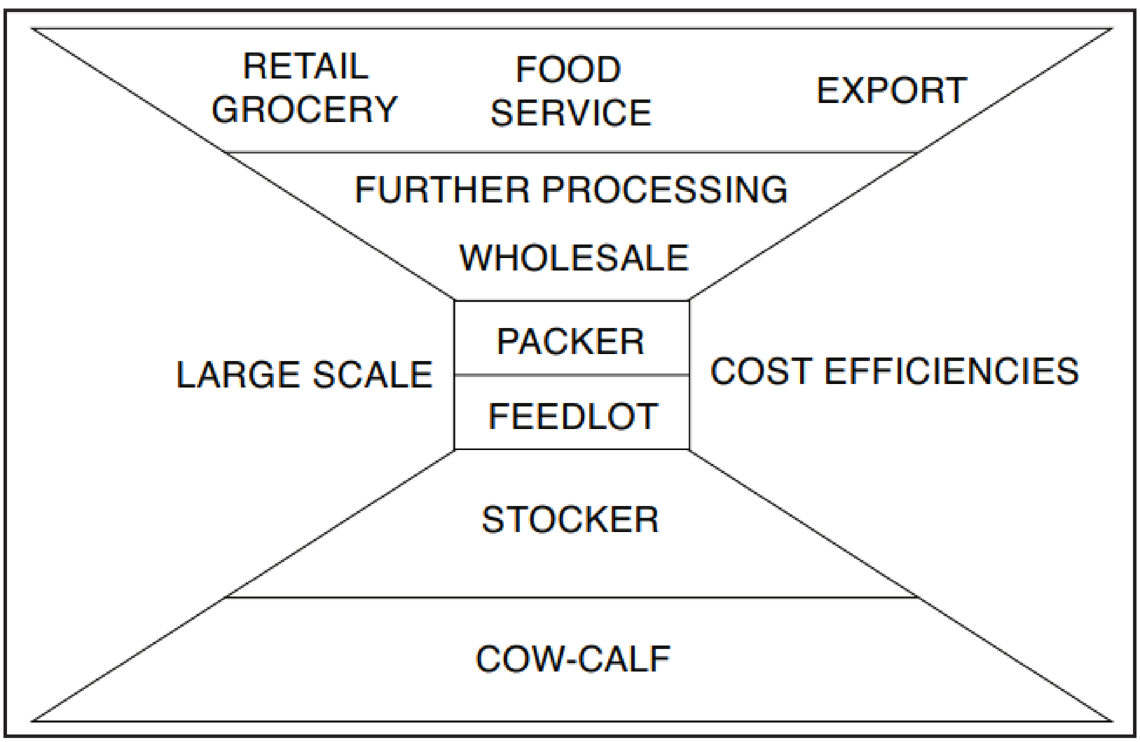
Chapter 1

Introduction

1.1 Overview

The United States beef sector is complex, incorporating an intricate array of cattle production and marketing activities, which supplies thousands of unique beef products. These products are then marketed through a diverse set of final markets at both the wholesale and retail levels, all of which are coordinated through a multitude of interconnected market transactions (Peel, 2021). The magnitude of the beef industry is difficult to capture in one single figure and will be discussed more in depth in Chapter 2. However, Figure 1.1 created by (Peel, 2021), from Chapter 1 in the 2021 U.S. Beef Supply Chain Workshop, briefly summarizes the complexity of the industry.

Figure 1.11 Structure of Beef Industry



Source: Peel (2021).

In 2021, the U.S. generated $72.9 billion USD in cash receipts for cattle marketed for beef production, yielding 28 billion pounds of beef, 84% of the 28 billion pounds was sold as either Choice or Select quality (the two most prevalent beef qualities, described in further detail in Chapter 2) (USDA-ERS, 2023a). After Prime, Choice and Select are the second and third highest beef qualities in the U.S. In 2001 after the implementation of Mandatory Price Reporting (MPR) the United States Department of Agriculture (USDA) began publishing the prices packers were paying to feedlots for different qualities of cattle (Hogan, 2003). Figure 1.2 outlines one of the reports (LM_CT155) published weekly by the USDA's Agricultural Marketing Service (AMS). The highlighted value in Figure 1.2 is the price difference between Choice and Select beef carcasses, known commonly as the Choice-Select spread. The Choice-Select spread is utilized by cow-calf operations, feedlots, and producers to help determine the relative demand for Choice and Select beef. For economists, the spread provides insights into derived consumer demand as well as consumers' substitutability among differing grades of beef. The Choice-Select spread is a complex indicator, as it is affected by the supply and demand schedules for both Choice and Select beef, as well as a number of other factors. The Choice-Select spread is also influenced by the seasonal demands for specific cuts of meat. The Choice and Select markets are interconnected insofar as they both draw from the same pool of supply and contain similar end products; however, they are also somewhat independent given that each quality of meat maintains its own derived demand curve for consumers.

Figure 1.12 Weekly Average of Premiums and Discounts

LM_CT155
St. Joseph, MO   Mon Apr 10, 2023   USDA Market News Service

NATIONAL WEEKLY DIRECT SLAUGHTER CATTLE - PREMIUMS AND DISCOUNTS
For Week of: 4/10/2023
Value Adjustments

	Range	Simple Avg.	Change
Quality:			
Prime	0.00 - 35.00	16.25	0.14
Choice	0.00 - 0.00	0.00	0.00
Select	(20.00)- (8.00)	(13.75)	(0.08)
Standard	(53.00)- (10.00)	(30.43)	(0.22)
CAB	2.00 - 6.00	4.00	0.29
All Natural	24.00 - 50.00	33.45	0.00
NHTC	19.00 - 26.00	22.00	0.00
Dairy - Type	(15.00)- 0.00	(2.64)	0.00
Bullock/Stag	(55.00)- (15.00)	(36.00)	0.00
Hardbone	(55.00)- (20.00)	(37.70)	(0.20)
Dark Cutter	(55.00)- (20.00)	(34.58)	0.00
Over 30 Months of Age	(40.00)- 0.00	(14.29)	0.00
*Cutability Yield Grade, Fat/Inches			
1.0-2.0 < .10"	0.00 - 8.00	3.58	0.00
2.0-2.5 < .20"	0.00 - 4.00	1.77	0.00
2.5-3.0 < .40"	0.00 - 4.00	1.38	0.00
3.0-3.5 < .60"	0.00 - 0.00	0.00	0.00
3.5-4.0 < .80"	0.00 - 0.00	0.00	0.00
4.0-5.0 < 1.2"	(15.00)- (8.00)	(11.92)	(0.17)
5.0/up > 1.2"	(25.00)- (10.00)	(17.25)	(0.67)
Weight:			
400-500 lbs	(45.00)- 0.00	(29.29)	0.00
500-550 lbs	(45.00)- 0.00	(22.64)	0.00
550-600 lbs	(35.00)- 0.00	(11.57)	0.00
600-900 lbs	0.00 - 0.00	0.00	0.00
900-1000 lbs	(15.00)- 0.00	(1.07)	0.00
1000-1050 lbs	(20.00)- 0.00	(5.00)	0.00
over 1050 lbs	(25.00)- (5.00)	(15.71)	0.00

Source: USDA-AMS (2023a).

1.2 Outline of Research

The objective of this research is to provide insights into the determinants of the Choice-Select spread. More specifically, to determine and quantify the driving factors which effect the seasonal patterns in the Choice-Select spread. The Choice-Select spread can fluctuate significantly throughout the year. For example, a Choice ribeye steak purchased in January will not have a noticeable quality difference then one purchased in August, but the price of that steak could be quite different at different points in time. These fluctuations have extensive financial impacts on the stakeholders within the market, as the increased discount for Select grading cattle directly affects cattle feeder profitability. The observation window is the U.S. beef market from 2018-2023.

1.3 Key Findings

This research has analysed several determinants of the Choice-Select spread. The most influential determinant for the Choice-Select spread is the percentage of Choice beef graded, with a 1% increase leading to a $24/cwt decrease in the spread. Interestingly, the increase in grid-based pricing systems has led to an increase in the percentage of Choice graded beef causing the discount for Select graded carcasses to increase over time (Hogan, 2003). The percentage quantity of Choice graded beef also exhibits seasonal patterns. Grilling season, the period from approximately April through the Labor Day weekend for most of the U.S., is also an influential determinant of the spread, due to lessened demand for lower-quality cuts (i.e. Select beef) during these months. Consumers derived demand for Choice meat is also an influential driver of the spread as preceding prices have significant impact on the current and future price of the spread.

Chapter 2

Background

2.1 United States Cattle Industry

The rise of the United States (U.S.) cattle industry has been well documented in (Peel, 2021). Although cattle are not a native species to North America, the U.S. is the worlds largest producer of beef, accounting for 21.7% (28 billion lbs) of the global beef production in 2021(USDA-AMS, 2021). Cattle were first introduced to the new world on the second expedition of Christopher Columbus in 1493. Three decades later in 1521 Hernán Cortés and Ponce de Leon introduced cattle to modern-day Mexico and Florida respectively. However, it was more likely the subsequent introductions from the Spanish expeditions that helped cattle become established in the southeast region of the United States. Cattle imported by the Spanish missions around the early 17th century crossed the Rio Grande and entered into modern-day Texas. In the 17th and 18th centuries the cattle eventually escaped or were released by the Spanish and began to roam wild in south-eastern Texas and would later become the iconic Texas Longhorn. The post-Civil War era saw the beginning of the modern cattle industry. Rising demand for beef in eastern US cities led to the recapture of ranches which had been abandoned before the war. This led to millions of Longhorn cattle being rounded up and turned into domestic herds. As railways grew westward improving access to railheads, most ranchers constructed fences and penned in their cattle. By the late 19th century major stockyards started to appear near packing plants in Chicago, Omaha, Kansas City, Fort Worth, and Oklahoma City. Most cattle were transported by rail to these terminal markets and were traded privately through stockyard commission organizations. The significance of railroads and the importance of the central stockyards decreased as the trucking sector grew. Major urban stockyards in cities like Chicago, Kansas City, and Fort Worth started to deteriorate and eventually closed in the 1950s as packing industries started to move closer to cattle feeding areas. Some of these terminal markets continued to function as feeders after converting to auctions. Most notably the Oklahoma City stockyards which are still in operation to this day (Peel, 2021). The domestication of these cattle started the cyclical expansion and contraction of the national heard size and beginning one of the most prominent features of the cattle industry, the cattle cycle. The cattle cycle is a multi-year expansion and liquidation cycle of the U.S. cattle stockpile. It has been coined the "Ten-year cycle", although the past seven cattle cycles have ranged from anywhere between 9 to 14 years (Peel, 2021). Regardless of whether the industry was trending higher or lower in overall inventory, the cyclical propensity has been maintained and is still a distinguishing trait to this day.

2.1.1 Cow-Calf

Cow-calf production is the backbone of the U.S. beef industry as it is the main supply of feeder cattle into feedlots. A beef cow/heifer once bred will typically produce calves that are slaughter-ready in approximately 2.2 years, being weaned around 3-7 months (USDA-ERS, 2023b). Heifer calves may be sold to other farmers as replacements, kept in the herd for growth or replacement purposes, or sold alongside steers to feedlot operators for growth prior to slaughter. Currently, there are over 31 million beef cows spread out over 730,000 farms and ranches in the United States (Fairbairn et al., 2021). The U.S cow herd maintains two distinct components: beef and dairy. These two markets have much different driving forces behind them. The main goal of the dairy market is milk production, however dairy animals are still utilized for the beef industry, specifically male dairy calves, culled dairy replacement heifers, and culled dairy cows. In 2021, the U.S. cow herd contained approximately 76.7 percent beef cattle and 24.3 percent dairy cattle (Peel, 2021), whereas in 1945 the proportion of beef cows was only 37%, compared to 63%

dairy cows. After World War II the number of beef cows expanded rapidly, reaching a peak in 1975 when they made up slightly over 80% of all the total U.S. cow herd. This was also the largest the U.S. cow herd has ever been at 132 million head.

2.1.2 Cattle Feeders

Feedlots are an integral part of the cattle production process, turning calves into fed cattle by providing cattle with high quality feed to mature to slaughter weight and quality. At the time of weaning, producers must decide whether to expand their herds by retaining heifer and bull calves to replace older cows and bulls. Bull calves not retained for breeding, are typically castrated to become feeder steers, and heifer calves not retained for breeding are sold at some point that varies among farm operations for eventual slaughter. If not retained on-farm until being sent to a feedlot, many animals enter a stocker program, a 30- to 60-day preconditioning program or a 90- to 120-day backgrounding program which allows animals to reach an appropriate weight to be sent to a feedlot. Before being fed in each of these programs, the calves will undergo an animal health protocol consisting of deworming, dehorning, and vaccination (USDA-ERS, 2023b). The feeding period can range from 90 to 300 days, with an average daily gain of 2.5 to 4 pounds on 6 pounds of dried feed per pound of gain, 70-90 percent of rations consist of grains and protein concentrates, with silage, alfalfa, and other nutrients serving as supplements. In the United States, the cattle feeding industry is primarily concentrated in the Great Plains, as well as portions of the Corn Belt, Southwest, and Pacific Northwest. The majority of U.S. feedlot operations have a capacity of less than 1,000 cattle, but they market a relatively small proportion of the overall fed cattle. In contrast, feedlots with a capacity of 1,000 head or more account for only 5 percent of all feedlots but market 80–85 percent of fed cattle. 40 percent of fed cattle are sold by feedlots with a capacity of 32,000 head or more, and the industry continues to shift toward these specialized feedlots that concentrate on raising high-quality cattle for specific markets (USDA-ERS, 2023b). To monitor the amount of cattle on feed at any given time, *Cattle on Feed Reports* are issued monthly by the National Agricultural Statistics Service of the USDA (USDA-NASS, 2020).

2.1.3 Beef Packer-Processors

The packer-processor sector is an essential component of the U.S. cattle industry, responsible for the harvesting, processing, packaging, and distribution of beef for both domestic and international consumption. In 2021, U.S. beef production was roughly 28 billion pounds and U.S. commercial slaughter was 31 million head, with 14% of the total exported to over 130 nations (USDA-AMS, 2021). After four to six months of finishing at feedlots, cattle are typically transported to slaughterhouses when they are between 18 and 24 months of age. Cattle are slaughtered and the carcasses are processed into beef products at the plant. Depending on the location, these products may be packaged into boxed beef and sent directly to retail customers or sent to additional processing facilities before reaching their final destination. The U.S. packing industry has four large corporations that account for more than 85 percent of the country's beef processing and packing. The majority of packing plants are comparatively small, with 92 percent slaughtering fewer than 50,000 heads per year; however, large plants with capacity over 50,000 heads accounted for 96.5 percent of all cattle slaughtered in 2020 (USDA-ERS, 2023a). These large packers have constructed their facilities near the main cattle-feeding regions of the United States, namely Nebraska, Kansas, Texas, and Colorado, which together account for approximately 70 percent of cattle production in the United States.

2.1.4 Wholesale and Retail Beef

Wholesale and retail stores represent the key institutions in the final step in the U.S. beef supply chain. These are the businesses in the supply chain that are responsible for marketing boxed beef products produced to final consumers. Retail grocery stores mainly sell Choice and Select beef, as these are the two most common qualities for consumers to purchase. Prime grade beef is primarily sold to restaurants and steakhouses (Peel, 2021). Interestingly, grocery stores did not start marketing beef quality grades until around 1980. Since beef grading was voluntary, and grocery stores would normally buy whole carcasses, they never saw a need for having the beef graded (Peel, 2021).

2.2 Beef Grading and Processing in the U.S.

In 1916, a preliminary version of the United States Standards for the Grades of Dressed Beef was developed. This served as the foundation for the uniform reporting of dressed beef markets according to grades, which was launched as a national service at the beginning of 1917. The new *Standard for the Grades of Dressed Beef* was published in the Department's Bulletin No. 1246 "Market Classes and Grades of Dressed Beef," in August 1924, after undergoing some minor revisions to accommodate their inclusion. The grading standards was recently updated in 2017, the USDA added revisions to incorporate dentition and documentation of actual age as a means of determining maturity groupings for quality eligibility (USDA-AMS, 2017). Although the proposed standards were developed primarily for meat market reporting purposes, they have been applied to numerous other practical uses. The beef grades were used to select cattle for the Army, and Navy during World War I. Later, they were included in the Emergency Fleet Corporation's specifications for purchasing cattle supplies. They were subsequently incorporated into the specifications of numerous commercial enterprises, such as steamship lines, restaurants, hotels, dining car services, and hospitals. The grading of beef is based on two distinct criteria: quality grades that assess, intramuscular marbling and yield grades that evaluate the quantity of usable lean meat present on the carcass. Increased amounts of intramuscular fat or marbling, result in a higher quality grade, because of the positive impact of additional marbling upon taste; Figure 2.2 illustrates the differences among the top three quality grades.

