CONSTRUCTION FACTORS INFLUENCING BEEF DEMAND INDEX RESULTS

by

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Abstract

Demand indices are used by many industries as a measurement tool to track changes and make yearly comparisons. Many different sources use demand indices to track the demand for beef. Indexes are an important tool to help better understand why demand shifts the way that it does and help strategically plan for the future of the industry. There are a wide variety of beef demand indices out in academia and many are constructed in different ways. This study advances the literature by testing which factors of index construction effect the results the greatest.

This study tested four separate factors in the construction of demand indices. These iterations are as follows, changes in retail price data, changes in elasticities chosen, changes in export data, and changes in construction in terms of quantities instead of prices. Changes in retail price data do not appear to be statistically different. All estimates in this study where elasticities were changed appear to be different statistically, however the level of concern with this finding may be minimal due to the small increments of change in magnitudes of difference between indices. Results from omitting export data does appear to result in statistically different indices, but again the level of concern with the difference may be small. Finally, index construction in terms of prices versus construction in terms of quantities does not appear to have statistically different results, as the indices in this comparison move similarly. For all practical purposes in industry, it does not appear to matter which index is chosen for comparisons, as long as one remains consistent with which index is chosen for comparisons.

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Dedication

I would like to dedicate my thesis to my loving parents, Scott and Valerie Strevell. You guys have always been there when I needed anything and I truly appreciate it. Thanks for the continued love and support. I have learned so much from you over the years and would not have been able to complete graduate school without your help.

Chapter 1 Introduction

Beef demand indices allow one to compare year to year changes in demand for the beef industry. These indices measure the demand for beef and helps give useful information about how demand for the industry is changing. To fully understand how these indices are useful, one must understand the difference between demand and quantity demanded. *Demand* is defined by economists as a schedule of beef quantities a consumer will purchase over a range of offered prices. *Quantity demanded* is defined as the quantity of beef consumers will demand at one given price, all other factors held constant (Tonsor 2010). A multitude of research has been conducted on factors that impact demand, and rightfully so as it is very important to understand these economic drivers. However, little research has been done on analyzing the construction of demand indices themselves and how construction can impact results. This study advances the research in this area by focusing on the impacts of constructing these demand indices in various ways. The purpose of this study was to see if changing different factors while constructing these indices changed the results on demand observed.

Demand indices are used as an indicator of the overall strength of an industry. In other words, they are used to determine if an industry has increasing or decreasing demand over a time period. The results from these indices can have serious monetary implications. These results effect not only the producer side of the industry, but the consumer side as well. For example, if demand for beef is growing this signals opportunity for industry growth. It is easy to see how important using correct demand information is to determine strategies for the firms in this industry.

This study specifically focuses on the factors that are involved with creating demand indices. To construct a beef demand index the following information is needed, nominal retail

beef prices, information on beef consumption, consumer price indices for deflating the nominal prices, and an estimated beef price elasticity (Tonsor 2010). This research will examine the impacts on the results of indices based upon using different retail and wholesale beef price data, changing elasticities during construction, and constructing indices in terms of quantities instead of in terms of prices.

1.1 Objectives

This research analyzes the impacts of the factors involved in constructing beef demand indices. Regression analysis will define by what magnitude, if any, these various factors effect the results of the demand indices.

This study will focus on the following objectives:

1. Review previous literature to determine which factors of index construction can influence the results of demand indices.
2. Replicate demand indices from previous research to use regression analysis to examine the effects of the factors of construction on demand index results. This will include changing elasticities and different categories from which beef demand data were originated.
3. Discuss impact of index construction iterations to the industry from the regression and graphical analysis.

With previous research taken into account it is expected that changing the estimated elasticities when constructing indices can influence the results one gets from constructing a demand index. Another possibility is origination of data, such as category of beef, could impact

the results from the demand index created, as well as constructing the index in terms of quantities instead of in terms of prices.

1.2 Project Description

This project consists of 5 separate beef demand indices that have been replicated from previous research to analyze the effects of changing variables in construction of the index. These 5 beef demand indices will be compared using alternative regression-based tests. The factors changed during creation of the demand indices will be changing elasticities, changing retail beef price data, and constructing the index in terms of quantities instead of in terms of prices. This analysis will determine the statistical significance of these variables on the results of the demand indices created. A discussion on the econometric results will be made to determine what the potential impacts are to the beef industry and to the academic community.

1.3 Benefit to the Industry

Beef demand indices can be a useful tool when comparing year to year increases or declines in retail, or primary, beef demand (Marsh 2003). The effect of the change in primary beef demand can have large monetary impacts to livestock producers. John M. Marsh analyzed these effects in his paper *Impacts of declining U.S. retail beef demand on farm-level beef prices and producers* (Marsh 2003). Marsh found that changes in primary beef demand prices are transferred to all livestock producers in the supply chain. While looking at the time period of 1976-1999, a time period in which beef demand declined, Marsh states " the retail beef demand index declined by 65.9%....Results indicate, with no allowance for supply response, the real slaughter demand price decreased by 39.8% and real feeder demand price declined by 47.7%." It is easy to infer how important understanding why demand is declining (increasing) to all

producers in the beef industry. Understanding if demand is declining (increasing) year to year is not possible without using demand indices (Marsh 2003). Accurate demand index information is very important to the beef industry so it can implement correct business strategies. This research will analyze which factors of constructing demand indices effect the results observed and will identify if the magnitude of difference is anything to be concerned with.

1.4 Organization of Thesis

This thesis is organized into 6 chapters. Chapter 2 provides a review of relevant literature that helps give insight into beef demand, how demand indices are constructed, and how demand index results are interpreted and put to use by the industry. Chapter 3 includes a description of the data, as well as review of methods into the construction of the indices used in this study. Chapter 4 includes discussion on different methods used to compare indices and a description into the methods used in this study. Chapter 5 gives graphical and econometrical results and discusses the impact of the findings on the industry. Finally, Chapter 6 provides conclusions about this research and will discuss options further research into the construction of demand indexes.

Chapter 2 Literature Review

Demand indexes have been widely used throughout many industries, including agriculture, as a measurement tool to compare yearly growth and decline. Demand index results can be used for strategic planning and as an overall benchmark for how the industry is performing. The following section will review the basics of demand, demand indexes used in previous literature, and limitations of demand indexes.

2.1 Review of Demand

To fully understand the information a demand index gives, one must understand what demand actually is. Dr. Purcell, a former professor at Virginia Tech, wrote a paper to help better understand beef demand titled, *A Primer on Beef Demand*. This paper will be used to give a general overview of some of the common misconceptions about demand and will help set a foundation for better understanding demand indices.

Purcell defines demand as any product or service along a schedule of quantities that consumers will take at various price (Purcell 1998). Purcell states through the law of demand that consumers will take more quantity only at a lower price. Purcell gives an example of this by discussing a shoe store having a buy one pair of shoes get one pair half off scenario. He states if you have ever purchased a second pair of shoes with the intention of only buying one pair that you did so because the price was lower. Purcell argues that your demand for shoes did not change, but your quantity demanded was different at the lower price. This scenario helps show the demand curve with prices on the y axis and quantities on the x axis has a negative slope (Purcell 1998).

Purcell gives a number of rules in this paper discussing the common misconceptions of beef demand. Purcell's first rule states that one should not talk about demand being "strong" because an increased quantity was sold at a lower price than the previous day. Purcell argues that some people in the industry believe this to be the case and states that one can sell a quantity of anything at a certain price. Purcell then goes on to discuss the importance of understanding what a change in demand is. He states that demand has not changed just because people purchase more at a lower price. Purcell states that a change in demand is a shift in the actual demand curve and this can be brought about by three main causes, changes in consumer preferences, changes in consumer incomes, and changes in prices of substitute products (Purcell 1998).

Purcell then goes on to discuss how changing consumer demand for beef is affecting everyone in the industry. Purcell argues that if beef demand is shifting down, which was what research showed during the time his paper was published, the beef industry would continue to have to discover new cost-reducing technology to keep prices low or many producers would go out of business. Purcell argues this low-cost production strategy is not the way the beef industry should go because the only way one can remain profitable in this strategy is to continually cut costs. Purcell claims that this strategy will not work for the beef industry because there is a limit on how cheap one can produce beef (Purcell 1998).

Purcell also discusses another misconception in this paper that he believes occurs in the beef sector. This misconception is that per capita consumption is a measure of demand. Purcell argues that per capita consumption is actually a measure of supply. He claims that if you produce more per capita, then one's per capita consumption will go up because the market will

go to whatever level is needed to clear the increased production and this leads to lower prices (Purcell 1998).

Another important point Purcell makes in this paper is that one cannot say that beef demand is "weak" because of high prices. He states that prices are part of the demand schedule, and the set combination of prices and quantities and cannot be a demand shifter (Purcell 1998).

Purcell gives another rule in his paper which states that one must be able to analyze both price and quantity data to understand what is happening with respect to demand. This key point Purcell makes shows that understanding demand is very important, and one tool for understanding demand are demand indices. Further discussion into the importance of demand indices will be argued in this study. Purcell discusses two simple methods for analyzing price and quantity data and both methods involve adjusting for price inflation. This adjustment is made by dividing one's price data by the Consumer Price Index, (CPI). In the first method one finds the difference in price of year one and the price of the second year and then divides this difference by the price of year one. This method will give results on how much demand increased or decreased as a percentage (Purcell 1998). The next method uses the concept of elasticities to calculate what the price would have been if demand had remained constant over time. Purcell states that the concept of elasticities is based on percentage changes in price and quantity and is defined as Elasticity = % Change in Quantity / % Change in Price. Purcell then gives an example of using elasticities to determine how prices and quantities will react. Purcell gives an elasticity of -0.67, per capita consumption of 67.4 pounds in year 2, and per capita consumption of 65.4 pounds in year 1. Purcell's example is as follows.

$-0.67 = (67.4 – 65.4 / 65.4) / X$. In this equation X, which is the price change in response to the quantity increase if demand is held constant, equals -0.46. By multiplying that figure by

100, we get a 4.6% decrease in price associated with a 3.1% increase in quantity. This is then compared to the actual change in price to estimate the change in demand over the two years (Purcell 1998).

2.2 Intuition and Creation of Beef Demand Indices

Dr. Tonsor, Associate Professor at Kansas State University, wrote a short paper on beef demand indices titled *Intuition and Creation Detail of Beef Demand Indices* (Tonsor 2010). In this paper Dr. Tonsor gives a review of what demand is and how it is useful, concepts of understanding beef demand indices, and what factors go into the creation of indices.

First Dr. Tonsor gives definitions of demand and quantity demanded to better understand demand indices. Dr. Tonsor defines demand as a schedule of quantities consumers would purchase over a range of prices, and defines quantity demanded as the quantity of a product consumers would purchase at a given price when all other factors are held constant. Tonsor then gives more insight into this graphically by saying demand refers to a demand curve where prices are on the y-axis and quantities are on the x-axis. Quantity demanded is a single point on the demand curve (Tonsor 2010).

Dr. Tonsor then gives insight into the meaning of per capita consumption by saying it does not represent demand. Tonsor defines per capita consumption as production (net volume of domestic production, cold storage adjustments, and international trade) divided by resident population (Tonsor 2010). Tonsor points out that it is important to note that per capita consumption gives little information into beef demand when considered independently from prices (Tonsor 2010).

Next, Tonsor gives intuition into the interpretation of what demand indices measure. Tonsor states that beef demand indices map out changes in demand rather than quantity demanded. Tonsor then states beef demand indices measure vertical shifts in beef demand over time relative to a base year (i.e. 2000=100). Next, Tonsor gives another way to understand indices by saying, creating a beef demand index involves calculating the real beef price which we would expect to observe if beef demand was consistent with that experienced in the base year. The expected, constant beef demand in real beef prices is then compared to the real beef price actually observed in the market to give insight into the changes in demand. Tonsor then gives an example into interpreting the index results. Tonsor's example gives a beef demand index value of 78 in 2009 and assumes a base year of 1990 (i.e. 1990=100). Tonsor states this value would indicate beef retail prices in 2009 where 22% lower than they would have been if demand was at the 1990 level (Tonsor 2010).

Tonsor then goes on to discuss the different factors that go into index creation. Tonsor states that information on beef consumption, nominal retail beef prices, consumer price indices, and an assumed beef price elasticity estimate are all needed for index creation (Tonsor 2010).

Last, Tonsor discusses the sensitivity of demand index results with regards to which estimated beef price elasticity is chosen during creation. Tonsor discusses the multitude of estimated beef price elasticities in literature and shows graphically how demand index results can be impacted (Tonsor 2010).

2.3 Defining and Quantifying Certified Angus Beef

Lance Zimmerman and Dr. Ted Schroeder wrote a paper on branded beef demand titled "*Defining and Quantifying Certified Angus Beef Brand Consumer Demand*" (Zimmerman and

Schroeder 2011). In this paper Zimmerman and Schroeder (2011) summarize concepts of demand in the beef industry, provide 3 wholesale demand indices, and discuss the benefits and challenges with using such indices for measuring demand.

Zimmerman and Schroeder (2011) state that beef demand, in its simplest form, is the relationship between prices and quantities, which is influenced by prices of competing proteins and changing consumer preferences. They then go on to say that recognizing when a change occurs in demand is easier than pinpointing the cause of the change. Zimmerman and Schroeder (2011) attribute this difficulty of identifying the exact change in demand due to the complex nature of consumer beef demand. This complexity in demand makes demand indices a useful tool in recognizing changes over time in beef demand. They also discuss how wholesale and retail beef prices are influenced by quality grade and seasonality. They give examples of demand for beef increasing during the summer months and how beef demand becomes less sensitive to price changes during this time period. Zimmerman and Schroeder (2011) also discuss how Select grade of beef is more elastic, more sensitive to price changes, at the wholesale level than Choice grade of beef is. They attribute this due to the fact that Select beef has more substitutes than does the Choice grade. Zimmerman and Schroeder (2011) also state that Choice and Select beef demand are derived directly from the consumer demand for retail beef. They indicate that greater consumer demand for Select and Choice beef at the retail level result in greater demand for beef at the wholesale level (Zimmerman and Schroeder 2011).

Next, Zimmerman and Schroeder (2011) discuss demand indices and how they measure demand. Zimmerman and Schroeder (2011) state that demand indices combine information about prices, quantities, population, and inflation to provide a standardized measurement for estimating demand over time. They state that demand indices can be a great tool to better

understand consumer demand and the beef industry as a whole (Zimmerman and Schroeder 2011).

Zimmerman and Schroeder (2011) then go on to discuss the creation of demand indices for the Certified Angus Beef Brand and interpret the results of those indices. During this discussion of the results, Zimmerman and Schroeder (2011) identify an overall trend from a sensitivity analysis that showed the magnitude of demand index measurements increased as the price elasticity of demand became more inelastic. Zimmerman and Schroeder (2011) then compare the demand index results for Certified Angus Beef with Select and Choice quality grades to compare how demand changed over time (Zimmerman and Schroeder 2011).