2.2.1 Yield Grades

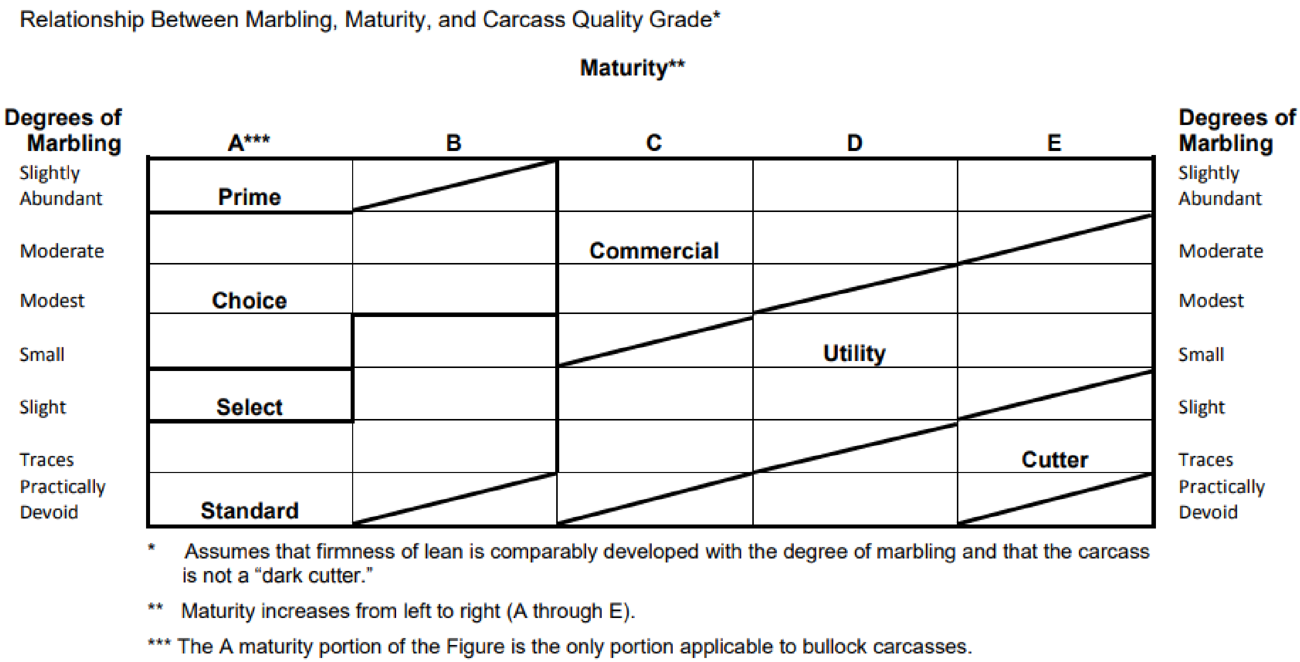
Cattle yield grades are used to assess the amount of fat and lean meat on a carcass. The yield grade considers four main characteristics, those being the amount of external fat, the amount of fat on the kidney pelvic and heart, area of the ribeye, and the carcass weight (USAD-AMS, 2017). Yield Grade 1 has a thin layer of external fat over the ribs, loins, rumps, and clods, with slight deposits of fat in the flanks and cod or udder. Yield Grade 2 is nearly completely covered with fat, but lean muscle is plainly visible through the fat. Yield Grade 3 is completely covered with fat and the lean muscle is visible through the fat only on the necks and lower part of the outside of the rounds. Yield Grade 4 is also completely covered with fat, but with only muscles visible on the shanks and over the outside of the plates and flanks. Finally, Yield Grade 5 has more fat on all parts than Yield Grade 4, a smaller area of ribeye, and more kidney, pelvic, and heart fat. The yield grade of a beef carcass is calculated using the following equation.

$$
\begin{aligned}
Yield\ Grade = 2.50 &+ (2.50 * adjusted\ fat\ thickness, inches) \\
&+ (0.2 * percent\ kidney, pelvic\ and\ heart\ fat) \\
&+ (0.0038 * hot\ carcass\ weight, lbs) \\
&- (0.32 * area\ ribeye, square\ inches)
\end{aligned}
$$

2.2.2 How Beef is Graded

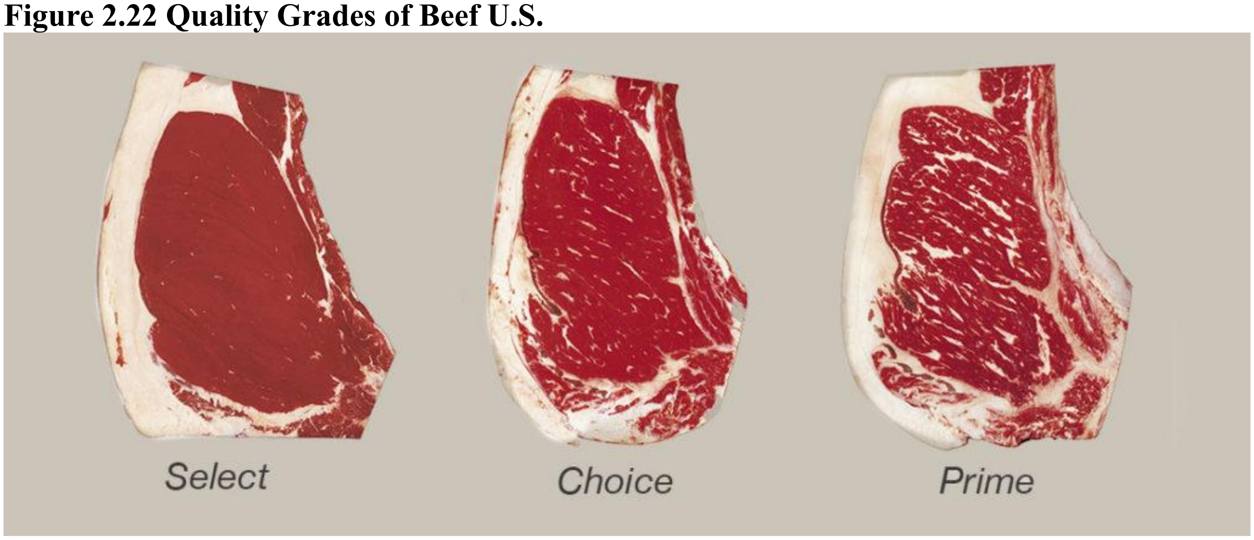
After the animal has been slaughtered and converted into a carcass, it is split down the back separating it into two sides. At least one side must be separated into hind and forequarter, this is done by “a saw cut perpendicular to both the long axis and split surface of the vertebral column across the 12th thoracic vertebra of the carcass” (USDA-AMS, 2023b), leaving not more than one-half of this vertebra on the hindquarters. A single knife cut across the ribeye muscle is then made, terminating opposite of the saw cut, the cut then extends across the ribeye muscle, perpendicular to surface of the skin angled towards the hindquarter. The angle of the cut should be slightly greater than the angle of the 13th vertebral column. Beyond the ribeye the knife cut continues between the 12th and 13th ribs which should adequately expose the amount of fat and lean muscle. This process is called ribbing the carcass and is done on each graded carcass. The next step in the grading process is to determine the maturity of the carcass. This is done by evaluating the size, shape and ossification of the bones and cartilages, specifically the split chine bones, as the ossification process begins at an earlier stage of maturity. The thoracic vertebrae ossify later in maturity and are helpful in determining carcasses older than 30 months. The second step to determining maturity is the color and texture of the lean flesh. Younger carcasses will have very fine texture and light greyish red color, well more mature carcasses will have coarser texture and a darker red color. Since the color and texture of the lean flesh is not solely dependant on maturity, grading carcass maturity gives more emphasis on skeletal structure and ossification. As seen in Figure 2.1 Prime, Choice, Select, and Standard quality grades are only eligible for carcasses with a maturity grade of A or B, anything more mature than B is utilized for Commercial, Utility, or Cutter.

Figure 2.21 Marbling, Maturity, and Quality Grades



Source: USDA-AMS (2017).

Figure 2.22 Quality Grades of Beef U.S.



Source: Flannery (2023).

2.2.2.1 Prime

Prime beef makes up around 10.6% of total beef graded, with around 2.2 billion lbs of beef produced in 2021 (USDA-AMS, 2021). The Prime grade is given to carcasses which range from the youngest eligible for beef production to carcasses on the intersection of the A and B maturity groups. The determinates of Prime quality grade are as follows, slightly red to tinged with red chine bones, cartilages on the ends of the thoracic vertebrae and have some evidence of ossification, the ribeye muscle is light red in color and fine in texture, with an abundance of intramuscular marbling (USDA-AMS, 2017). Prime beef is most often sold to restaurants hotels and food service institutions.

2.2.2.2 Choice

Choice beef makes up around 74.5% of the total market with around 16 billion lbs of beef produced in 2021 (USDA-AMS, 2021). The maturity qualifications are the same as Prime graded beef, the difference is Choice beef has a modest to moderate amount of intramuscular marbling (USDA-AMS, 2017). Choice beef is the most abundantly available quality of meat in retail grocery stores.

2.2.2.3 Select

Select beef makes up around 14.6% of the total market with around 3.1 billion lbs of beef produced in 2021 (USDA-AMS, 2021). The maturity qualifications for Select beef is the same as Prime and Choice. However, the ribeye maybe moderately soft compared to Prime or Choice. The main difference between Choice and Select beef is the amount of intermuscular marbling, with Select there is very little to slight marbling. Select beef is of particularly consistent quality and is typically leaner than higher-quality grades. It is relatively tender, however, due to reduced marbling, it may lack some of the flavour and juiciness of the upper grades (USDA-AMS, 2017).

2.2.2.4 Standard

Standard beef makes up <0.01% of the total market with around 2 million lbs of beef produced in 2021 (USDA-AMS, 2021). The Standard quality grade is the lowest of the “retail grades”, and only utilizes maturity groups A and B. Any carcass which does not qualify for any of the above grades yet still maintains a maturity grade of A or B will be put into the Standard grade. The amount of intramuscular marbling can range from small to practically devoid, with a ribeye muscle softer and coarser (USDA-AMS, 2017). Standard quality grades of cattle are infrequently sold to consumers and are typically used in store brand ground beef and almost never sold at the retail level.

2.2.2.5 Lower grades

The lower grades of beef are Commercial, Utility, Cutter, and Canner and are rarely, graded as it is not worth the cost of grading low quality beef since it will rarely be sold at the retail level. Instead, lower grades of beef are used to create ground beef and processed goods. As opposed to the Standard grade, the Commercial grade allows carcasses that are more advanced in their maturity. These carcasses maintain hard white chine bones and barely visible cartilages on the ends of the thoracic vertebrae. The ribeye muscle is moderately dark red and slightly coarse in texture for the youngest group, and dark red and coarse in texture for the most mature group. The ribeye muscle is also slightly firm for the youngest group and firm for the most mature group. Utility quality grades are similar to Commercial grades only with less marbling, harder chine bones, and more coarse texture. In 2021 there was zero Cutter and Canner quality grades produced in the U.S. (USDA-AMS, 2017).

2.3 Choice-Select Spread

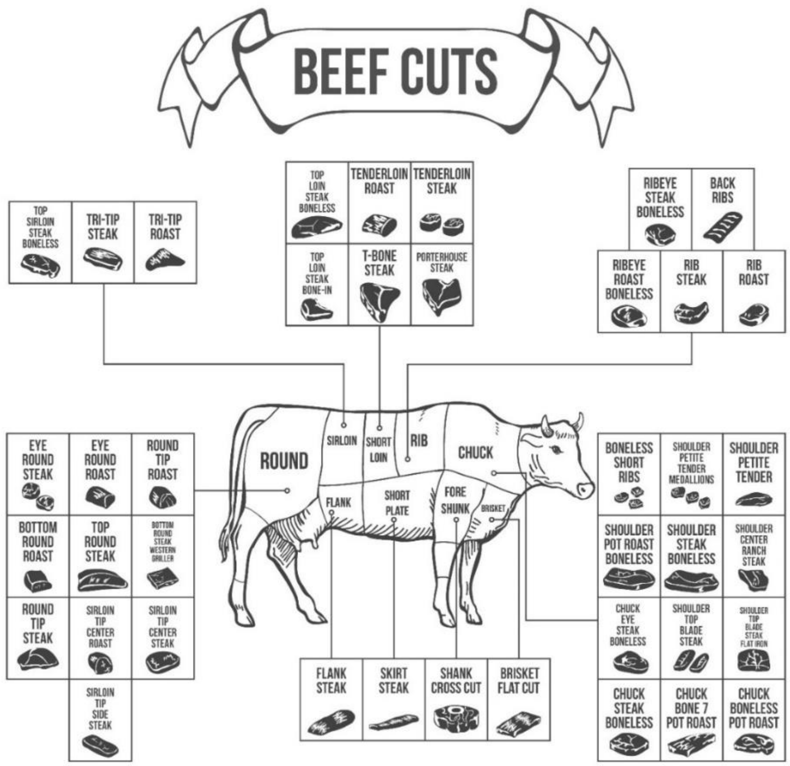
The Choice-Select spread is the discount between the cut-out[1] value of Choice and Select beef carcasses. It is one of the important market signals for feedlots as it has a direct effect on the price of fed cattle and how long feedlots decide to leave cattle on feed. The Choice-Select spread is affected by four main factors, those being, the demand for Choice beef, the supply of Choice beef, the demand for Select beef, and the supply of Select beef (Lacy, 2007). However, the demand for Choice and Select beef is much more uncertain than the supply.

2.3.1 Cut-Out Values

After the cattle are slaughtered, they are processed into seven major cuts, also known as primal cuts, see Figure 2.3. The seven primal cuts are too large to be sold at the retail level and require further processing.

[1] A cut-out is the total monetary value of the carcass after it has been cut into individual retail cuts. It is the total value of the carcass minus the hide, head, feet, and other inedible parts. The cut-out is an important measure of the efficiency of the beef production process, as it indicates the amount of usable meat that can be obtained from a given carcass. (USDA-AMS, 2023)

Figure 2.3 Primal and Sub-primal Beef Cuts



Source: Marconda's Beef (2023).

Each primal is cut down to smaller individual cuts of meat called sub-primals, similar to products you would see in a grocery store,[2] see Figure 2.4. The value of each primal is the aggregate value of all of its sub-primals; the value of the sub-primal cuts is calculated by utilizing the two-day weighted average price per hundred pounds (hundredweight, or cwt) for that specific cut. To find the value each sub-primal adds to its overall primal cuts, the packer multiplies the percentage of overall weight the cut adds to the primal (yield) by the per-cwt price of the cut (two-day

[2] Sub-primal cuts are the large sections of meat that are cut from the primal cuts of beef. These cuts are usually further divided into smaller, more manageable cuts for retail sale. Examples of sub-primal cuts include the ribeye, strip steak, flank steak, and brisket (USDA-AMS, 2023).

weighted price). This can be seen in Figure 2.4 where the first column is multiplied by the second to arrive at the value for that specific sub-primal cut.

Figure 2.34 Sub-Primal Components Cut-Out Value for 116A Chuck Roll

#6 - 116A Chuck roll

Item Components	#6 Yield	2-day Weighted Average	#6 Value
114A Trimmed Clod	16.54%	$188.64	$31.20
114F Clod Tender	0.66%	$279.59	$1.84
116A Chuck Roll n/o	19.40%	$250.26	$48.55
116B Chuck Tender	2.71%	$199.12	$5.39
130 Chuck Short Rib	3.06%	$292.42	$8.94
Pectoral Meat	2.00%	$258.56	$5.17
50% Trimmings	4.91%	$43.03	$2.11
73% Ground Beef	9.61%	$106.45	$10.22
81% Ground Beef	3.24%	$148.02	$4.79
90% Ground Beef	3.17%	$213.16	$6.75
Chuck Trim (Ground Chuck)	5.25%	$161.74	$8.49
Shank Meat (Ground Chuck)	5.02%	$161.74	$8.11
Fat	8.77%	$21.25	$1.86
Bone	15.24%	$4.50	$0.68
Shrink	0.42%		
Total Percentage	100.00%		$144.10

Source: USDA-AMS (2023b).