Zimmerman and Schroeder (2011) discuss the implications of the results in this study, as well as the weaknesses of the index results. They point out that wholesale demand index results are one market segment removed from consumer purchasing behavior, but these measurements provide a view of the industry as a whole. Zimmerman and Schroeder (2011) state the index only provides a snapshot of demand changes and gives no insight into why demand shifted the way it did. They also state another weakness of demand indices being the assumption that demand elasticities are constant over time and different levels of per capita supply. They state this may not be the case with supply of the product changing rapidly and this brings uncertainty into the demand index results. Zimmerman and Schroeder (2011) also state another weakness to be the demand elasticities used in index creation are estimated from expert opinion in previous research.

2.4 Impacts of Declining Retail Beef Demand

John Marsh published an article, *Impacts of Declining U.S. Retail Beef Demand on Farm-Level Beef Prices and Production*, in the *American Journal of Agricultural Economics* (Marsh 2003). The purpose of Marsh's paper was to evaluate the impacts of shifts in (primary) retail demand on (derived) farm level prices and production. A beef demand study group was formed to address this problem by developing ways to stabilize and increase consumer demand for beef. Marsh indicated that to meet this objective the beef demand study group (BDSG) first needed a measure of demand. Thus, the BDSG economists created an annual retail beef demand index. This index measured yearly shifts in retail demand and was used to plan and budget for the BDSG's goal of improving consumer demand for beef. Marsh then goes on to explain that the BDSG's demand index does not include implicit shifts in demand that are caused by changing consumer preferences, consumer incomes, competitive prices, etc. Marsh also states that changing retail prices do not exclusively measure demand shifts since they may be reflecting shifts in the supply schedule (Marsh 2003).

Marsh then goes on to explain the beef demand index created by the BDSG. He states that the demand index is based on percentage differences between observed retail beef prices and estimated retail beef prices holding demand constant. The prices are in real terms and by allowing for quantity changings these differences represent shifts in retail beef demand. Marsh states that by adding these differences to a base year yields the BDSG demand index. Marsh also comments on the demand index construction with the assumption of a constant demand elasticity could be problematic (Marsh 2003).

Marsh then gives an example of the monetary implications of a 6% increase in demand calculated from the retail beef demand index for the time period of 1998-2000. Marsh estimates

the long-term impacts by assuming the 6% increase is permanent and that retail beef supply is less than perfectly elastic. This estimate of consumers increasing spending of retail beef by 6% yields an increase of $2,160.4 million. Marsh also states that about 57% of this increase would go to the retail and processing sectors, and about 42% would be the total producer share. Marsh then concludes with opportunities for future research by refining the demand index since it used aggregated data. Marsh indicates further research on disaggregated demands of different markets and different beef cuts may beef helpful (Marsh 2003).

2.5 Beef Demand Determinants

Beef Demand: Recent Determinants and Future Drivers was published in 2013 by Dr. Ted Schroeder, Dr. Glynn Tonsor, and Dr. James Mintert. This research summary discusses the value of correctly defining what beef demand actually is, as well as discusses different factors that can influence beef demand. Schroeder, Tonsor, and Mintert (2013) point out many relevant points when discussing how to understand beef demand. These include defining what quantity demanded means versus demand, which was discussed in the Intuition and Creation of Demand Indices review, noting that beef demand is not per capita consumption, beef demand is not beef's relative share of total meat consumption, and beef demand is not the share of consumer's income spent on beef. This study goes on to discuss different demand shifters that can affect the demand for beef such as food safety impacts, changing consumer preferences, and health information impacts. It is important to note that this study uses a choice retail beef demand index to discuss yearly shifts in beef demand (Schroeder et al. 2013)

2.6 Other Indexes

There are many different indices used throughout many different industries. This section gives a couple of examples of how widely indices are used and shows how many people find indices useful to track changes. Dr. Ron Plain, Professor at the University of Missouri, puts out multiple meat demand indices on the Agricultural Electronic Bulletin Board. Most relevant to this study is Dr. Plain's index on U.S. Annual Retail Meat Demand (AG Bulletin Board 2014). In this index Plain uses many of the same steps conducted in this study, and Plain gives the sources for obtaining data for the construction of his indices on the website. Another index in an unrelated industry is the Political Instability Index, which is located on the website "The Economist." This index shows the level of threat posed to governments by social protest. This index is derived by combining measures of economic distress and underlying vulnerability to unrest. This index is constructed in a much different way than the indices in this study, but it does show the broad range of variety in which indexes are used (The Economist 2014). The Survey Research Center of the University of Michigan also posts a monthly index in a series called the Survey of Consumers. This index assesses the attitudes and expectations of consumers. There are many industries and applications for indices and it is very relevant to study how they are constructed to ensure accuracy in the results (Survey of Consumers 2014).

Chapter 3 Data and Methods

There are numerous ways of creating a demand index. This section will outline and discuss the methods used to create the different demand indices in this study. This section will also discuss and analyze the data used in the research.

3.1 Data Sources

The main objective of this study was to determine which factors of index construction should receive the most attention. In particular, the goal is to determine the sensitivity of beef demand indexes to alterative assumptions used to construct the index. This objective was accomplished by constructing several indices on beef demand. The indices were modeled after those developed by Tonsor and by Zimmerman and Schroeder as reported on agmanager.info and by the study *Defining and Quantifying Certified Angus Beef Brand Consumer Demand*, respectively (Zimmerman et al 2011). Data for each of the following indices will be outlined and discussed in the following paragraph. The Choice Index created in this study used data on annual per capita beef consumption (in pounds) for the years of 1980 through 2012 obtained from the Livestock Marketing Information Center website (LMIC). Nominal choice beef retail prices (in cents per pound) for 1980 through 2012 were also obtained from the LMIC website. The Consumer Price Index (CPI) data were obtained from the Bureau of Labor Statistics for the years of 1980 through 2012.

The All Fresh Index constructed in this study used data on annual per capita beef consumption (in pounds) and nominal all fresh beef retail prices (in cents per pound) for the

years of 1980 through 2012 obtained from the LMIC website. Again, this index used CPI data for the time period of 1980 through 2012 obtained from the Bureau of Labor Statistics.

The U.S. Wholesale Index created in this study used data on total domestic beef production and beginning and ending beef stocks obtained from the LMIC website. Both total domestic beef production data and beginning and ending beef stocks data were for the time period of 2002 through 2012. This index also used estimated United States population data (in July) for the years of 2002 through 2012 found on Census.gov. Wholesale cutout value and loads data were obtained from the LMIC website. Finally, this index used data on the producer price index (PPI) obtained from the Bureau of Labor Statistics website for the years of 2002 through 2012.

The World Wholesale Index constructed in this study obtained the same total domestic beef production data, as well as, beginning and ending beef stocks data from the LMIC website. PPI data were again found on the Bureau of Labor Statistics website for the years of 2002 through 2012. Wholesale cutout value and loads data were obtained from the LMIC website. World population data for the years of 2002 through 2012 were obtained from the Census.gov website.

The final index, Choice Quantity Index, created in this study used the same data as the Choice Index described above. None of the data in this index was changed, the only iterations were on index construction in terms of quantities instead of construction in terms of prices. The construction of this index will be described later in this study.