Once all the values for each sub-primal are calculated they are summed to create the value of the primal cut. Not all primal cuts are the same; some larger wholesale customers can request special types or styles of cut. For example, in Figure 2.5 primal chuck can be cut as either 113C Semiboneless Neck-Off Chuck or 116A Chuck Roll. These styles are simply a different way of cutting the same portion of carcass, since the carcass has two side more than one style of cut could be used on one carcass.

Figure 2.35 Chuck Styles

Chuck Styles	Loads	Price
#3 - 113C Semi-Bnls Nck-Off Chuck	2.0	$143.00
#6 - 116A Chuck roll	5.0	$144.10
Composite Chuck Primal Value: $143.78		

Source: USDA-AMS (2023b).

The value of the styles is averaged to attain the primal composite for the whole carcass. Similar to the sub-primal value the final carcass cut-out price is then calculated by each primal price by its yield and summing up all the values see Figure 2.6. Interestingly, there are some cuts which have higher demand and therefore priced higher than others, these being the so-called "middle meats" consisting of primals from the rib and loin (see Figure 2.6). As of August 14th 2023, a Choice primal Rib cut is valued at $473 per CWT while a primal loin cut is valued at $407 per CWT (USDA-AMS, 2023c). The rib and loin cuts are more than double the value of the other primal cuts, and make up about 9% and 16% of the carcass weight, respectively (Montana State University Ag Extension, 2013). These middle meats may have more of a driving presence in the price of boxed beef then other cuts. For more information regarding carcass cut-out values and middle meat demands, see Clark (2019).

Figure 2.36 Composite Primal Value

Composite Primal Value

	Primal Value	x	Yield Factor	=	Contribution to Cutout
Rib	$337.05	X	11.40%	=	$38.42
Chuck	$143.78	X	29.62%	=	$42.58
Round	$153.32	X	22.32%	=	$34.22
Loin	$228.91	X	21.26%	=	$48.67
Brisket	$151.93	X	4.95%	=	$7.52
Short Plate	$108.38	X	7.10%	=	$7.69
Flank	$85.61	X	3.35%	=	$2.87
Carcass Cutout Value = $181.97					

Source: USDA-AMS (2023b).

2.3.2 Relevance of the Choice-Select Spread

The Choice-Select spread is the measure of two distinct markets, which both draw from the same pool of supply (the U.S. national cattle herd). The importance of the Choice-Select spread is mainly as a market signal for feedlots, as the spread indirectly displays the marginal cost of keeping cattle on feed longer, given that the more time cattle are on feed the more likely they are to grade Choice. Therefore, if the Choice-Select spread is large, it may be worth it for feedlots to leave their cattle on feed longer thus ensuring more cattle grade as Choice, and avoid the discount of Select grade (Pruitt, 2017). The Choice-Select spread can also be a good measure of the demand of Choice beef (McCully, 2010;) a wider spread could mean higher demand for Choice beef. However, higher demand does not always mean increased consumption, as Lacy (2007) described, consumer demand and consumption are separated, and high demand does not always equate to higher consumption. For the past two decades, the proportion of cattle being priced on an individual basis or grid system has increased dramatically from 46% in 2006 to 76% in 2018 (USDA-ERS, 2023a) as feedlots have much better understanding of how their herd will grade and when to bring them to sale. Combined with the increase of genetic technology and animal welfare, this has led to a steady increase in the amount of Choice beef graded as cattle are able to achieve a Choice grade more easily.

2.4 Literature Review

2.4.1 Lusk (2001)

Research conducted by Lusk et al (2001) looked at the seasonality and demand elasticity of Choice and Select beef. Those authors found that during winter and fall there is a smaller difference in prices between Choice and Select beef, due to consumers having a higher degree of substitutability for Choice and Select beef during that period. However, during spring and summer when people tend to barbecue more (so called “grilling season”), there is less substitutability between these two beef types which leads to a larger spread in the Choice-Select spread due to the increase in demand for Choice beef. Subsequent studies by Hogan (2003), and Hogan and Ward (2005) supported this finding.

2.4.2 Hogan, Carlberg, Ward (2003, 2005, and 2012)

Another explanation for seasonality in the Choice-Select market was theorized by Hogan (2003) suggesting the variations in cattle supply throughout the year could also play a role. Calves weaned in early fall are put on feed through winter, moved to feedlots during the first weeks of March and finished for sale in August, September, and October. This provides buyers with enough supply to be selective when making procurement bids. Thus, seasonally affecting the Choice-Select spread. This claim is further supported by Hogan and Ward (2005). Hogan (2003) also stipulated that an increase in the boxed beef price will cause feeders to market their cattle sooner to take advantage of the price. This action would lead to a smaller percentage of Choice cattle creating a larger quality discount for select beef. This is because producers will be incentivized to sell their animals at a higher price, increasing the amount of Select cattle in the kill, resulting in the discount widening or becoming more negative. Conversely, an increase in production should lead to a greater number of Choice animals, leading to a decrease in the discount or a less negative value. Hogan and Ward (2005) found an increase in the percentage of Choice and yield grade 4-5 cattle being slaughtered should result in a decrease in the discount or a less negative value. Interestingly, more recent research regarding the Choice-Select spread by Hogan et al. (2012) found no statistical evidence of seasonality in their models concerning grilling season. However, they did observe an increase in the percentage of beef graded as Choice narrowing the Choice-Select discount.

Chapter 3

Theory

3.1 Expected Utility Maximization

Consumer utility maximization theory assumes consumers have a known utility function they are trying to maximize and will therefore purchase the bundle of goods & services that maximizes their utility function within a budget constraint. This theory provides a solid framework for analysis of consumer behavior when facing changes in price, income, and preferences. However, this neoclassical model is sometimes criticized as lacking the reality of consumer behavior, where consumers may not have a clear idea of their utility function and, will not always know which bundle of goods will maximize their utility (Thomsen, 2018).

3.2 Lancaster

Lancaster (1966) proposed a model similar to the neoclassical approach, with adaptations in the preferences and budget set of the consumer. The three assumptions Lancaster made were One, the goods themselves do not give the consumer utility, the goods possess characteristics, and those characteristics are what provide utility. Two, goods possess more than one characteristic, and many goods share multiple characteristics. Three, combinations of goods may posses characteristics different then those goods would possess separately (Lancaster, 1966). Therefore, the consumers are not buying bundles of goods which maximize their utility; rather, they are purchasing goods which satisfy characteristics for which they (the consumer) desire (Thomsen, 2018). As an example, a consumer looking to have a barbeque goes to the grocery store to purchase food to grill. The past theory would be to assume the consumer will purchase a bundle of goods which will maximize their utility, well spending efficiently with in their budget. The Lancaster approach/model would say, it is not the goods themselves the consumer is interested in, but the characteristics which the goods provide. The consumer may actually be indifferent towards the bundles of goods, but is interested in the certain characteristics, such as, juiciness, tenderness, flavour, and other characteristics which cannot always be quantified. Similar to the neoclassical approach the characteristics the consumer prefers can be satisfied by multiple different bundles of goods. However, the difference between the neoclassical approach and the Lancaster approach is, the consumer does not care about the different substitutable bundles of goods. They care about which combination of goods can provide these their preferred characteristics. The difference is very subtle, but this way of thinking puts the consumers preferred characteristics as the starting point of decision making. The goods are simply a vessel for providing the characteristics the consumer desires, rather than the goods themselves having innate properties which gives the consumer utility. Assuming these characteristics can be measured, a consumer could construct a utility curve constrained to a budget based on their preferred characteristics. Some examples of quantifiable characteristics are horsepower in a car or marbling in a steak. Lancaster called this utility curve the efficient consumption frontier (see equation 3.1), akin to a budget frontier it represents a combination of products which provide the consumer with the most of their preferred characteristics (Lancaster, 1966). The efficient consumption frontier is shown in equation (3.1) and is a function of characteristics c_{ij} for which i is the product characteristic of one unit of j product. A simplistic example is a characteristic for beef products, ribeye steak and T-bone steak, for simplicity say the consumers only care about one characteristic, quality grade. c_{11} would represent the amount of characteristic 1 (quality grade) in product 1 (Ribeye steak), c_{12} would represent the amount of characteristic 1 (quality grade) in product 2 (T-bone steak). To construct this efficient consumption frontier, the characteristics the consumer desires must be quantifiable. Some third-party firms can be to measure more abstract characteristics in food products such as mouthfeel, scent, and flavour.

(3.1) $$U = f(c_{11}, c_{12}, c_{21}, c_{22} \dots\ c_{ij})$$

3.3 Ladd and Suvannunt Consumer Goods Characteristics

Expanding on Lancaster's paper in 1966, Ladd and Suvannunt further explored the pricing of goods based on their characteristics. They found from their empirical analysis of goods characteristics that the price paid equals the sum of the marginal monetary values for that product's characteristics (Ladd and Suvannunt, 1976). The marginal monetary value of product characteristics is equal to the quantity of that characteristic obtained by a consumer from consuming one unit of the product, multiplied by the marginal implicit price of the characteristic (Ladd and Suvannunt, 1976). This implies the monetary value a consumer should get from a characteristic can be quantified by the amount they receive from one-unit times the implicit price of that characteristic. This is quite relevant towards beef quality pricing and determinants, as the quantifiable characteristics of Choice and Select beef products such as marbling, firmness, color, and texture, change very little throughout the year. Therefore, according to theory, consumers preferences towards this product should stay stable and unchanging, as the marginal monetary value of the characteristics is stable throughout the year. However, customers may value certain characteristics more during different parts of the year. For example, during the summer months consumers may want more intramuscular marbling in their meat as it makes it more flavourful for grilling. There is clearly there is plenty of variation in demand and price of these two qualities of products, suggesting the relevance of certain characteristics could be changing seasonally or are influenced by some nonquantifiable characteristics.

3.3.1 Hedonic Prices

As goods provide utility deriving characteristics (Lancaster, 1966) and characteristics of goods can be quantified into monetary values (Ladd and Suvannunt, 1976), it is reasonable to hypothesize a function which represents the equilibrium relationship between the relevant utility derived characteristics within the product itself and the price of that product. Such functions are referred to as "hedonic price functions" or "hedonic functions" (Nesheim, 2006). Hedonic prices have many useful functions, they can help price new products which have no known demand, measure consumer or producers' valuation of certain products and most importantly for empirical applications, provide quality adjusted price indexes for products (Thomsen, 2018).

The beef industry utilizes quality adjusted price indexes for premiums and discounts in grid-based marketing of cattle. For example, if consumers prefer characteristics of flavour and juiciness in their beef products, and given that higher levels of intramuscular fat provide those characteristics, then hedonic price theory would suggest that additional intramuscular fat in a cut of beef should cause an increase in price. This is exactly what pricing of higher quality beef demonstrates, a product with increased marginal monetary characteristics is priced higher than ones with less of that characteristic. Although there is a marginal cost to producers to create this preferred characteristic (i.e. leaving cattle on high quality feed for longer), the markup in price hopefully will be higher than the extra production costs. If it is not, then feedlots would not endeavour to produce Choice beef.

3.3.2 Hedonic Demand

Consumers are looking to maximize their utility (u) of characteristics which are provided by the goods they purchase; this is represented mathematically in equation (3.2). Where $z \in Z_m$, z is equal to a single good or a bundle of goods which embody the vector of known utility affecting characteristics for the consumer, Z_m is the given feasible set of goods given the current market conditions. *p(z)* is the price for the bundle of z products, and $x \in X$, x is a vector of characteristics which effect consumers utility (income, education, preference, etc.), and X is a space of all the different consumer types in the market. Importantly, there is heterogeneity among the consumers, meaning there is sufficient variation in income, preference, and tastes.

(3.2) $$max_{\{z \in Z_m\}}(u(x, z, p(z))$$

(3.3) $$z = d(x)$$

The solution to equation (3.2) differs for each consumer and provides each with their own demand curve (3.3). For bundle z, and given the consumers vector of utility defining characteristics they will possess the demand function *d*. However, two consumers x_1 and x_2 where $x_1 \neq x_2$ will normally choose different bundles and derive different utility from them. In theory, the slope of the hedonic price function is the measure of consumers' marginal willingness to pay for a product or service (Nesheim, 2006). The marginal willingness to pay for different bundles of goods has many important economic implications and can be derived differently in plenty of different special cases, two important ones are continuous choice and discrete choice. In continuous choice models consumers will choose from and option of continuous alternatives, some examples being size of tv, square footage of a home. In a continuous choice case, the marginal willingness to pay is solved with the first order condition of the consumer's hedonic demand. The second special case is discrete choice, when consumers are faced with finite choices, this case is more applicable to the decision facing consumers when choosing between Choice and Select beef at the grocery store. Suppose there are now J elements within the m^{th} product (Z_m), meaning there is a finite number of options available to the consumer within the market. Now, let z_j be the j^{th} element in Z_m and $p_j = p(z_j)$ for all J's, and $k \in \{1,\ldots, J\}$ is simply another set of utility characteristics derived from a different set of goods.

$$u(x, z_j) - p_j \geq u(x, z_k) - p_k \tag{3.4}$$

Equation (3.4) states a consumer would prefer z_j over z_k as they would derive more utility for the price. However, some consumers may be faced with the following:

$$u(x, z_j) - p_j = u(x, z_k) - p_k \tag{3.4.1}$$

where $k \neq j$ means the consumer is indifferent towards the bundles z_j and z_k thus any difference between price of z_j and z_k is compensated for by utility between the bundles (Nesheim, 2006). Making their willingness to pay for z_j over z_k the following:

$$p_j - p_k = u(x, z_j) - u(x, z_k). \tag{3.4.2}$$

For consumers who are not indifferent between *j* and *k*, their willingness to pay is.

$$u(x, z_j) - u(x, z_k) > p_j - p_k. \tag{3.4.3}$$

Since the set of bundles available to the consumer is finite the hedonic price function can provide an explicit measure of the willingness to pay for consumers who are indifferent versus consumers who have a preference over certain products.

3.4 Nerlovian Distribution Lag Models and Partial Adjustment Model

The modern partial adjustment model postulated by Nerlove and Addison (1958) is a distributed lag model with one lag length. Nerlove and Addison assumed a behavioral model which implied a single period distributed lag, rather than testing for significance at each across differing lag lengths (Carlberg, 2003).The justification for the use of the partial adjustment model is due to the inherent, lagged value within the construction of the carcass cut-out values. Nerlove and Addison believed short-run elasticities would have less accurate outcomes due to their results corresponding to a single point in time and stipulated that long-run elasticities are often inaccurate due to constantly changing prices and adjustment paths (Carlberg, 2003). Nerlove and Addison decided that implementing a dynamic model instead of a static model was the solution because dynamic models have coefficients which are more plausible in sign and magnitude and provide residuals with less serial correlation (Carlberg, 2003). Nerlove and Addison explain that the amount of a commodity demanded changes only in proportion to the difference between the long-run equilibrium quantity desired and the current quantity demanded (Nerlove and Addison, 1958). For this study, the constructed models were estimated using the partial adjustment model. The partial adjustment model is useful for estimating models which rely heavily on past prices such as the Choice-Select spread. As discussed in Chapter 2, the Choice-Select spread maintains a similar lagged price in the calculation of the values for primal and sub-primal cuts. The partial adjustment model is outlined in equations (3.5) through (3.7).

$$q_t^* = \alpha + b_1 p_t + c y_t + \varepsilon_t \tag{3.5}$$

The equations above explain the relationship between the unobservable q^*_t and q_{t-1}. Equation (3.5) represents the long run quantity demanded of a product (q^*_t), α is the intercept, p_t is the price of the product, y_t is income of consumers, and ε_t is the error term. As this equation is not estimable due to constant changes in price and quantity, q^*_t is not observable, however, what is observable is the difference between the current quantity demanded and the long-run equilibrium, which is shown in equation (3.6).

$$q_t - q_{t-1} = \theta(q_t^* - q_{t-1}) \tag{3.6}$$

Theta is now the adjustment coefficient of the relationship between q^*_t and q_{t-1}. Theta has two constraints, theta must be in-between 0 and 1. Theta must be positive (greater than 0) since the adjustment must be in-line with the direction of the relationship between q^*_t and q_{t-1}. Theta must be less than 1 since this is a <u>partial</u> adjustment between q^*_t and q_{t-1}, therefore, if theta was equal to one the adjustment to the long-run equilibrium would be completed in one period, thus being contradictory to the partial adjustment. To estimate this model simply substitute the q^*_t in equation (3.5) with the right side of equation (3.6), after simplifying the theta through and isolating q_t the result is equation (3.7).

(3.7) $$q_t = \theta\alpha_0 + \theta b_1 p_t + \theta c y_t + (1-\theta)q_{t-1} + \gamma_t$$

When the partial adjustment model is estimated, the coefficients collected are a combination of the partial adjustment coefficient theta and the normally estimated coefficients, apart from the lagged quantity demanded. Solving for theta then provides the adjustment coefficient for the model. The adjustment coefficient can be explained as, how much the previous periods quantity demanded will adjust towards the relationship between q^*_t and q_{t-1}. Consequently, the Choice-Select spread is constructed using the carcass cut-out values of Choice and Select grade beef, which are calculated by utilizing the past two-day average of price for each of the seven primal cuts; this implies that the Choice-Select spread inherently has the previous two days of prices built into it and therefore that previous prices impact present day prices. However, this model utilizes weekly data and the effect of previous prices from week to week will not be as extreme compared to daily price changes.

Chapter 4

Data Overview and Collection

4.1 Overview

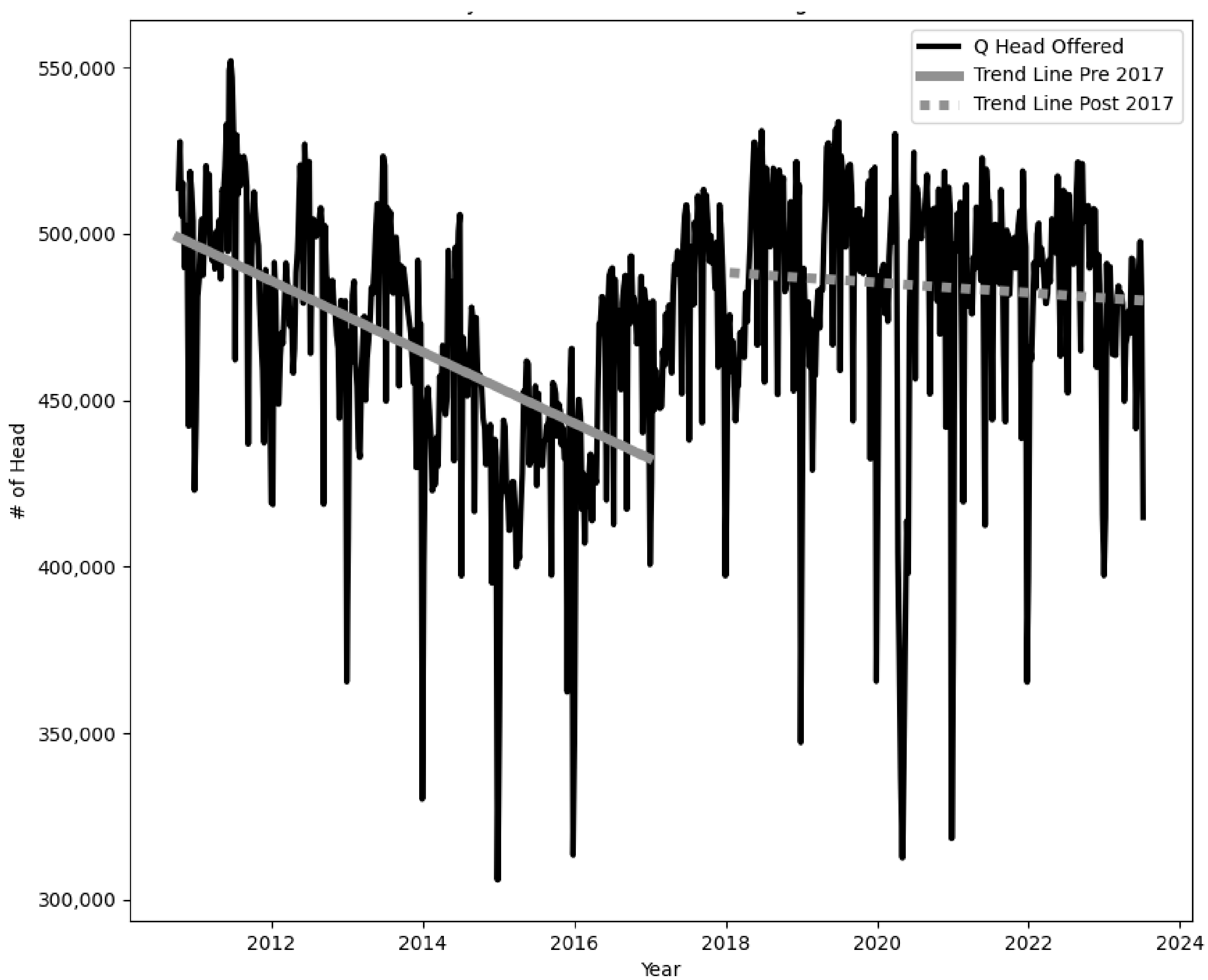
Data for this research were provided by two main sources: the United States Department of Agriculture's (USDA) Agriculture Marketing Service (AMS), and the Livestock Marketing Information Center (LMIC). The study period runs from January 6th, 2018, to July 23rd, 2023, a period of 262 weeks. Table 4.1 provides summary statistics for the data series used in this thesis.

Table 4.11 Summary Statistics of Variables

Variable Stats	Max	Min	Mean	Var	Skewness	Kurtosis
Choice-Select Spread	37.22	1.91	15.81	63.03	0.39	-0.75
Choice Boxed Beef Price	459.04	201.24	248.80	1,756.17	1.48	3.28
Percent Graded Choice	0.7549	0.6796	0.72	0.00	-0.13	-0.13
Quantity Head Offered	533,638	312,626	484,125.63	1,351,466,516.52	-2.02	5.11
Choice Driver	1	0	0.58	0.24	-0.34	-1.88
Grilling	1	0	0.43	0.25	0.27	-1.93

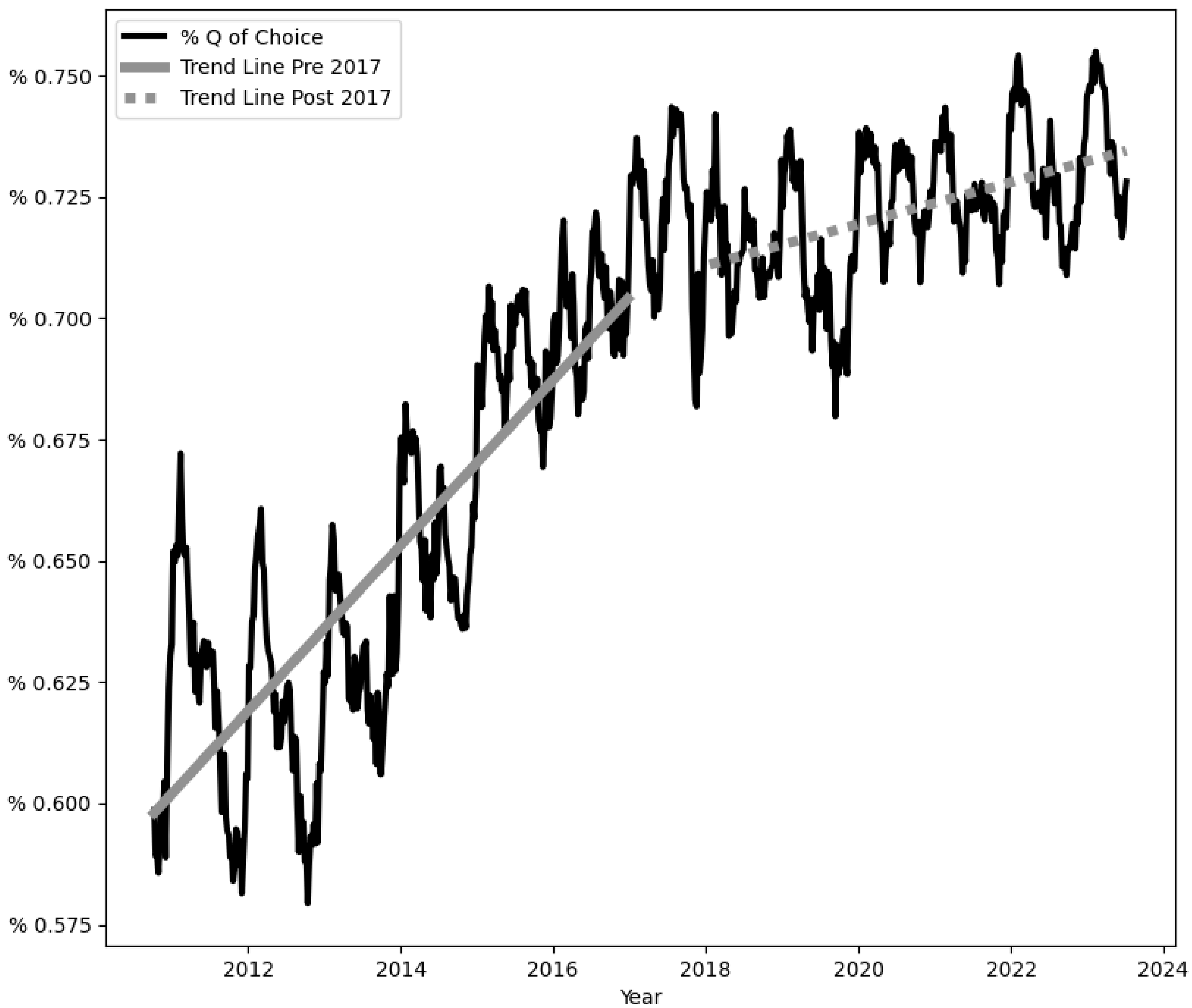
The four data sets used in this analysis are the average weekly Choice-Select spread – calculated as the difference between the average weekly carcass cut-out value of Choice and Select quality grades – along with the price of Choice boxed beef, the weekly percentage quantity of beef graded Choice, and the total number of head offered for grading that week. Interestingly, during the period of March 2020 to April 2021, as the Covid-19 pandemic impacted global food and commodity markets, the Choice-Select spread stayed constant and did not record any shocks. Due to the nature of the C-S spread the Covid pandemic did not affect it in any major way, as both the Choice and Select markets saw major increases in price during this time, meaning the spread between them remainder relatively stable. Therefore, since both markets had similar increases in price the C-S spread saw little to no change. To note, the original data set began on October 10th, 2010. However, during the period of 2015-2017 a structural change took place in the supply market for cattle. Figures 4.1 and 4.2 show this structural change in the quantity of head offered for grading, as well as the percentage quantity of Choice beef graded.

Figure 4.11 Weekly Head Offered with Trend Line



There is a clear structural shift in both supply data sets as the trend line in each figure has a significant adjustment pre and post 2017. The difference between the two structural shifts is one shift is permanent and one is cyclical. Figure 4.2 (% Choice Graded) displays a permanent shift in the structure of the market, with the increase of Choice beef graded unlikely to ever return to its previous mean of 50-65%. Figure 4.1 displays a cyclical shift in the market, as the total number of head offered will likely return to this state within the near future. The structural change in Figure 4.1 is likely due to the underlying 10-year cattle cycle.

Figure 4.12 Percent Quantity Choice Trend Lines



4.1.1 Choice-Select Spread

The data for the Choice-Select spread were compiled by the *Livestock Marketing Information* Center and published in the USDA report LM_CT155 titled *National Weekly Direct Slaughter*

Cattle - Premiums and Discounts; Figure 4.3 shows this report in its weekly (raw) publication format. The first column displays the range of premiums and discounts that week, to the right is the average of that week, the last column is the change in the average from the previous week. The highlighted value is the Choice-Select spread for that week. Figure 4.4 shows the Choice-Select spread for the period in question, illustrating the significant volatility and seasonality in the spread.

Figure 4.13 National Weekly Direct Slaughter Cattle Premiums and Discounts

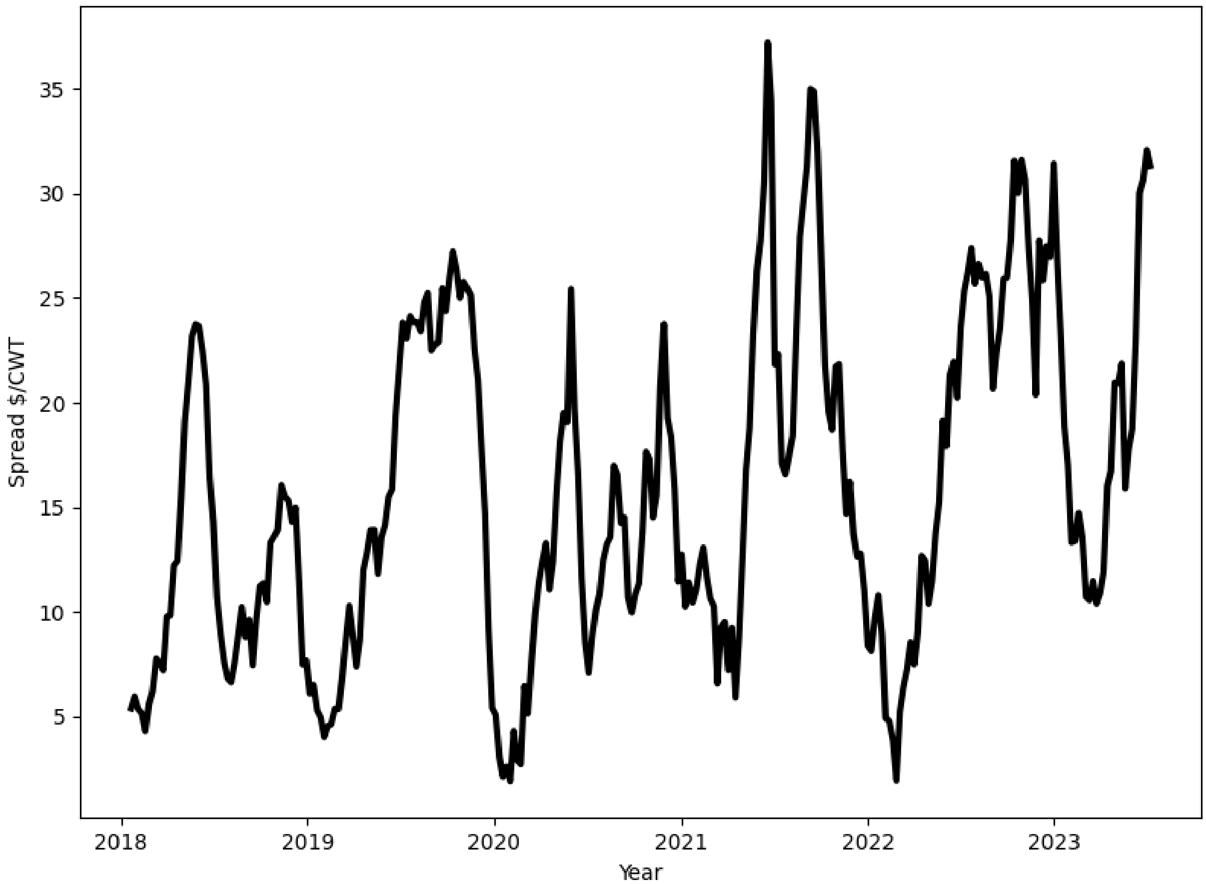
LM_CT155
St. Joseph, MO   Mon Mar 13, 2023   USDA Market News Service

NATIONAL WEEKLY DIRECT SLAUGHTER CATTLE - PREMIUMS AND DISCOUNTS
For Week of: 3/13/2023
Value Adjustments

	Range	Simple Avg.	Change
Quality:			
Prime	0.00 - 31.00	15.75	(0.23)
Choice	0.00 - 0.00	0.00	0.00
Select	(20.00)- (8.00)	(13.75)	1.33
Standard	(53.00)- (10.00)	(30.29)	1.21
CAB	2.00 - 9.00	4.71	0.00
All Natural	24.00 - 50.00	33.45	0.00
NHTC	19.00 - 26.00	22.00	0.00
Dairy - Type	(15.00)- 0.00	(2.64)	0.00
Bullock/Stag	(55.00)- (15.00)	(36.00)	0.00
Hardbone	(55.00)- (20.00)	(35.56)	1.11
Dark Cutter	(55.00)- (20.00)	(34.58)	0.00
Over 30 Months of Age	(40.00)- 0.00	(14.29)	0.00
*Cutability Yield Grade, Fat/Inches			
1.0-2.0 < .10"	0.00 - 8.00	3.58	0.00
2.0-2.5 < .20"	0.00 - 4.00	1.77	0.00
2.5-3.0 < .40"	0.00 - 4.00	1.38	0.00
3.0-3.5 < .60"	0.00 - 0.00	0.00	0.00
3.5-4.0 < .80"	0.00 - 0.00	0.00	0.00
4.0-5.0 < 1.2"	(15.00)- (8.00)	(11.75)	0.00
5.0/up > 1.2"	(25.00)- (10.00)	(16.58)	0.00
Weight:			
400-500 lbs	(45.00)- 0.00	(29.29)	0.00
500-550 lbs	(45.00)- 0.00	(22.64)	0.00
550-600 lbs	(35.00)- 0.00	(11.57)	0.00
600-900 lbs	0.00 - 0.00	0.00	0.00
900-1000 lbs	(15.00)- 0.00	(1.07)	0.00
1000-1050 lbs	(20.00)- 0.00	(5.00)	0.00
over 1050 lbs	(25.00)- (5.00)	(15.71)	0.00

Source: USDA-AMS (2023a).