3.2 Methods

The Choice Index in this study was modeled after Tonsor's Beef Demand Index from Agmanager.info. This Choice Index first took Choice beef consumption in pounds per capita for the time period of 1980 through 2012 and calculated the percent change in year to year consumption. The next step was to use the nominal Choice beef retail price data from years 1980 through 2012 and the CPI (consumer price index) to convert the nominal beef price into the real beef price in terms of 1982-1984 dollars. Once the real beef price was found, a simple percent change from year to year in real price was found to serve as a visual on how real price was changing from year to year. The next step was to calculate the constant demand expected percent change from year to year in real price. This was accomplished by finding the year to year percent change in beef consumption and multiplying that figure by the flexibility, or one over the elasticity. Using the real Choice beef price figure along with the constant demand year to year percent change in real price figure, the constant demand expected real choice beef price was obtained. The final step in this demand index creation was taking the real choice beef price and dividing that figure by the expected real choice beef price figure to arrive at the demand index for Choice beef. The Choice Beef Demand Index was then found for the time period of 2000-2012, and this was done to align with the other indices where data was only available from this time period. The following figure, Table 16, might help as a visual for the steps described

above. A larger version of this table for the Choice Beef Demand Index can be found in the Appendix.

	choice				Assumed Beef Price Elast		**-0.54**	1980=100			
					Assumed Beef Price Flexi		**-1.85**	Constant Demand			
Year	Beef	Year to Yea	Nominal	CPI	(82-84 $)	Year to Yea	1980=100	Expected	Beef Demand Index		Beef Der
	Consumption	% change in consump	Beef Price		Real Beef Price	Actual % change	Demand Year to year	(1982-84 $)	1980=100		2000=10
	(lbs/capita)		(cents/lb)		(cents/lb)	in real price	Expected % change in Real Quantities	Real Beef Price (cents/lb)			
1980	76.6		233.6	82.4	283.46				100		
1981	78.3	2.16	234.7	90.9	258.09	-8.95	-4.01	272.09	94.85		
1982	77.1	-1.52	238.4	96.5	247.00	-4.29	-1.14	280.23	88.14		
1983	78.6	1.91	234.1	99.6	235.02	-4.85	-4.70	270.13	87.01		
1984	78.5	-0.11	235.5	103.9	226.67	-3.55	-4.50	270.70	83.74		
1985	79.3	0.99	228.6	107.6	212.54	-6.23	-6.37	265.40	80.08		
1986	78.9	-0.45	226.8	109.6	206.90	-2.66	-5.51	267.85	77.24		
1987	73.9	-6.33	238.4	113.6	209.80	1.40	6.56	302.04	69.46		
1988	72.7	-1.62	250.3	118.3	211.69	0.90	9.46	310.26	68.23		
1989	69.0	-5.06	265.7	124.0	214.30	1.23	18.34	335.45	63.88		
1990	67.8	-1.82	281.0	130.7	215.08	0.36	21.38	344.05	62.51		
1991	66.8	-1.43	288.3	136.2	211.71	-1.57	23.71	350.67	60.37		
1992	66.5	-0.47	284.6	140.3	202.83	-4.19	24.47	352.82	57.49		
1993	65.1	-2.09	293.4	144.5	203.13	0.15	27.83	362.34	56.06		
1994	67.0	2.92	282.9	148.2	190.84	-6.05	23.24	349.32	54.63		
1995	67.5	0.67	284.3	152.4	186.59	-2.23	22.15	346.23	53.89		
1996	68.2	1.08	280.2	156.9	178.66	-4.25	20.39	341.25	52.35		
1997	66.9	-1.91	279.5	160.5	174.15	-2.53	23.53	350.16	49.73		
1998	68.1	1.77	277.1	163.0	170.00	-2.38	20.66	342.03	49.70		
1999	69.1	1.49	287.8	166.6	172.76	1.62	18.22	335.10	51.55		
2000	67.8	-1.91	306.4	172.2	177.94	3.00	21.40	344.13	51.71		100.00
2001	66.3	-2.15	337.7	177.1	190.73	7.19	24.93	354.11	53.86		103.08
2002	67.7	2.15	331.5	179.9	184.32	-3.36	21.48	344.34	53.53		103.49
2003	65.0	-4.05	374.6	184.0	203.59	10.45	28.11	363.14	56.06		106.35
2004	66.2	1.85	406.5	188.9	215.23	5.72	25.20	354.89	60.65		115.97
2005	65.6	-0.90	409.1	195.3	209.47	-2.67	26.65	358.99	58.35		111.13
2006	65.9	0.42	397.0	201.6	196.94	-5.98	25.97	357.08	55.15		105.24
2007	65.2	-0.98	415.8	207.3	200.56	1.83	27.54	361.51	55.48		105.40
2008	62.5	-4.25	432.5	215.3	200.86	0.15	34.24	380.51	52.79		98.57
2009	61.1	-2.16	426.0	214.5	198.55	-1.15	37.50	389.76	50.94		94.40
2010	59.6	-2.49	439.4	218.1	201.53	1.50	41.18	400.17	50.36		92.56
2011	57.3	-3.81	482.7	224.9	214.60	6.49	46.66	415.71	51.62		93.81
2012	55.4	-3.30	502.3	229.6	218.77	1.94	51.23	428.67	51.03		91.94

The second index, All Fresh Beef, was again modeled after Dr. Glynn Tonsor's Beef Demand Index from Agmanager.info. It was constructed in with all the same steps as the Choice Beef Index described above with the only variation being the nominal Choice beef retail price was changed to the nominal All Fresh beef retail price. The excel spreadsheet example for this index can be found in the Appendix as Table 17.

The United States Wholesale Beef Demand Index was modeled after Zimmerman and Schroeder's wholesale demand index from Defining and Quantifying Certified Angus Beef Brand Consumer Demand (Zimmerman et al 2011). First data on total beef production (in millions of pounds) for wholesale U.S. beef was obtained for the time period of 2002 through 2012. Next, beginning and ending stock wholesale beef data was used to find the net total production of wholesale U.S. beef (in millions of pounds). The wholesale per capita consumption in the U.S. was obtained by taking the net total production figure and dividing that by the estimated U.S. population for the time period of 2002 through 2012 (for July). Using the U.S. population provides the assumption of the U.S. having no exports for beef. Next a figure on percent change in consumption from year to year was calculated to give a visual graphic on the change in beef consumption in the U.S. The next step was to take the weighted annual wholesale nominal cutout value (in cents per pound) and divide by the PPI (producer price index) to obtain the real wholesale cutout value figure. Another figure on yearly percent change of real wholesale cutout value was created to give some insight into the change in wholesale value from year to year. Next, the constant demand yearly percent expected change in real price was found by using the percent change in wholesale per capita consumption and multiplying that figure by the flexibility, or one over the elasticity. The figure on demand expected in real wholesale cutout value was found by using the real wholesale cutout value figure along with the constant demand

yearly expected percent change in real price figure. The last step was taking the real wholesale cutout value and dividing that by the expected demand real wholesale cutout value to obtain the demand index. The following figure can again help visually walking through the steps of the creation of this index. This table, Table 18, can be found in a larger format in the Appendix.

Year	Total Production Net Beginning and Ending Stocks	US Estimated Population	Wholesale per Capita Consumption in US	Year to Year % Change in Consumption	Weighted Annual Wholesale Cutout Nominal Value	PPI Base Year 82-84	Wholesale Real Cutout Value	Yearly Change in Real Price	Constant Demand Yearly Expected % Change in Real Price	Demand Expected (82-84 $) Real Wholesale Cutout Value	U.S. Wholesale Demand Index
	in million lbs	in July	(lbs/person)	(%)	in (cents/lb)		in (cents/lb)	(%)	2002=100	cents/lb	2002=100
2002	27482.7	287625193	0.0001	n/a	111.22	138.9	80.07	n/a	n/a	100	100
2003	26365.6	290107933	0.0001	-4.89	134.88	143.3	94.13	17.56	9.05	87.31	107.80
2004	24943.8	292805298	0.0001	-6.26	136.29	148.5	91.78	-2.50	20.08	96.15	95.45
2005	24886.9	295516599	0.0001	-1.14	140.20	155.7	90.05	-1.88	21.97	97.66	92.20
2006	26471.4	298379912	0.0001	5.35	139.51	160.4	86.98	-3.41	13.24	90.67	95.93
2007	26669.8	301231207	0.0001	-0.20	145.66	166.6	87.43	0.52	13.59	90.95	96.13
2008	26829.3	304093966	0.0001	-0.35	151.19	177.1	85.37	-2.36	14.19	91.43	93.37
2009	26137.8	306771529	0.0001	-3.43	139.49	172.5	80.87	-5.28	20.05	96.13	84.12
2010	26573.6	309349689	0.0001	0.82	154.11	179.5	85.86	6.17	18.70	95.04	90.34
2011	26458.8	311587816	0.0001	-1.15	178.58	190.5	93.74	9.19	20.61	96.57	97.07
2012	26159.6	313914040	0.0001	-1.86	187.95	194.2	96.78	3.24	23.68	99.03	97.73

The World Wholesale Index was again modeled after Zimmerman and Schroeder's Wholesale Index from *Defining and Quantifying Certified Angus Beef Brand Consumer Demand*. The World Wholesale Index in this study was constructed in the same fashion as the U.S. Wholesale Index in this study, with the only change in indices being the U.S. Wholesale Index used the United States population for consumption and the World Wholesale Index used the estimated World population for consumption. The limitation with this assumption is that only world population was used, and not world consumption or production which would provide more accurate information. This table, Table 19, can be found in the Appendix.

The final index created for this study was the Choice Quantity Index. This index was constructed as an iteration to the Choice Index used in this study and was constructed in a similar fashion. The difference between the Choice Quantity Index and the Choice Index begin with the constant demand expected percent change from year to year figure. With the original Choice Index the constant demand expected percent change figure was in terms of real prices, but with the Choice Quantity Index the figure changes to constant demand expected percent change in real quantities. Another difference is this constant demand expected percent change figure is also found using the elasticity for this index instead of using the flexibility. The next step is finding the constant demand expected in real quantity by using the beef consumption per capita figure and multiplying that by one plus constant demand expected yearly percent change figure over 100. The final step is taking the beef consumption per capita figure and dividing that be the constant demand expected real quantity figure to obtain the demand index in terms of quantities.

The following figure may help one visually walk through the steps of index creation and a larger version of Table 20 can be found in the Appendix.

Year	Beef	Year to Year	Nominal	CPI	(82-84 $)	Year to Year	1980=100	Expected	Beef Demand Index		Beef Demand
	Consumption	% change in	Beef Price		Real Beef Price	Actual % change	Constant Demand Year	(1982-84 $)	1980=100		2000=100
	(lbs/capita)		(cents/lb)		(cents/lb)	in real price	Expected % change in Real price	Real			
1980	76.62		233.59	82.41	283.46			Quanity	100.00		
1981	78.28	2.16	234.67	90.93	258.09	-8.95	4.85	80.33	97.44		
1982	77.09	-1.52	238.36	96.50	247.00	-4.29	6.97	81.96	94.06		
1983	78.56	1.91	234.08	99.60	235.02	-4.85	9.26	83.71	93.85		
1984	78.48	-0.11	235.48	103.88	226.67	-3.55	10.86	84.94	92.40		
1985	79.25	0.99	228.63	107.57	212.54	-6.23	13.56	87.01	91.09		
1986	78.90	-0.45	226.78	109.61	206.90	-2.66	14.64	87.83	89.82		
1987	73.91	-6.33	238.38	113.63	209.80	1.40	14.08	87.41	84.55		
1988	72.71	-1.62	250.34	118.26	211.69	0.90	13.72	87.13	83.44		
1989	69.03	-5.06	265.66	123.97	214.30	1.23	13.22	86.75	79.57		
1990	67.77	-1.82	281.02	130.66	215.08	0.36	13.07	86.64	78.23		
1991	66.81	-1.43	288.33	136.19	211.71	-1.57	13.72	87.13	76.68		
1992	66.49	-0.47	284.61	140.32	202.83	-4.19	15.42	88.43	75.19		
1993	65.10	-2.09	293.44	144.46	203.13	0.15	15.36	88.39	73.66		
1994	67.00	2.92	282.88	148.23	190.84	-6.05	17.71	90.19	74.30		
1995	67.46	0.67	284.33	152.38	186.59	-2.23	18.52	90.81	74.28		
1996	68.18	1.08	280.23	156.85	178.66	-4.25	20.04	91.97	74.13		
1997	66.88	-1.91	279.53	160.52	174.15	-2.53	20.90	92.63	72.20		
1998	68.07	1.77	277.12	163.01	170.00	-2.38	21.69	93.24	73.00		
1999	69.08	1.49	287.77	166.58	172.76	1.62	21.17	92.84	74.41		
2000	67.76	-1.91	306.42	172.20	177.94	3.00	20.18	92.08	73.59		100.00
2001	66.31	-2.15	337.73	177.07	190.73	7.19	17.73	90.20	73.51		101.82
2002	67.73	2.15	331.54	179.88	184.32	-3.36	18.96	91.14	74.31		101.93
2003	64.99	-4.05	374.62	184.01	203.59	10.45	15.27	88.32	73.58		104.03
2004	66.19	1.85	406.53	188.88	215.23	5.72	13.05	86.61	76.42		110.20
2005	65.59	-0.90	409.09	195.29	209.47	-2.67	14.15	87.46	75.00		107.08
2006	65.87	0.42	397.02	201.59	196.94	-5.98	16.54	89.29	73.77		103.18
2007	65.23	-0.98	415.84	207.34	200.56	1.83	15.85	88.76	73.48		103.38
2008	62.45	-4.25	432.45	215.30	200.86	0.15	15.79	88.72	70.39		99.08
2009	61.10	-2.16	425.97	214.54	198.55	-1.15	16.23	89.06	68.61		96.21
2010	59.58	-2.49	439.44	218.06	201.53	1.50	15.67	88.62	67.23		94.73
2011	57.31	-3.81	482.72	224.94	214.60	6.49	13.17	86.71	66.10		95.21
2012	55.42	-3.30	502.28	229.59	218.77	1.94	12.37	86.10	64.37		93.41

Chapter 4 Models Section

There are many ways to compare demand indices over time. Some methods are as simple as using graphs or tables to visually analyze if there are differences between indices. One may also use basic calculations to determine the percentages at which the indices are increasing or decreasing. While these methods can provide some sort of idea of how demand is actually changing, it does not provide the whole picture or give any explanations to why demand shifted in the way that it did. Another method is calculating the differences between indices and using a simple t-test to test whether the differences are significantly different than zero. One method used in this study to test the differences between indices is an Ordinary Least Squares regression analysis. The specific OLS regression models used in this analysis will be described in detail later in this chapter. While this analysis does not provide the whole picture with regards to changing demand, it does allow for certain variables to be examined to test demand sensitivity to underlying assumptions. The ability to statistically compare the effects of changing different variables in the index calculation makes regression analysis superior to other simple methods of comparing demand indices.