Figure 4.14 Choice-Select Spread, 2018-2023



4.1.2 Price of Choice Boxed Beef

The data for the price of Choice boxed beef were compiled by the *Livestock Marketing Information Center* (LIMC, 2023) and published in the USDA report NW_LS410 *USDA Beef Carcass Price Equivalent Index Value*; see Figure 4.5 for an overview of this report.

Figure 4.15 USDA Beef Carcass Price Equivalent Index Value

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NW_LS410
Des Moines, IA     Tue, Jun 27, 2023     USDA Market News

USDA BEEF CARCASS PRICE EQUIVALENT INDEX VALUE

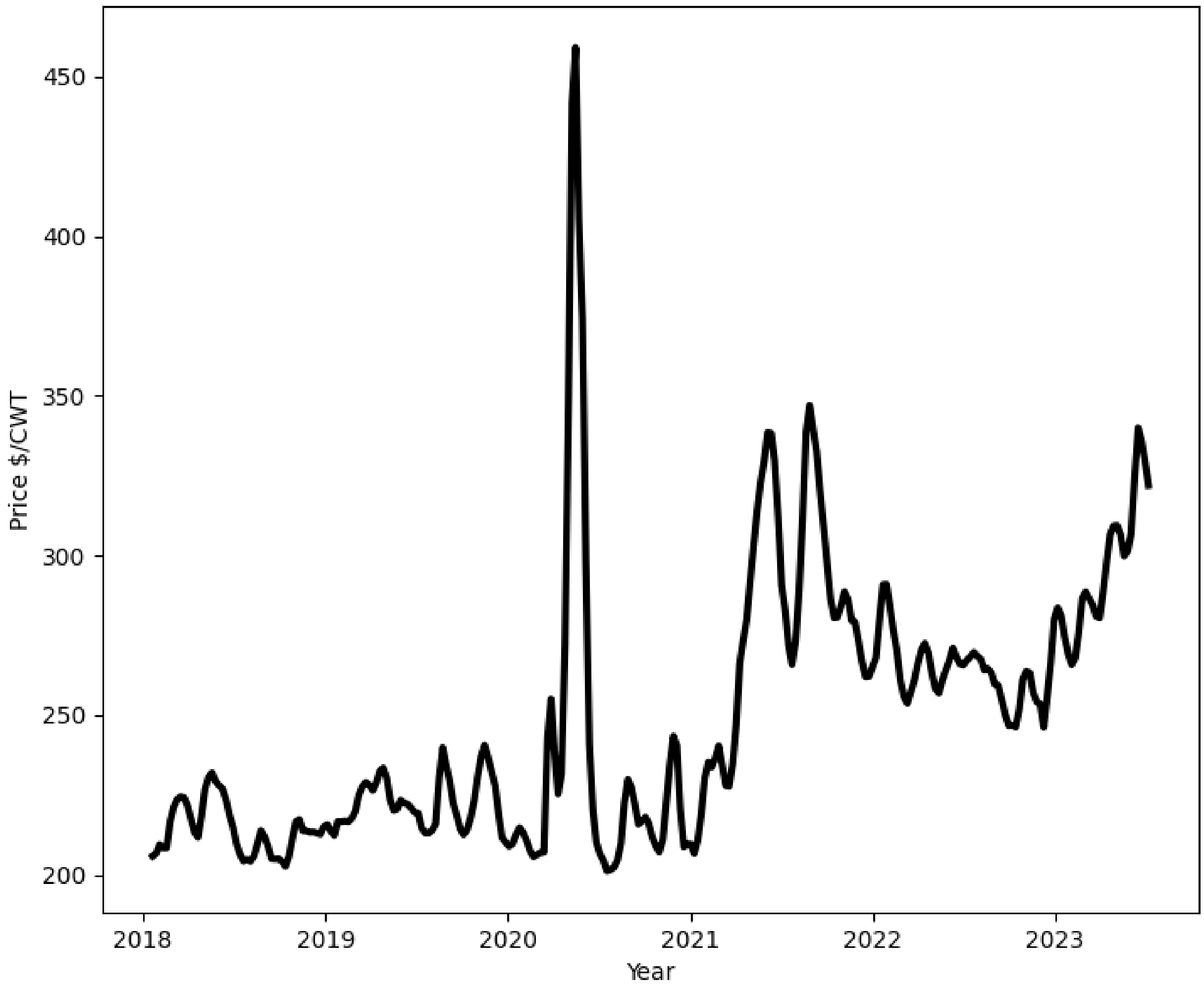
                             CHOICE              SELECT
Index                       600-900#            600-900#
 Values =>                    $297.11             $268.60
 Change =>                      -2.01               -0.72
------------------------------------------------------------------------------
Current Index Reflects the Equivalent of 100,866 head of cattle.
SUPPLY (Live)  60,023 Hd
Equivalent:                   $277.00             $250.78
DEMAND (Box)   40,843 Hd*
Equivalent:                   $317.23             $286.43
Live-Box Spread:             ($40.23)            ($35.65)
----------------------------  Input Breakdown   -----------------------------
         National Daily Direct Cattle          :      Boxed Beef Cutouts
        (5 day accumulated wghtd avg)          : Ch 600-900#          $329.23
                  Weight    Price     Head     : Se 600-900#          $298.43
  Live Steer:          1429   $182.86   37,005: Current Lds:           146.8
  Live Heifer:         1279   $182.17   14,072: Previous Lds:           82.0
  Drsd Steer:           913   $290.02    6,679
  Drsd Heifer:          831   $287.36    2,267
------------------------------------------------------------------------------
      Grading % Breakdown            :         Drop Credit      :        13.31
 Ch 600-900# :                 84.43%:         Steer Dressing % :       62.92%
 Ch 600-750# :                 34.13%:         Heifer Dressing %:       62.93%
 Ch 750-900# :                 50.30%:         Processing Cost  :        12.00
 Se 600-900# :                 15.57%:         Slaughter Cost   :        50.50
 Se 600-750# :                  4.06%:
 Se 750-900# :                 11.50%:
------------------------------------------------------------------------------
 Equivalent Values for Outlying Beef Carcass Types
 Basis Value = 297.11                      Carcass Weights
                             400-500#500-600#  600-900#  900-1000#  1000#/up
 Qlty/Yield      (1)           -29.29    -17.11               -3.04    -15.71
------------------------------------------------------------------------------
 Prime 1-3           14.74   $282.56   $294.74   $311.85   $308.81   $296.14
 Certified 1-3        6.21   $274.03   $286.21   $303.32   $300.28   $287.61
 Choice 1             3.58   $271.40   $283.58   $300.69   $297.65   $284.98
 Select 1           -22.17   $245.65   $257.83   $274.94   $271.90   $259.23
 Stndrd 1-3         -35.01   $232.81   $244.99   $262.10   $259.06   $246.39
 Prime 4              1.47   $269.29   $281.47   $298.58   $295.54   $282.87
 Choice 4           -11.92   $255.90   $268.08   $285.19   $282.15   $269.48
------------------------------------------------------------------------------
```

Source: USDA-AMS (2023c).

The *USDA Beef Carcass Price Equivalent Index Value* is a report which is published daily, hence why the *Livestock Marketing Information Center* compiled the raw data to calculate the weekly averages in its weekly (raw) publication format. Figure 4.6 shows the price of Choice boxed beef for the study period. The price of Choice boxed beef represents the wholesale demand and supply for Choice beef, which is derived from the demand at the retail level (Hogan, 2003). Figure 4.6 displays the price of Choice boxed beef over time. Visually, the data series appears to have a slight upward trend with a significant price increase occurring with the onset of the

Covid-19 pandemic in March 2020. Interestingly, the Choice-Select spread did not change significantly with the onset of the pandemic since both Choice and Select experienced price increases of similar magnitudes; therefore, the spread remained relatively constant.

Figure 4.16 Price of Choice Boxed Beef, 2018-2023



4.1.3 Quantity Percent of Choice Graded Beef

The source of this dataset was the USDA report *National Steer and Heifer Estimated Grading Percent Report*; see Figure 4.7 for a sample of this report.

Figure 4.17 USDA National Steer & Heifer Estimated Grading Percent Report

NW_LS196
Des Moines, Iowa   Mon Mar 13, 2023   USDA Market News

USDA NATIONAL STEER & HEIFER ESTIMATED GRADING PERCENT REPORT
For Week Ending: 3/4/2023

National, Regional, and State Breakdown of Official USDA Quality Grades.
Percentages derived from each category numerical total, divided by the total
number offered for USDA quality grading in each corresponding area.

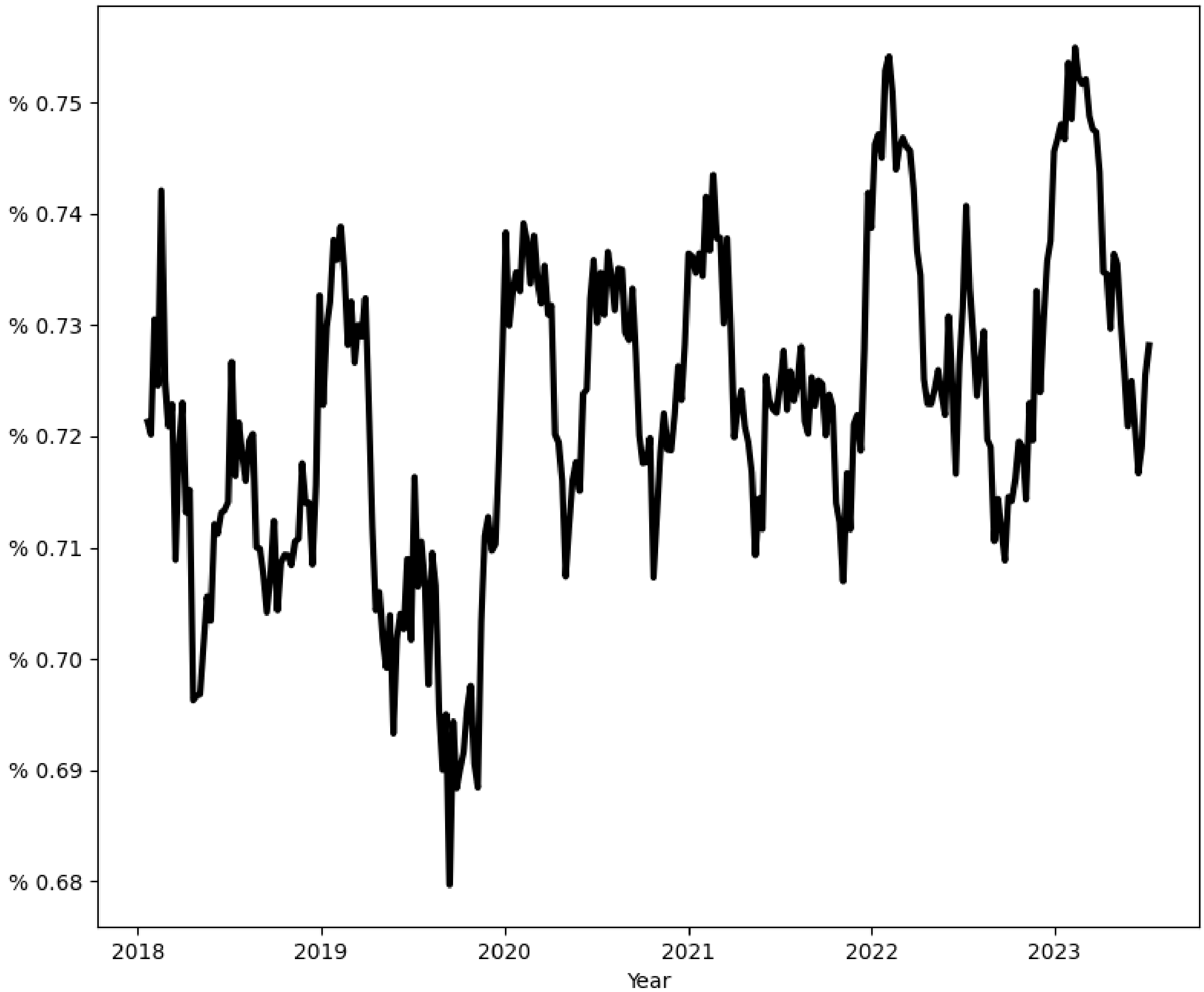
	National	Region 1-5	Region 6	Region 7-8	Region 9-10
Prime	9.82%	14.10%	4.92%	9.72%	15.91%
Choice	75.21%	71.84%	67.94%	77.30%	76.75%
Select	11.97%	10.75%	24.71%	9.78%	5.19%
Other	3.00%	3.31%	2.43%	3.20%	2.14%

	Nebraska	Kansas	Texas
Prime	11.34%	8.27%	4.92%
Choice	75.33%	78.75%	67.94%
Select	9.00%	10.14%	24.71%
Other	4.33%	2.83%	2.43%

Source: USDA-AMS (2023d).

The dataset used in the model was compiled by the *Livestock Marketing Information Center* (LMIC, 2023) from January 2018 to July 2023. The *National Steer and Heifer Estimated Grading Percent Report* (USDA-AMS, 2023d) reports the regional and national quality grading percentages for a given week; from 2010-2015 the amount of Choice beef graded on a national level varied between fifty-eight and sixty-five percent. However, since 2015, the percent of Choice beef graded has increased to over 75%. Potential explanations for this change include improved cattle genetics, improved food quality, and increased animal welfare (Peel, 2021), as well as the increase of individual and grid-base marketing systems for cattle. Figure 4.8 shows clear seasonal patterns within the percentage quantity of Choice beef graded; this could be due to the supply cycles of cattle as they are moved from cow-calf operations to feedlots during different times of the year.

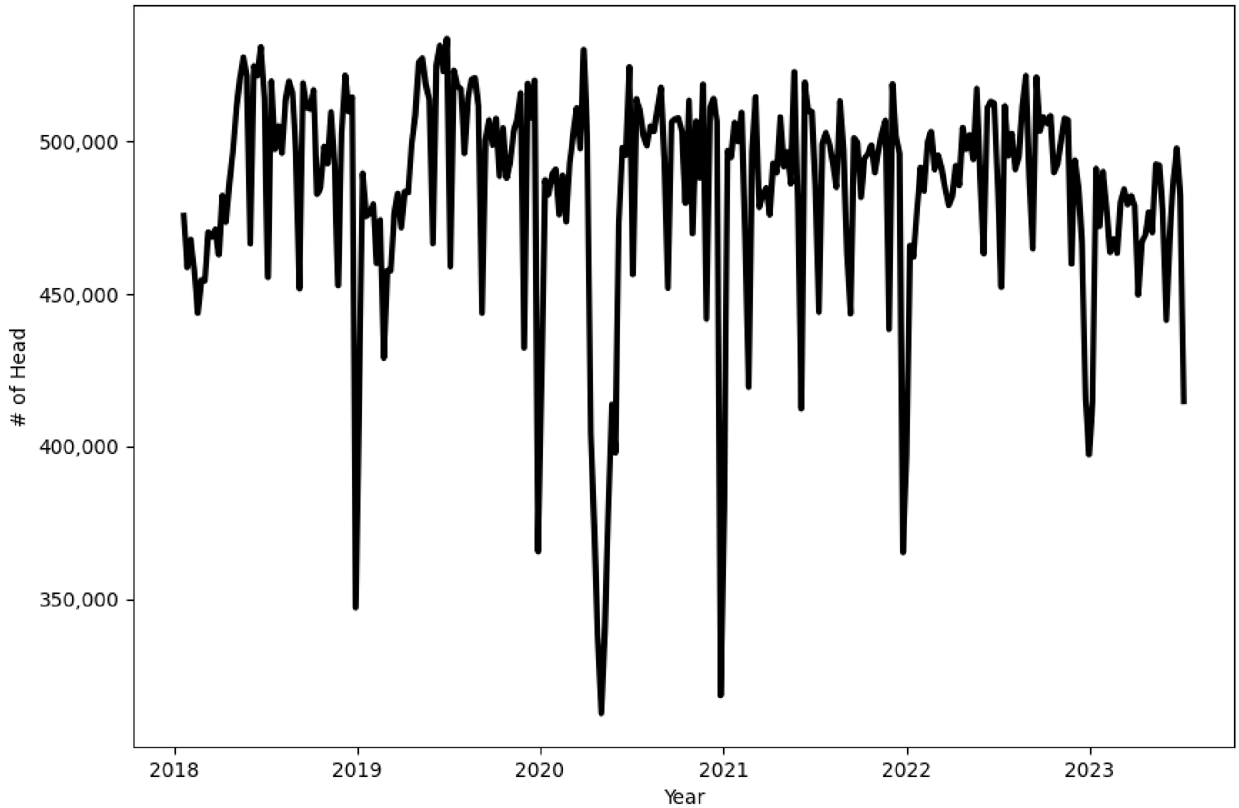
Figure 4.18 Percent Quantity Choice Graded, 2018-2023



4.1.4 Head Offered

The data for the head offered for grading was compiled and published by the *Livestock Marketing Information Center* (LMIC, 2023); see Figure 4.9 for a representation of the data over the period of observation. The head offered for grading variable is the second supply variable in this model and captures the overall supply of cattle within the United States. Interestingly, the number of head offered over the study period is quite stable, ranging from 300,000 to 550,000 per week, with an average of 488,000. To note, each year there are one to two weeks of outlier observations which report vastly less head offered, these are shorter weeks during Christmas and New years, hence a reduced overall head for those weeks.

Figure 4.19 Head Offered, 2018-2023



4.1.5 Grilling Season

Using a grilling season dummy variable is designed to capture the seasonality of consumer demand within the Choice-Select spread. Historically, grilling season is considered to range between approximately Memorial Day through Labor Day, as these are the summer months in the U.S. when people tend to grill more often, and usually choose high-quality (i.e. Choice) cuts of meat for this purpose. Lusk et al (2001) was among the earliest researchers to include grilling season as a measure of seasonality in the beef industry. His work examined demand elasticities of different meats and preferences for higher-quality cuts during summer months due to this grilling season effect. To ensure that meat packers are able to fill orders properly, most retail grocery stores place orders for beef products one month in advance (Peel, 2021). To capture this effect, the month of April has been added to the grilling season months, as grocery stores prepare for the increased demand from May to August.

4.1.6 Spread Driver Dummy Variable

The spread driver variable is designed to capture the underlying movements of each market (Choice and Select) by comparing the absolute values of Choice and Select boxed beef from one period to the next. If the price of Choice boxed beef has a larger movement than the price of Select boxed beef, then the spread driver dummy variable equals one, whereas if the converse is true, then the spread driver dummy equals zero. This dummy variable attempts to quantify the interconnectedness of the two markets, to determine whether one or the other is more prominently influencing the spread. Determining which market is more influential could aid in the search of seasonal effects; for example, if the Choice market has more influence on the spread, economists could then look at seasonal effects within the Choice market such as the seasonality of the quantity percent of Choice graded beef, to help determine patterns within the Choice-Select spread. Choice beef was the "driver market" for 147 out of the total 262 weeks of observations, thus it was the "driver market" 56% of the time. Table 4.1 outlines the first ten observation weeks of the driver dummy variable.

Table 4.12 Driver Dummy Variable First Ten Observations

Date	Price Choice Boxed beef	Price Select Boxed Beef	Choice Price Differenced	Select Price Differenced	Driver Dummy
10/9/2010	152.42	145.21	0	0	N/A
10/16/2010	153.19	146.04	0.77	0.83	0
10/23/2010	159.19	152.31	6	6.27	0
10/30/2010	161.54	154.12	2.35	1.81	1
11/6/2010	159.57	152.33	1.97	1.79	1
11/13/2010	157.79	148.92	1.78	3.41	0
11/20/2010	158.6	149.64	0.81	0.72	1
11/27/2010	161.01	150.71	2.41	1.07	1
12/4/2010	163.01	152.55	2	1.84	1
12/11/2010	164.4	153.23	1.39	0.68	1

Chapter 5

Procedure and Methodology

5.1 Models Construction

The partial adjustment model is used to estimate the effects of the independent variables upon the value of the Choice-Select spread. This lagged dependent variable model is ideally suited for the Choice-Select spread due to the dependent variable being influenced by previous prices as discussed above in Chapter 3. Therefore, the partial adjustment coefficient will help capture the impact previous prices have on the estimation of the model and determine the adjustment factor towards the long-run equilibrium. The model contains six independent variables, three being quantitative data sets collected from the USDA-AMS, two dummy variables, and the lagged Choice-Select spread (shown in Table 5.1). To provide a more thorough analysis of the independent variables robustness under varying conditions four models were estimated. Table 5.2 outlines the variables within the four different models estimated using GLS. The reasoning for four different models is to outline the robustness of the grilling season and other variables, as the addition of a second supply variable within the model, added multitude of disturbances within the model. Instead of tinkering with alternative variations of the model until the results were satisfactory, the results present the estimation of all models.

Table 5.11 Model Variables

Variable name	Variable notation
Lagged Choice-Select Spread	$P_{C-S_{t-1}}$
Quantity Percentage of Choice	$q\%_{Ch_t}$
Price of Choice Boxed Beef	P_{BB_t}
Quantity of Head Offered	q_{Head_t}
Grilling Season Dummy	δ_{1_t}
Choice Driver Dummy	δ_{2_t}

Table 5.12 Model Outlines

	Model 1	Model 2	Model 3	Model 4
Intercept	X	X	X	X
Choice Boxed Beef Price	X	X	X	X
Percent Quantity Choice Graded	X	X	X	X
Choice-Select Spread (Lagged)	X	X	X	X
Grilling Season	X	X	X	X
Driver	X	X		
Quantity of Head Offered	X		X	

5.1.1 Driver Dummy Variable

As discussed in Chapters 3 and 4, the Choice-Select spread consists of two interconnected markets: one for Choice beef and one for Select beef. These markets can and do fluctuate independently form each other and possess their own unique demand curves. Nevertheless, they also have some influence on one another because each draw from the same pool of supply (the U.S. cattle herd) and each contains similar end products primal and sub-primal cuts of meat that are highly substitutable. Understanding which market has more influence over the spread in any given week – i.e. which market "drives" the spread – may provide information to the market, as it provides insights into underlying market conditions and the direction in which the spread is trending. Accordingly, this "market driver" indicator (dummy) variable is designed to capture which of the two markets (Choice or Select) dominates the magnitude of the spread in any given week. It does this by comparing the absolute value of the change in the price of Choice and

Select boxed beef, given that the Choice-Select spread is simply the difference of carcass cut-out values, the boxed beef prices have a better representation of the consumers derived demand and thus, which quality of beef has the increased demand that week.

$$x_1 = \Delta\, Price\ of\ Choice\ Boxed\ Beef$$

$$x_2 = \Delta\, Price\ of\ Select\ Boxed\ Beef$$

The Spread driver is thus created by taking the absolute value of the change in price for Choice and Select boxed beef (per cwt) and comparing them to each other; whichever market has the larger change in price that week is assigned to be dominating the market and assigned as the driver of the spread for that week. For example, if the price of Choice boxed beef had a change of $5 and the price of Select boxed beef had a change of $2, the Spread driver variable would take on a value of one, as Choice would have been the driving market during that week. Conversely, if the change in the price of Select boxed beef was greater than for Choice, the variable would take on a value of zero.

$$\delta_{2_t} = 1, \qquad if\ |x_1| > |x_2|$$

$$\delta_{2_t} = 0, \qquad if\ |x_1| < |x_2|$$

5.1.2 Model Equation and Estimation

The Choice-Select model 1 is shown in equation (5.1).

(5.1) $$P_{C-S_t} = b_{1_t} + b_2 q\%_{Ch_t} + b_3 P_{BB_t} + b_4 q_{Head_t} + \delta_{1_t} + \delta_{2_t} + v_t$$

Equation (5.2) shows the relationship between the unobservable P^*_{C-S} and $P_{C-S_{t-1}}$

(5.2) $$P_{C-S_t} - P_{C-S_{t-1}} = \theta(P^*{}_{C-S_t} - P_{C-S_{t-1}})$$

It is important to note that when estimating the partial adjustment model, the resulting coefficients are a product of both the adjustment coefficient θ and the ordinary estimation coefficients b as seen in equation (5.3).

(5.3)
$$P_{C-S_t} = \theta\alpha_{0_t} + (1-\theta)P_{C-S_{t-1}} + \theta\alpha_2 q_{\%Ch_t} + \theta\alpha_3 P_{BB_t} + \theta\alpha_4 q_{Head_t} + \theta\alpha_5\delta_{1_t} + \theta\alpha_6\delta_{2_t} + \varepsilon_t$$

The product of theta and b is the coefficient β seen in equation (5.4)

(5.4)
$$P_{C-S_t} = \beta_{0_t} + \beta_1 P_{C-S_{t-1}} + \beta_2 q_{\%Ch_t} + \beta_3 P_{BB_t} + \beta_4 q_{Head_t} + \beta_5\delta_{1_t} + \beta_6\delta_{2_t} + \varepsilon_t$$

Thus, the resulting adjustment coefficient can be found via equation (5.5). The model was estimated first using OLS, however, after testing for autocorrelation and dynamic heteroskedasticity (see Table 5.3), it was determined that generalized least squared (GLS) estimation would be necessary.

(5.5)
$$\theta = 1 - \beta_1$$

5.2 Overview of Hypothesis Tests

Hypothesis testing were as follows; four models outlined in Table 5.2 were estimated using GLS. The models with the best goodness of fit would be the one used to draw interpretations of the coefficients. The goodness of fit statistics are outlined in Table 6.2. The models were created using the data outlined in Chapter 4 and we were estimated using the statsmodels version 0.14.0 library in Python (Perktold et al., 2023). When estimating models with time series data there can be the possibility of specification errors, which could affect the magnitude of the coefficients, and/or inflate the standard error and thus a reduction in the t-statistics of the model. This Chapter will investigate the procedures of testing for any relevant specification errors as well as the construction of the dummy variables used.

5.2.1 Assumptions for Linear Modeling

There are six main assumptions when conducting linear modelling, and when followed the estimation should produce statistically valid linear findings. The first assumption is the value of y for each value of x_i for (x_1, x_2, ..., x_i) is equal to an equation of coefficients $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_i x_i + \varepsilon$ and an error term ε. The second assumption is the expected value of the error term is $E(\varepsilon) = 0$ since $E(y) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_i x_i$. The third assumption is that no heteroskedasticity is present within the error terms, meaning the variance of the random error ε is $var(\varepsilon) = \sigma^2 = var(y)$. The fourth assumption is no autocorrelation is present within the error terms, meaning the covariance between any pair of random errors ε_i and ε_j is $cov(\varepsilon_i, \varepsilon_j) = cov(y_i, y_j) = 0$. The fifth assumption is the variables x_i are not random and take on different values. The sixth and final assumption is the error term is normally distributed around their mean $\varepsilon \sim N(0, \sigma^2)$ (Hill et al., 2001).

5.2.2 Tests for Stationarity

Estimating models with non-stationary data can violate the linear modeling assumptions mentioned in above (Hill et al., 2001). Therefore, when working with time series data it is always good practice to confirm the order of integration of the data before proceeding with analysis. Stationarity can be described as time series data which has a constant mean and variance over an indefinite period. The two types of trends for non-stationarity time series data are deterministic trends and stochastic trends. A deterministic trend means the observations will always increase with time, this is not to say the observations cannot fluctuate randomly period to period, but if the window of observation is large enough there will be a clear upwards trend in the data set. A good example of a deterministic trend is the nominal price of goods. Over a long period of time the prices will continue to rise around the trend, which in this case is the rate of inflation. The second type of trend is a stochastic trend, which can be describe as a random walk. This type of trend can change from period to period and is much more effected by shocks or external influence. If a data set with a stochastic trend experiences a shock, the future observation of the data will be centered around a new mean due to this shock. To determine whether a data set is stationary, one must test for unit roots. Unit roots are stochastic trends which can be found in time series data sets (Everitt et al., 2010), and can be tested for using (among other methods) the Augmented Dicky-Fuller (ADF) test.

Table 5.2 Stationarity Test of Exogenous Variables

Variables	Test-Statistic	p-value	# Lags Used	Decision
Percent Choice Graded	-4.210	<0.01	6	Stationary
Choice Boxed Beef Price	-2.572	0.11	8	Not Stationary
Quantity of Head Offered	-9.141	<0.01	0	Stationary
Choice Boxed Beef Price Differenced	-7.896	<0.01	7	Stationary

Table 5.3 shows the results of the ADF test for price of Choice boxed beef, quantity of Choice beef graded, and quantity of head offered for grading. The only variable to be non-stationary during the study period is the price of Choice boxed beef, probably due to the general inflation of food product prices over the period in question. Differencing is one method of making the series stationary; this is done by subtracting the value of the series in the current period of observation from its previous value. Once differenced, price of Choice boxed beef now represents the change in price from one period to the next, this still maintains the level of randomness from the data while removing the underlying trend responsible for the non-stationarity.