Zimmerman and Schroeder explain some concerns with demand indices in the 2013 paper *Defining and Quantifying Certified Angus Beef Brand Consumer Demand.* One assumption is that demand elasticity is constant over time and across different levels of per capita supply. This assumption may not be realized and this may provide some uncertainty to the accuracy of the demand index (Zimmerman and Schroeder 2013). To combat this assumption, a simple ordinary least squares (OLS) regression analysis was chosen to analyze the effects constant demand elasticity across time and different per capita supply. The following OLS regression used in this study to determine if there is bias between two series was also

conducted in Colling and Irwin's study, *The Reaction of Live Hog Futures Prices to USDA Hogs and Pigs Reports,* published in the *American Journal of Agricultural Economics* in February of 1990 (Colling et al 1990). The Colling and Irwin study was examined again to provide analysis on the regression analysis and this was used in this study to provide a better understanding of the econometrical models used (Colling et al 1992).

This study used a base econometric model with two alternative models with restrictions or specifications that tested which elements during construction of these indexes will make them significantly different from each other. The base model is as follows:

$$Index_{jt} = B_0 + B_1 Index_{kt} \qquad (1)$$

where in equation 1 *j* and *k* are denoted as two separate indexes that were tested against each other, t refers to year, B_0, represents the intercept in the model, and B_1 denotes the coefficient on the independent variable in the model. The first model, equation 1, was a joint test where the intercept, B_0, was tested along with the coefficient, B_1. The two tests for equation 1 are as follows:

H_0: $B_0 = 0$ $\qquad$ H_0: $B_1 = 1$

H_a: $B_0 \neq 0$ $\qquad$ H_a: $B_1 \neq 1$

If the test on equation 1 is rejected then B_0 does not equal 0 and B_1 does not equal 1. This suggests that the two indexes are significantly different from one another. If B_0 equals zero than this implies that the index is unbiased and if B_1 equals one than this implies that the two indices compared move one for one. Both B_0 and B_1 are tested together to determine if the indices have

bias, as well as, if the indices move in tandem. If this test is rejected then the two indices are statistically different from each other. The joint test makes failing to reject the null more complicated to interpret than rejecting. If we fail to reject then either B_0 equals 0, B_1 equals 1, or B_0 equals 0 and B_1 equals 1. Any of these results would suggest that the two indexes are not significantly different from each other.

A weakness with model 1 is that it is a joint test that to be rejected implies together B_0=0 and B_1=1. It could be the case that B_1=1 but there is a bias in one index relative to the other meaning that B_0 is different from zero. The joint test therefore may be rejected despite nearly perfect correlation between the two indexes. As such, alternative tests were also considered to further dissect the differences between any two series of demand indexes.

The alternative models are as follows:

$$Index_{jt} = B_1 Index_{kt} \qquad (2)$$

$$Index_{jt} = B_0 + B_1 Index_{kt} \qquad (3)$$

In equation 2 above j and k are also denoted as two separate indexes, and B_1 represents the coefficient on the independent variable in the model. The intercept, B_0, was removed from the model by restricting it to equal zero. This was done to independently test the coefficient, B_1, to see if the two indexes have one for one movements. By setting the intercept to zero, this test allows one to gain some insight into whether the two indexes tend to move one-for-one.

The test for equation 2 is as follows:

H_0: $B_1 = 1$

H_a: $B_1 \neq 1$

If the null hypothesis above is rejected then the two indexes do not have one for one movements and they are significantly different from one another. If we fail to reject the null hypothesis then that would suggest that the two indexes are not significantly different from one another.

In equation 3 above *j*, *k*, B_0, and B_1 are denoted the same as in equation 2 and equation 3. However, in equation 3 B_1 is restricted to the value of one to independently test the intercept, B_0. This test essentially tests if there is a difference in the average index values across the two indices. If the intercept is zero then this test is showing there is no difference in the averages between the indices. For example, $Index_{jt} - Index_{it} = B_0$, if the intercept in this example was not zero then there would be a difference between the two indices.

The test in this equation is as follows:

H_0: $B_0 = 0$

H_a: $B_0 \neq 0$

If the null hypothesis is rejected in this model then the intercept does not equal 0. This would imply the index getting tested is biased and the two indexes are statistically different from one another. If the intercept equals zero then we fail to reject the null hypothesis. This would suggests that the index is not biased and the two indexes are not different from each other. One

limitation to this model is that it provides only information on if the two indices are biased, but does not provide any information into the correlation of the two indices.

Each of these models have their own limitations when testing the difference between indices. All these models separately do not tell the whole story. One must look at the results from each of the models together to get the full picture if these indices actually are significantly different.

4.1 Comparisons and Estimated Elasticities Chosen in this Study

In this study a total of 5 indices were created to compare with each other. The indices created are All Fresh Retail, Choice Retail, World Wholesale, United States Wholesale, and Choice Retail Quantity. The first 4 indices listed above were created by using real beef price data and dividing that by the constant expected real beef price to calculate an index that estimates the vertical demand shift. The final index, Choice Retail Quantity, was created in terms of quantities, per capita consumption divided by constant demand expected real quantity to calculate the index as a horizontal demand shift.

The first comparison is between the All Fresh index and Choice index at the elasticity of -0.54. These two indices were tested with each other to determine if different retail price data used statistically affects the results of the demand indices. The All Fresh beef retail price is a mixture of beef products derived from the Choice beef retail price. The aim of the All Fresh retail price is to estimate the average retail value of the total beef production (USDA 2012). The All Fresh beef retail price is generally assumed to give an idea into the consumer's demand of the mixed quality grades of beef in the market, while the Choice beef retail price holds quality

constant so that shifting quality mixture over time does not in itself shift the demand (USDA 2012). Theoretically, it might be reasonable to assume that choosing price data that holds quality constant rather than choosing price data that is a mixture of quality could impact the results on the index created. The All Fresh Index will be compared with the Choice Index at a constant elasticity of -0.54 to determine the impact of this theory of changing price data. This elasticity of -0.54 was chosen from Schroeder et al. paper, Beef Demand Determinants, which gave a summary of estimated beef demand elasticities from selected studies (Schroeder et al 2000). These elasticities ranged from -0.25 to -0.85, with the majority of elasticities being in the range of -0.40 to -0.70 (Schroeder et al 2000).

The next comparison made was between the All Fresh index at the elasticity of -0.54 and the All Fresh index with an elasticity of -0.64. This comparison was made to test how sensitive the demand index results are to changing elasticities. The -0.54 was chosen as the base elasticity and was estimated from Schroeder, Marsh, and Mintert's Beef Demand Determinants (Schroeder et al 2000). The elasticity of -0.64 was chosen to compare to the base elasticity estimated to serve as an upper bound on the range of elasticities from Schroeder, Marsh, and Mintert's 2000 study. Generally not much concern is put into which estimated elasticity is chosen as long is the elasticity is within an accepted range of elasticities from previous studies. This assumption is due to the fact that the true elasticity can never be known exactly. The estimated elasticities chosen during index creation would assumedly impact the results, and further regression analysis will determine the magnitude of difference in index results due to changing elasticities.