5.2.3 Autocorrelation

Autocorrelation violates the fourth assumption of linear modeling (correlation of error terms across periods of observations). The implications of autocorrelation within the model can have serious negative impacts; smaller standard errors, larger t-statistics, and inefficient OLS estimators are some of the main disruptions' autocorrelation can cause (Hill et al., 2001). There are multiple ways to detect autocorrelation; for this research a Lagrange Multiplier (LM) class of test was selected; the Breusch-Godfrey test was used to detect autocorrelation. It detects autocorrelation by estimating the residuals of the OLS model and determining if serial correlation is present within the residuals. The null hypothesis of the Breusch-Godfrey test is there is no serial correlation among the residuals. The test results are shown in Table 5.3. As the results show, autocorrelation is present when using the Ordinary Least Squares (OLS) model, to address this, Generalized Least Squares (GLS) estimation is used (Everitt et al., 2010). To transform the model into GLS the correlated error term ε_t in equation (5.4) must be replaced by an uncorrelated error term γ_t,, where $\varepsilon_t = \rho\varepsilon_{t-1} + \gamma_t$. After isolating ε_{t-1}, the transformation of the equation can commence, by multiplying the equation by ρ (the autocorrelation coefficient).

(5.6) $$P_{BB}{}_t^{*} = P_{BB_t} - \rho P_{BB_{t-1}} \qquad t = 2,3,4, \dots, T$$

The first step in the GLS process is to transform all the independent variables with the ρ term. Equation (5.6) shows this transformation of the price of Choice boxed beef variable; this equation is repeated for each independent variable for all observations.

(5.7) $$P_{C-S_t}^{*} = P_{C-S_t} - \rho P_{C-S_{t-1}} \qquad t = 2,3,4, \dots, T$$

The next step is to transform the dependent variable shown in equation (5.7). The intercept is also transformed by equation (5.8).

(5.8) $$x_1^{*} = 1 - \rho$$

Once all dependent and independent variables have been transformed the equation is simplified and rearranging, the new GLS equation/model is seen in equation (5.9).

(5.9) $$P^*_{C-S_t} = x^*_1\beta_{0_t} + \beta_1 P^*_{C-S_{t-1}} + \beta_2 q^*_{\%Ch_t} + \beta_3 P^*_{BB_t} + \beta_4 q^*_{Head_t} + \beta_5 \delta^*_{1_t} + \beta_6 \delta^*_{2_t} + \gamma_t$$

Since each variable is now a lagged version of itself there will be a missing first observation. As the total observations in the data set is large (262), dropping the first observation will not have a significant impact on the estimation of the model.

Table 5.2 Lagrange Multiplier Test for Autocorrelation

	Model 1		Model 2		Model 3		Model 4	
	t	P>|t|	t	P>|t|	t	P>|t|	t	P>|t|
Breusch-Godfrey-Lagrange	15.967	0.101	16.847	0.078	16.544	0.085	17.252	0.069

Chapter 6

Results and Discussion

6.1 Overview

The results of the GLS models 1 through 4 are presented in Table 6.1. Estimation resulted in statistically significant coefficients for price of Choice boxed beef, lagged Choice-Select spread, the percentage of Choice beef graded, grilling season, and the driver dummy variable for models 2, 3 and 4. Head offered for grading was statistically insignificant in all models. The coefficients for the significant variables also maintain the expected signs. All models varied by less than 1% in their R-Squared values (Table 6.2), with each model explaining 89.5% to 90% of the variation in the Choice-Select spread. More contemporary measures of goodness of fit, including Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) are also reported in Table 6.2; Model 2 maintains the lowest AIC and BIC scores at 1265 and 1287 respectively.

Table 6.11 Regression Results Summary

	Model 1	Model 2	Model 3	Model 4
Intercept	12.727 (9.823)	16.79* (9.03)	15.32 (10.058)	18.1234* (9.242)
Price of Choice Boxed Beef Differenced	0.072** (0.013)	0.069** (0.01)	0.069** (0.013)	0.067** (0.012)
Percent Quantity of Choice Graded	-18.71 (12.555)	-21.68* (12.34)	-21.99* (12.862)	-24.0* (12.61)
Choice-Select Spread (Lagged)	0.938** (0.021)	0.93** (0.02)	0.932** (0.022)	0.9311** (0.022)
Grilling (April-August)	0.778** (0.327)	0.80** (0.32)	0.684* (0.334)	0.7042* (0.335)
Driver Variable (Choice)	-0.823** (0.276)	-0.79** (0.27)		
Quantity of Head Offered for Grading	3.97E-06 (4.11E-06)		2.76E-06 (4.18E-06)	

Note: Double and single asterisks denote statistical significance at the 5% and 10% levels, respectively. Standard errors are in parentheses.

Table 6.12 Goodness of Fit Summary Statistics GLS Models 1-4

Goodness of Fit	Model 1	Model 2	Model 3	Model 4
R-squared	0.9	0.898	0.895	0.894
Adj. R-squared	0.897	0.896	0.893	0.892
Akaike Information Criterion	1266	1265	1272	1271
Bayesian Information Criterion	1292	1287	1294	1289
Skew	0.014	-0.024	0.055	0.028
Kurtosis	5.419	5.362	5.745	5.682
Durbin-Watson	1.994	1.997	1.994	1.997
Jarque-Bera (JB)	69.738	66.526	89.922	85.75

6.1.1 Price of Choice Boxed Beef

The price of Choice boxed beef is statistically significant across all models. Based on the results from Table 6.1 a one dollar change in the price for Choice boxed beef leads to an increase of \$0.069 - \$0.072/cwt in the Choice-Select spread. This is logical as an increase in the price of Choice boxed beef is an increase in the derived demand and thus widens the spread, as Choice beef has increased demand compared to Select.

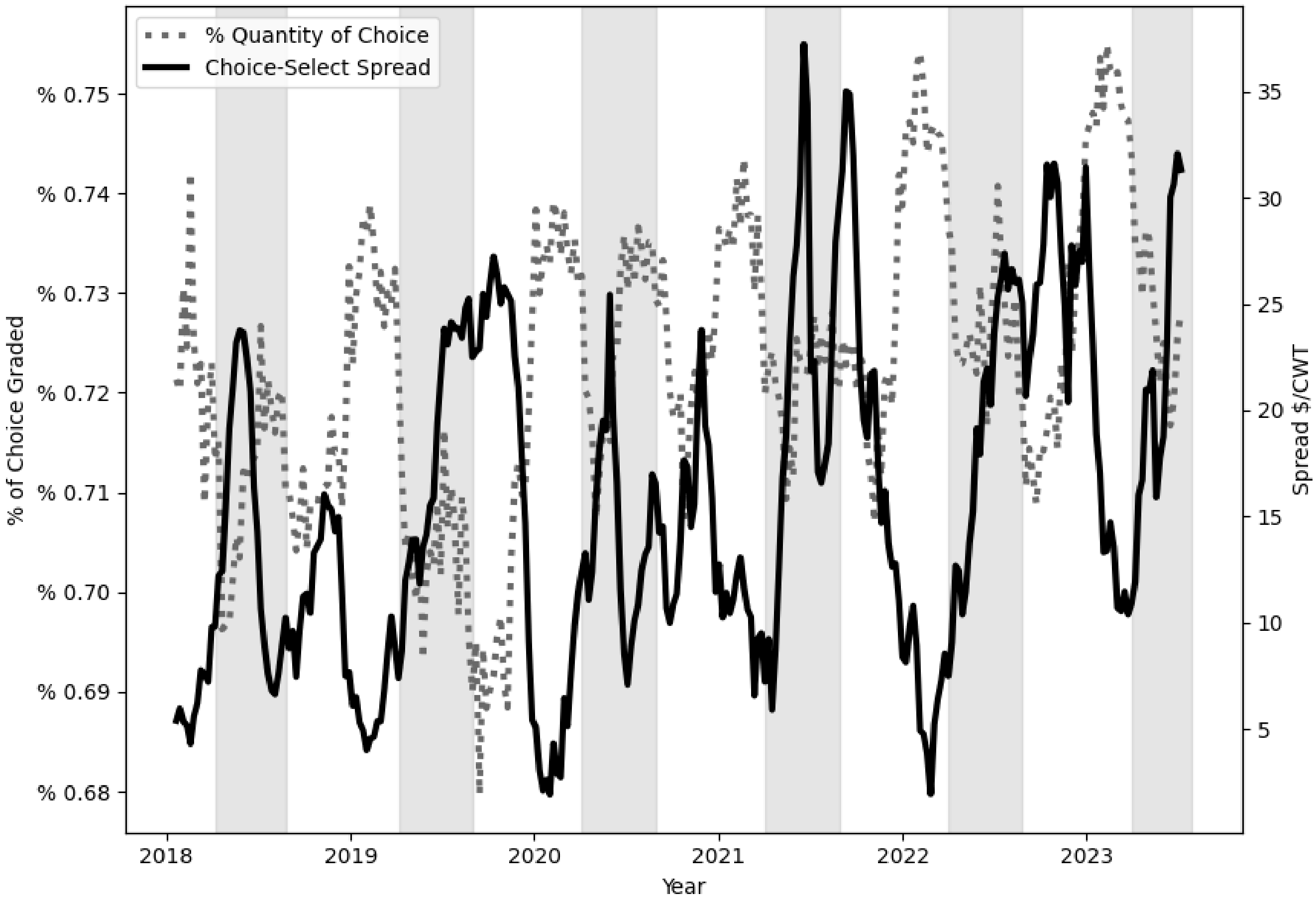
6.1.2 Head Offered

The quantity of head offered for grading does have the expected sign (i.e. as supply increases the spread decreases). However, it is not statistically significant ($P = 0.897$), so cannot make the case that total head offered for grading has an impact on the Choice-Select. An explanation for total number of head offered not having a statistical impact on the Choice-Select spread as follows. The ratio of Choice and Select graded cattle is the same whether there are 500,000 cattle offered or 300,000 cattle offered. The ratio of Choice graded meat will still be roughly 70-75%.

6.1.3 Quantity Percentage of Choice Graded

The quantity percentage of Choice graded beef is statistically significant, with the expected sign. The coefficient suggests that a 1% increase in the difference of national beef graded Choice leads to a \$21-24/cwt decrease of the Choice-Select spread. This is the most impactful of all the variables in any of the models estimated and has a clear inverse correlation to the Choice-Select spread as depicted in Figure 6.1.

Figure 6.11 Relationship of Percent Quantity Graded and Choice-Select Spread



Note: Shaded regions represent grilling season (April-August).

Thus, when the percentage of Choice meat graded increases or decreases it has a direct effect on the Choice-Select spread. The average change (difference week-to-week) of Choice beef percentage graded is 0.00023%. Similar to the number of head offered for grading, the percent of Choice beef graded is a supply variable which is inelastic.

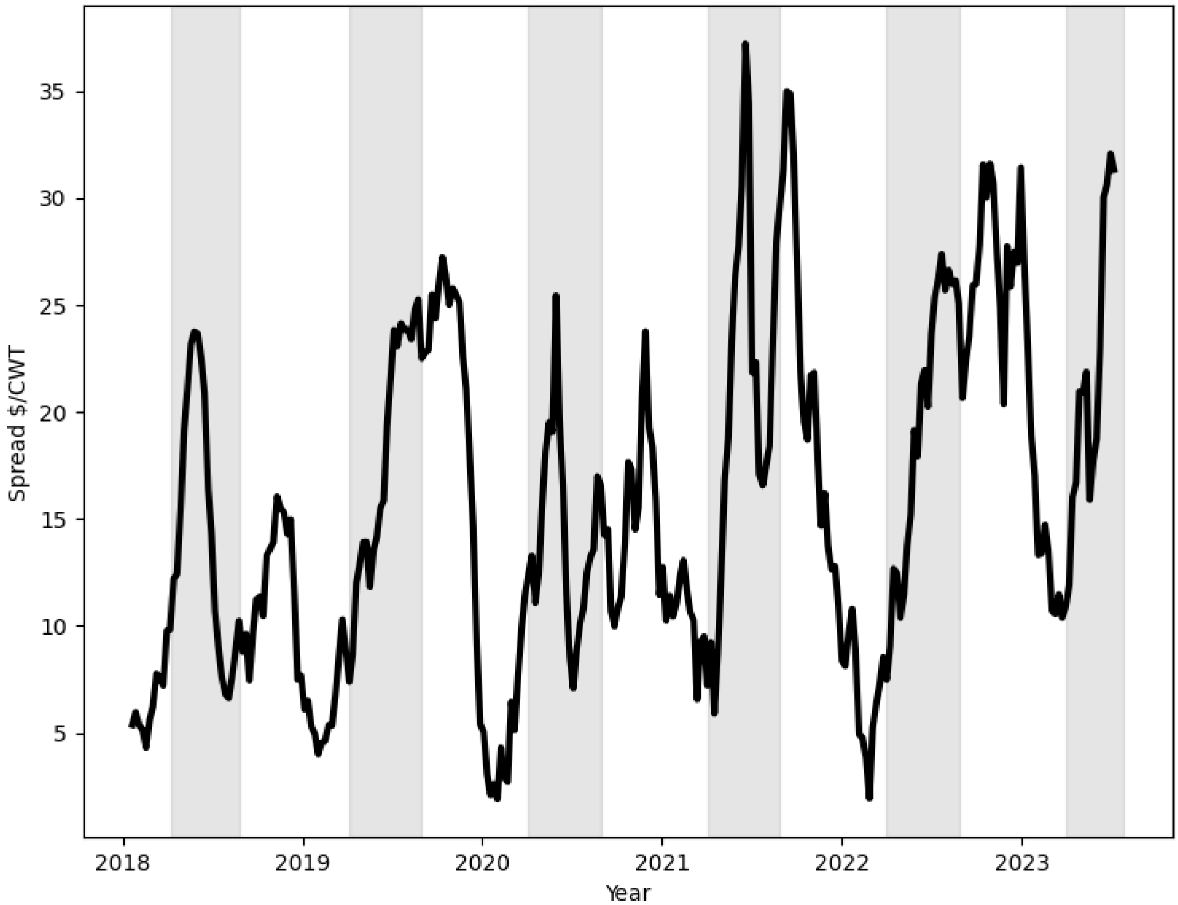
6.1.4 Grilling Season

The grilling season variable is statistically significant across all models, with a coefficient of 0.684-0.80 meaning means during the months of April to August the Choice-Select spread will increase between $0.684-0.80/cwt depending on the model. This makes sense as consumers decisions on beef purchases are affected by the grilling season. Consumers' substitutability between Choice beef and Select beef is lower because they would prioritize higher quality meat for grilling, thus, increasing the demand for Choice beef and widening the Choice-Select spread. As Figure 6.2 shows, during the grilling seasons (highlighted in grey), the spread tends to be at a peak in its yearly cycle. Figure 6.2 shows the Choice-Select spread with the grilling seasons highlighted for every year of observation. The Choice-Select spread has a cyclical peak during the start of the grilling season, which could be due to the seasonal influence of percentage quantity of Choice graded beef. The spread also has a cyclical low immediately before the grilling season begins. This variation during the grilling season could also be explained by the seasonal patterns from the percentage quantity of Choice graded beef. Figure 6.4 also corroborates these findings.

6.1.5 Adjustment Coefficient

The estimation for the lagged Choice-Select is statistically significant and has the expected sign. The coefficients of the adjustment are 0.938-0.93, which suggests there is an adjustment process towards the long-run equilibrium of $\theta = 0.062 - 0.07$ roughly 6.2-7% each week. This means it would take the market roughly 14 weeks to arrive at the long run equilibrium of the Choice-Select spread. However, since the market dynamic, each week the long run equilibrium will never be realized.

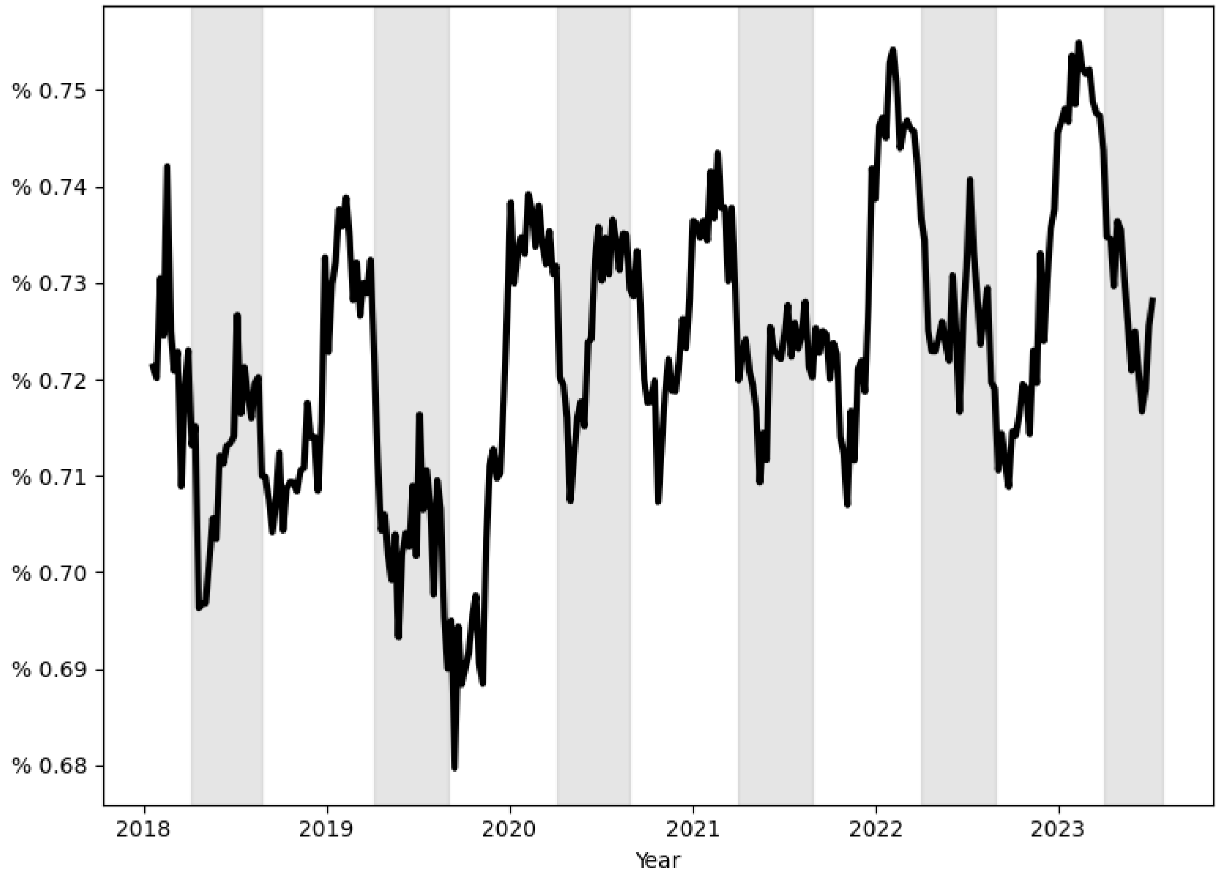
Figure 6.12 Choice-Select Spread with Grilling Season



Note: Shaded regions represent grilling season (April-August).

Figure 6.3 shows the percentage quantity graded Choice in relation to the grilling season. Interestingly the percentage of Choice graded beef spikes immediately before the grilling season, and then drops during the first few weeks. This is likely due to feedlots marketing more Choice cattle before the start of the grilling season as demand begins to rise. Then as the grilling season begins the percentage of Choice beef graded decreases, as most of the feedlots have marketed their cattle in anticipation of the increase in demand.

Figure 6.13 Percent Quantity Graded Choice vs Grilling Season



Note: Shaded regions represent grilling season (April-August).

6.1.6 Driver Variable

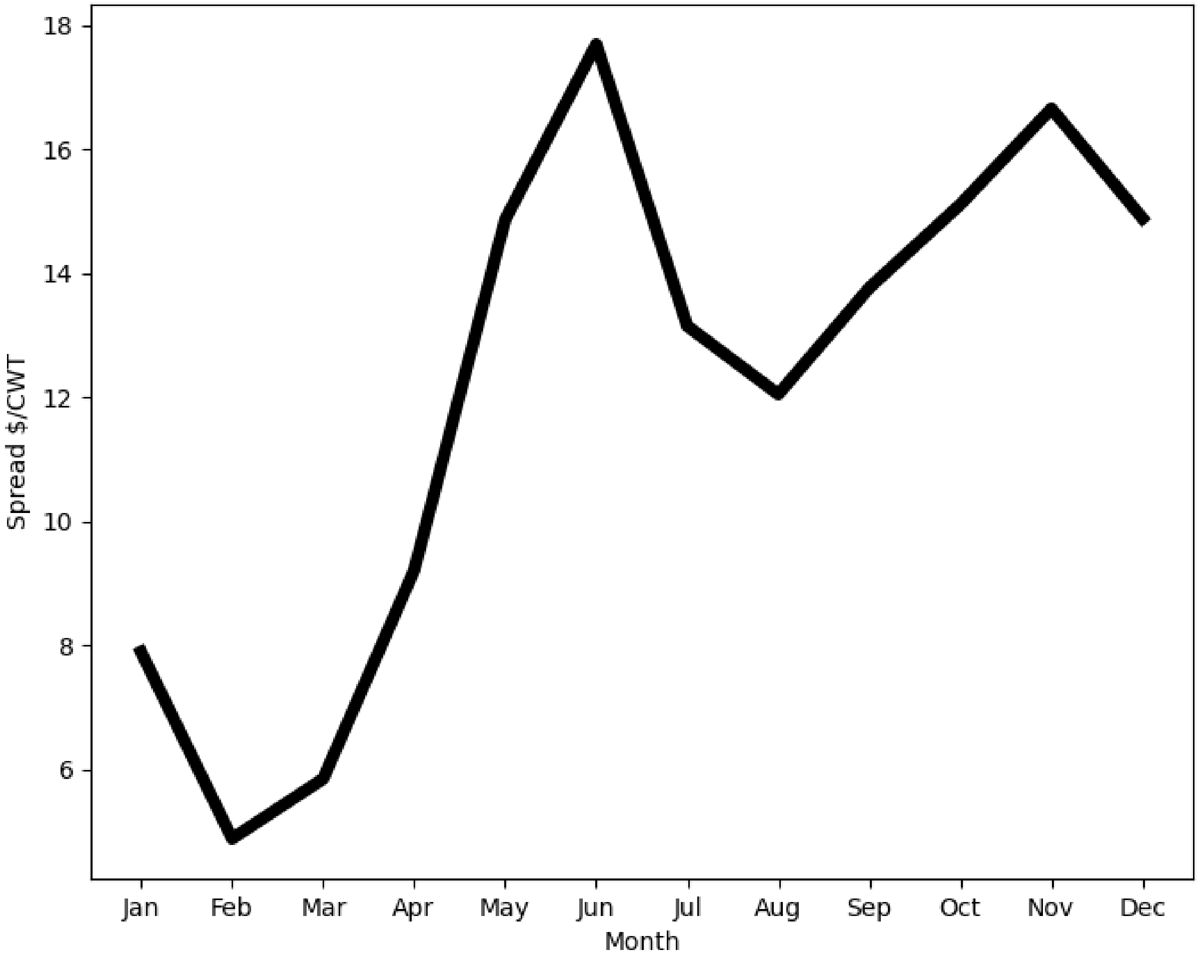