The third comparison was between the All Fresh index at the elasticity of -0.54 and the All Fresh index with an elasticity of -0.44. These elasticities were again estimated from Schroeder, Marsh, and Mintert's paper, Beef Demand Determinants (Schroeder et al 2000). The

elasticity of -0.44 was used to serve as a lower bound from the estimated elasticities from the selected studies. Again, this comparison was made to test how sensitive demand index results are to changing estimated elasticities, even if the elasticities estimated are from an accepted range from previous research.

The fourth comparison was between the Choice index at the elasticity of -0.54 and the Choice index with an elasticity of -0.64. Again, it is assumed that choosing an elasticity from an accepted range of estimated elasticities from previous research would not significantly impact index results. This comparison was again made to test if the demand index results were significantly different with the changing elasticities and worthy of concern during creation. These elasticities were estimated from the Beef Demand Determinants paper (Schroeder et al 2000). The elasticity -0.54 was chosen as the base estimated elasticity and -0.64 was chosen to serve as an upper bound on the estimates.

The next comparison was between the Choice index at the elasticities of -0.54 and -0.44. This comparison was again chosen to determine the impact of estimated elasticities chosen during index creation on the index results. This analysis will determine if the magnitude of difference from changing estimated elasticities should be cause for concern. These elasticities were chosen from the range of estimated elasticities from the 2000 study, Beef Demand Determinants, (Schroeder et al 2000). Again, -0.54 was the base elasticity used in the model and -0.44 served as a lower bound from the elasticity estimates.

Next the comparison between the World Wholesale Index was made with the U.S. Wholesale index at the elasticity of -0.54. The elasticity of -0.54 was estimated from the range of estimated elasticities from the 2000 study, Beef Demand Determinants (Schroeder et al 2000). Both the World and U.S. Wholesale Indices are created from wholesale beef cutout price data.

This wholesale price data is defined as the average value of beef as it leaves the packing plant and it is measure in cents per pound of retail weight (USDA 2012). This study did not have access to U.S. export data and a few assumptions were made during the creation of the U.S. Wholesale Index and the World Wholesale Index. The U.S. Wholesale Index in this study omits U.S. exports and assumes all of the beef produced domestically will be consumed by the U.S. population. This misspecification of data would presumably affect the index results as the U.S. does export large quantities of beef throughout the world. This assumption was made due to unavailability of U.S. export data to this study, but this assumption was a common observation when reviewing previous research and other indices created. Without proper U.S. export data to determine which countries imported beef from the United States, another assumption was made to better define the population which consumed U.S. beef. The World Wholesale Index created in this study assumed beef produced in the U.S. would be consumed over the entire world population. It can be assumed that demand index results would vary depending on which population of consumption was chosen during creation. This comparison was made to determine the magnitude of difference on index results by omitting U.S. exports during index creation. Regression analysis will determine if this factor in index creation significantly effects results and is cause for concern.

The next comparison was made between the World Wholesale Index at the elasticities of -0.54 and -0.64. These elasticities were estimated in the same fashion as in the comparisons made above. This test was conducted to determine the sensitivity of changing elasticities with different price information.

The World Wholesale Index was also compared with the elasticities of -0.54 and -0.44. This test was done to determine the impacts of changing elasticities on the results of the demand

index. These elasticities were estimated from the same range of elasticities from the 2000 study, Beef Demand Determinants (Schroeder et al 2000). The elasticity -0.54 served as the base elasticity in the model and was compared with the elasticity of -0.44, which was chosen as a lower bound on the range of estimated elasticities.

Next the U.S. Wholesale Index was compared at the elasticities of -0.54 and -0.64. These estimated elasticities were chosen in the same fashion as the comparisons above. This comparison was done to determine the effect of changing elasticities on the demand index results. This comparison will determine if this index's sensitivity to changing estimated elasticities is cause for concern during index creation.

A comparison was also made between the U.S. Wholesale Index at the elasticities of -0.54 and -0.44. The elasticities used in this comparison were estimated from Schroeder, Marsh, and Mintert's 2000 study mentioned above. The elasticity -0.44 was chosen to serve as a lower bound for the estimates, while the elasticity -0.54 served as the base between comparisons. This comparison was conducted to determine if the magnitude of difference between indices from changing estimated elasticities is cause for concern.

The next comparison was made between the Choice Quantity Index and the original Choice Index to determine if the creation of indices in terms of prices or quantities matters. The Choice Quantity Index in this study was created using the same data as the Choice Index from the previous comparisons above. However, the Choice Quantity Index in this study was created in terms of quantities instead of in terms of prices like the all the other indices created in this study. For clarification, one creates an index in terms of prices by taking the real beef price and dividing that by the expected real beef price to arrive at the demand index. Creating the index in terms of quantities means taking the real beef quantity and dividing that by the expected real beef

quantity to determine the demand index. Generally, almost all of the indices in previous research are determine in terms of prices. The only other difference between creating an index in terms of prices with creating an index in terms of quantities is whether an elasticity or flexibility is used. The flexibility, which is one divided by the elasticity, is used during index creation in terms of prices and the elasticity is chosen in terms of quantities. To clarify the previous comparisons above used flexibilities, but those were changed by using different elasticities. For example, the elasticity -0.54 has a flexibility of -1.85 and the elasticity of -0.64 has a flexibility of -1.56. The flexibility or elasticity in either case is used to determine the constant demand expected in prices or quantities. The Choice Quantity Index in this study used elasticities, while the original Choice Index from previous comparisons above used the flexibility. This comparison was made to identify if it matters whether the index is created in terms of prices or in terms of quantities. The Choice Quantity Index was compared with the original Choice Index at the elasticity of -0.54 to determine if the magnitude of difference is cause for concern. Two additional comparisons were made between the Choice Quantity Index at changing elasticities to determine the magnitude of sensitivity if index creation in terms of quantities. These elasticities compared between the Choice Quantity Index iteration were between -0.54 and -0.64 and between -0.54 and -0.44. This range of elasticities were estimated from Schroeder and Marsh's 2000 study mentioned above in this study.

The final two comparisons made in this study were between the Choice Index and the US Wholesale Index and the Choice Index and the World Wholesale Index. These two comparisons were made to identify if choosing a specific index matters when comparing yearly changes. An example of this would be someone involved in exporting beef choosing to use a wholesale index versus a choice index, which looks at retail beef prices. It could be reasonably assumed that one

in the exporting industry might want to use a wholesale index, so this comparison was made to determine if a specific index chosen matters to certain sectors of the beef industry. Both the Choice Index versus US Wholesale Index comparison and the Choice Index versus World Wholesale Index comparison were tested at the elasticity of -0.54.

Chapter 5 Results

This results section will focus on the effects changing elasticities, effects of category of beef chosen during construction, and effects of index creation in terms of prices versus in terms of quantities. This was accomplished by running one base regression model with two alternative regression models, Equations 1 through 3, described earlier in the methods section. This section will discuss results presented in Table 1 through Table 13 that are located in the Appendix, as well as discuss the difference graphically with Figure 1 through Figure 13.