The final dummy variable in the model is the driver variable that has a statistically significant coefficient equal to -0.823, suggesting when the price of Choice boxed beef has a greater movement compared to the price of Select boxed beef, the Choice-Select spread decreases by \$0.823/cwt. For example, if the price of Choice boxed beef increases by \$5/cwt and the price of Select box beef increase by \$4 the spread will have an overall reduction of \$0.823/cwt. This seems counter-intuitive since the Choice-Select spread is the discount of Select, relative to Choice and an increase in the relative change in Choice should logically increase the spread. The average absolute change in price per week for Choice boxed beef is \$4.76/cwt and \$4.31/cwt for

Select boxed beef. The interpretation of the driver variable is an area which could benefit from future research, some ideas on how to determine the impact it has on the Choice-Select spread would be to create a more robust method of testing the significance of the driver variable. This may help with the interpretation of the coefficient and its relationship to the spread.

6.2 Results

The results of Table 6.2 show that model 2 is has the best goodness of fit with the lowest AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) out of all the models estimated. The most impactful determinants in model 2 is the percent quantity of Choice beef graded at $-21.68/CWT followed by the lagged price of the Choice-Select spread at $0.93/CWT. As stated in section 6.1.4 the percent quantity of the Choice beef graded, has an almost perfect inverse correlation with the Choice-Select spread. This finding is inline with basic supply and demand theory, as the supply of Choice beef increases the price discount for Select beef decreases, and visa versa. This is because there is less Choice beef in the market leading to beef packers reducing the discount of Select quality beef. Figure 6.4 displays the seasonality of the Choice-Select spread, depicting the monthly average spread price over the twelve-year observation window.

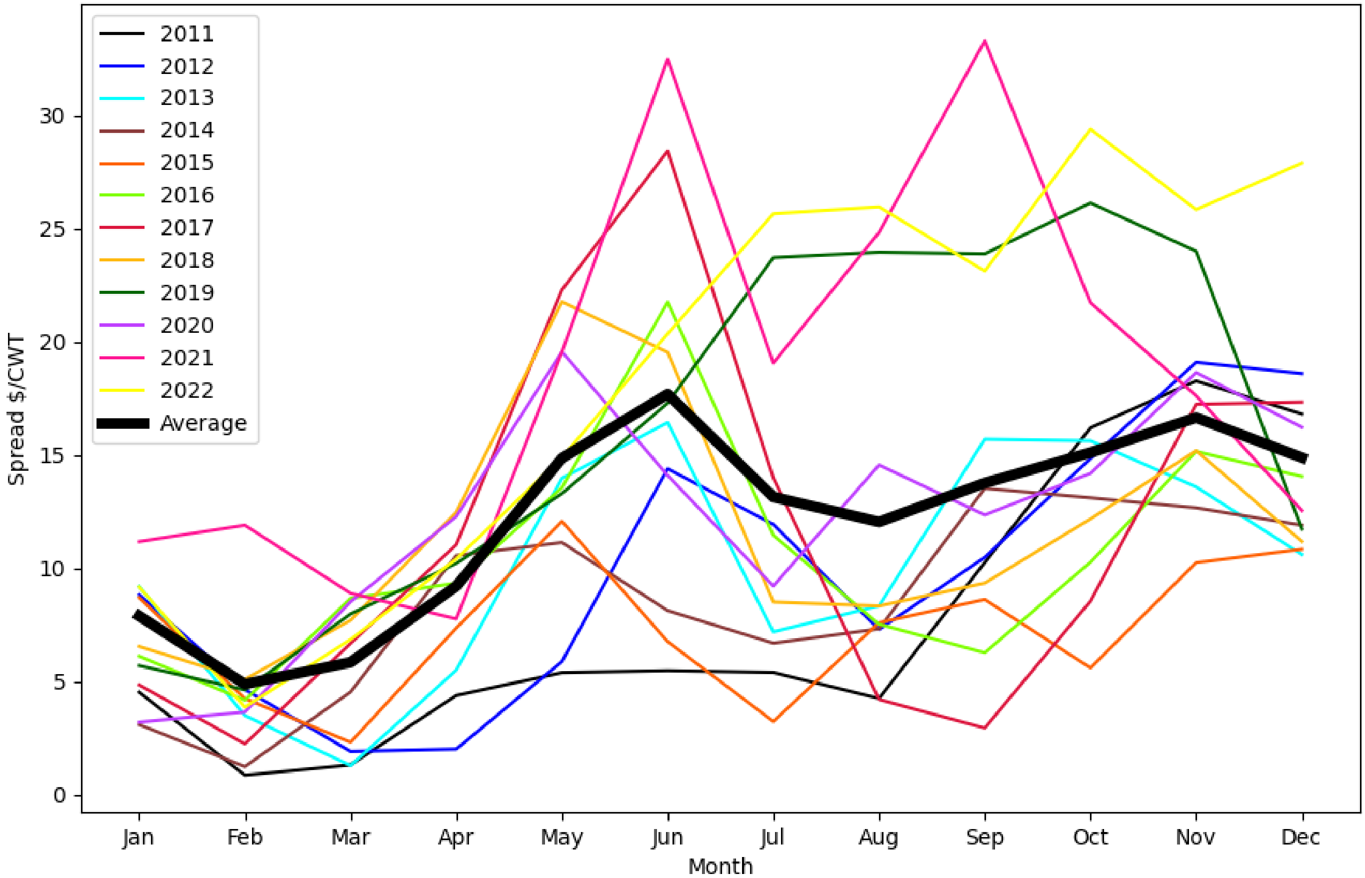
Figure 6.24 Monthly Averages of the Choice-Select Spread from 2010-2022



As Figure 6.4 shows, the widest spread occurs in April, May, and June with a narrowing spread through the summer and a spike again in the late summer early fall. A simple explanation for the seasonal pattern in April, May, and June are the ordering months for retail grocery stores anticipating higher demand for Choice meat in the summer, thus increasing wholesale demand for Choice beef and widening the spread. As the summer continues, the calves which were moved to feedlots in early March and fed out to slaughter weight by July, August and September effectively lead to decreasing the spread. The tail end spike in late fall, could be a mix of supply constrictions and purchasing for Thanksgiving and Christmas holiday; however, this is could not be a substantiated claim. The pattern of the widest spread that occurs April through June is emphasized in Figure 6.5, which depicts the monthly averages for each year from 2010-2022. The thicker black line represents the same values as Figure 6.4. Note that practically every year from 2010-2022, the highest peak has occurred in April, May or June. Based on the model results and the visual representation in Figure 6.4 and 6.5, it is clear the grilling season months have a statistically significant impact on the Choice-Select spread. Recall from Chapter 4, in April, May, and June retail grocery stores put in orders with meat packers anticipating the inflated demand for higher quality beef in the coming months. Therefore, the retail store is pre-empting the increase demand by stocking more high-quality meats and actively advertising these products to consumers.

The concern is then how much does consumer demand increase for these higher-quality meats during the months of April to August. As the Choice-Select spread is only the demand for wholesale beef, the connection to consumers' derived demand for this higher quality meat is not as clear. However, what is clear is the wholesale retail demand for higher quality Choice meat increases seasonally during the months of April to August. Moreover, the supply of cattle to the beef industry clearly contains seasonal trends (Figure 6.3). Calves weaned in early fall are put on feed through winter, moved to feedlots during the first weeks of March and finished for sale in August, September, and October. Some arguments for this seasonality could be due to the inelasticity of the cattle supply, and the 10-year cycle of the U.S. cattle herd. Figure 6.1 displays the clear relation between the percentage quantity of Choice graded beef and the Choice-Select spread.

Figure 6.25 Monthly Averages of the Choice-Select Spread Separated by Years, 2010-2023



Chapter 7

Limitations, Future Research and Conclusion

7.1 Summary

The goal of this research was to analyze and quantify the determinants of the Choice-Select spread. Utilizing data collected from the USDA-AMS and LMIC, this paper outlines the construction of partial adjustment models to represent the underlying supply and demand aspects of the Choice-Select spread as well as the dummy variable to represent seasonality. Results suggest a 1% increase in the difference of percentage of Choice beef graded has a $21-24/cwt decrease of the Choice-Select spread. Grilling season also affected the Choice-Select spread for the months April-August by roughly $0.684-0.80/cwt. Furthermore, the model suggests that a $1 increase in the price of Choice boxed beef leads to a $0.072-0.069/cwt increase in the Choice-Select spread and implies consumer demand has a major influence over the Choice-Select spread. Interestingly, the quantity of head offered was statistically insignificant. This is because the percent of Choice beef being graded (which is the more impactful supply determinant) does not change when there is a shift in overall cattle supplied. For example, if one week there was 500,000 cattle offered to be graded the ratio of Choice grading cattle would be around 75%. The next week there was 300,000 cattle offered for grading the ratio of Choice grading cattle would still be roughly 75%. This is why the total head offered for grading is statistically insignificant. Overall, the seasonality of the Choice-Select spread is influenced heavily by consumer demand and the percentage of Choice graded beef supply of cattle. This finding is in line with previous works from Lusk (2001), Hogan (2003), and Hogan and Ward (2005). However, it does contradict some of the findings from Hogan and Carlberg in 2012 where grilling season was not statistically significant.

7.2 Limitations and Future Research

The limitations of this research are mainly related to the data. The USDA-AMS provides data at a national level; however, the difference in supply and demand can change with different regions of the U.S., therefore research which dives deeper into the specific regional data may derive more prudent findings. For example, relative to other states, Texas has much more beef graded Select (see Figure 4.7), which is primarily due to the type of cattle being bred and the environment which the cattle are raised. Both those factors lend to a higher percentage of Select grading carcasses, which in turn can skew the national level of Choice and Select grading percentages. A potential solution to this issue might be an analysis data that is separated into two distinct markets (a northern market and a southern market), or perhaps even more disaggregated markets, because the cattle breeds, environment, and marketing, can be substantially different between regions. A possible future research project could be to separate the data to more regional specific models, this may provide a clearer picture of the variations in demand from region to region. This effort may alter the significance of the supply variables as the regions would be more effected by supply shortages and herd cycles, thus beef packers would be forced to take on more Select quality beef, reducing the spread. Another limitation was not considering the interconnected demands for different cuts of meat. Although the seasonality of Choice and Select beef is important, it is merely an analysis of seasonal determinants for differing qualities of beef. An equally important analysis could be conducted on the seasonal variations of distinct cuts of beef. Such a project could focus on understanding the seasonality of primal cuts of beef, i.e., analyzing how middle meats such as primal rib and primal loin vary throughout the year. This is an interesting area of study as the supply of these two products will always be identical however the demand for each cut varies tremendously. In a similar vein, it would be interesting to analyze the seasonality of different cuts of beef as well as their variations in quality.

7.3 Conclusion

In Conclusion, the complexity of the United States beef industry cannot be understated, and there are many determinants which influence the Choice-Select spread. This research found the percent quantity of Choice beef graded to be the most impactful determinant of the Choice-Select spread at with a 1% change in Choice beef grading accounting for a \$21-\$24/CWT increase in the spread. The grilling season dummy variable was also statistically significant. During the months of the grilling season (April-August) the spread increased by \$0.68-\$0.8/CWT. These findings will hopefully provide useful information for feedlot calculations on market timing. These determinants of Choice-Select spread have a direct impact on feedlots and beef packers, which in turn influence the consumer. Thus, quantifying these determinants can help improve the marketing, planning, and financial decisions of the stakeholders within the industry.

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