5.1 Results of Testing All Fresh versus Choice

This study will begin the analysis of the All Fresh Index and Choice Index with the same elasticity of -0.54 by comparing the two indices graphically. As you can see in Figure 1 located in the Appendix, these two indices seem to follow each other very closely. A few observations when comparing these two indices are from each of the years of 2006 through 2012 the All Fresh Index was higher than the Choice Index. The Choice Index was higher than the All Fresh Index in years 2001, 2003, and 2004. There are no major deviations between the two indices, with all years being within two to three units. This visual result would make sense as the All Fresh retail prices are derived from the Choice beef retail prices. Another important observation to note is

the direction of change between years during the index. Most people in industry focus solely on the direction of change from the previous year when looking at demand indexes, so it is useful to determine the amount of times the two indexes move in the same direction. When looking at this comparison specifically, there were two years from 2000 to 2012 where the indexes moved in opposite directions. From 2002 to 2003 the Choice Index increased in the demand value observed while the All Fresh Index decreased. Also, from 2006 to 2007 the Choice Index increased while the All Fresh Index decreased in demand value. These results would suggest the two indexes are different, but the change in demand values are almost constant in the two years that saw the indexes moving in opposite directions. Overall, visually these two indices do not appear to be all that different and the two indexes move in the same direction in almost every year with only small changes in the two years the indexes moved in opposite directions. The following regression results will determine if the two indices are statistically different.

The estimates of testing the categories of All Fresh Beef Demand versus Choice Beef Demand are located in Table 1 in the Appendix. The three regressions, Equations 1 through 3, found above in the methods section were tested at the elasticity of -0.54. Model 1, which was a paired F-test testing $B_0=0$ and $B_1=1$, rejected the null hypothesis at the p-value of 0.0349. This result would suggest the two indexes have bias and are statistically different. Model 2, which tested $B_1=1$, failed to reject the null hypothesis at the p-value of 0.2786. The results from Model 2 would suggest the two indexes are not statistically different and the two indexes do have one for one movements when the intercept is restricted to equal zero. Also, the parameter estimate for coefficient, B_1, was 0.99472. This result is very close to the value of one and would suggest that the two indices for practical purposes move one for one. Model 3 failed to reject the null hypothesis at the p-value 0.2622. This would suggest that the Choice Index is not biased and the

two indexes on average are not statistically different. While Model 1 rejected the null hypothesis and suggests the indices are different, Model 2 and Model 3 failed to reject the null hypothesis. When one combines these econometric results with the graphics it does not appear that the All Fresh Beef Demand Index is different from the Choice Beef Demand Index. While the USDA formula to estimate the All Fresh retail price continuously changes to estimate total beef production, it is reasonable to think using Choice beef retail prices or All Fresh beef retail prices could potentially matter when constructing future demand indexes.

5.2 Results of Testing Choice at the Elasticities of -0.54 and -0.64

This comparison will begin with analyzing the graphs of these two indices, Figure 2, located in the Appendix. The Choice Index at the elasticity of -0.54 appears to follow the Choice Index at the elasticity of -0.64. The Choice Index at -0.64 is higher in value in every year, from 2002 through 2012, than the Choice Index at the elasticity of -0.54. The two indices are within the value of one from the years of 2001 to 2006. However, after 2006 the two indices appear to increase in the difference between them. In year 2008 the difference between the indices is 1.98 and the difference between indices increases in each year from 2008 to 2012. The difference between the values of the indices in year 2012 is 3.75, which is considerably more than the difference between the years of 2001 to 2006. Also, it is again important to look at the how the indexes move from year to year to determine the percentage of time that they move in the same direction. These indexes in this comparison move in the same direction in every year except for one year. From 2001 to 2002 the Choice index at -0.54 increased in demand while the Choice Index at -0.64 decreased in demand value. Again, the year in which the two indexes moved in opposite directions saw only small changes in demand from year to year. Specifically the Choice

Index at -0.54 went from the demand values of 103.1 to 103.5, while the Choice Index at -0.64 went from 103.71 to 103.51. This small change would make it appear that the two indexes do move in the same direction when demand is not constant from year to year. Visually these two indices appear they could be biased and might not have one for one movements, but the two indexes move in the same direction in almost every year. The following results from the regression analysis will give a better picture about the difference of the two indices.

The results from testing Choice Beef Demand at these two elasticities can be found in Table 2 in the Appendix. Model 1, which was a joint test, rejected the null hypothesis at a p-value of 0.0007 and this would suggest changing the elasticity makes the indexes statistically different. Model 2 rejected the null at a p-value of 0.0017 and the parameter estimate on the coefficient was 0.98687. While the null hypothesis was rejected, suggesting the two indices are different, the coefficient is very close to the value of one. This would imply that the two indices are not that different from one another and might have one for one movements. The p-value of Model 3 was 0.001 and the null hypothesis was rejected. This would imply that intercept is not zero and the two indices are different on average. Comparing these indices visually and econometrically would suggest that there is a bias created by changing the elasticity. Model 1 and Model 3 suggest the two indexes are in fact different between the elasticities of -0.54 and -0.64, but Model 2's results are unclear about the magnitude of difference. Overall it would appear that these two indices may be statistically different from one another. These results would suggest that the indices themselves are sensitive to changing elasticities, but how much concern should one put into these altered results? For all practical purposes in industry it would appear the two indexes move very similarly with the small change in elasticities, however the small difference in indexes could be magnified if elasticities used had greater variation.

The general assumption with elasticities is they can never be known and it does not matter which point elasticity one chooses, as long as it is in a given range of estimated elasticities from previous research. These results may bring some concern to this general assumption as the estimated elasticities from previous research were found to be from the range of -0.25 to -0.85. This study focused on the range of elasticities most commonly estimated from previous research, this range was from -0.40 to -0.70. This range of estimated elasticities does not appear to be large in magnitude, but these results show it may matter which elasticity is chosen towards the results of the demand index. Further sensitivity analysis will be done in this study to determine if the point elasticity chosen affects index results enough to bring this method of index creation into question.

5.3 Results of Testing Choice at the Elasticities of -0.54 and -0.44

The discussion of comparing these two indices will begin with comparing the graph, Figure 3. The Choice Index with the elasticity of -0.54 is larger in value than the Choice Index at -0.44 in all years from 2001 to 2012. The graphics in this comparison look similar to the comparison of Choice Indices at elasticities -0.54 and -0.64. From years 2001 through 2007 the difference in values is around one, but from 2008 through 2012 the difference between the two increases each year. The difference between the two indices in year 2012 was 4.96, which again is considerably more than the difference from years 2001 through 2007. Again, it is important to note the direction of change in demand values from year to year when comparing the two indexes. The two indexes in this comparison move in the same direction in every year but one, from 2006 to 2007. Again the change from demand values in this year is almost constant and it would appear the two indexes move in the same direction. It would appear these two indices

may be different and may not move one for one with each other, but they do move in the same direction for all practical purposes.

The results of changing between the elasticities of -0.54 and -0.44 in the category of Choice Beef Demand are located in Table 3 in the Appendix. Model 1, which was a paired f-test, rejected the null hypothesis at the p-value of <.0001 and this would suggest the two indexes are statistically different from each other. The p-value from Model 2 was 0.0017 and the null hypothesis was rejected. However, the parameter estimate on the coefficient from Model 2 was 1.01993, which is very close to the value of one that his model was testing. Model 2's parameter estimate for the coefficient indicates an upward shift in the Choice Index at elasticity -0.54. This parameter estimate may imply the two indexes are not all that different from each other and may move one for one. Model 3 also rejected the null hypothesis at a p-value of 0.0006. This would suggest there is bias between the two indexes and that the indices are statistically different from one another. When looking at Figure 3 it would appear that these indices may be different. Model 1 and Model 3 also suggest a difference between the Choice Beef Demand Index at the elasticities of -0.54 and -0.44, but Model 2's results are less sure of statistical difference with the parameter estimate so close to one. The estimated point elasticity chosen may effect index results when one looks at the visual and econometric results together, but the magnitude of the difference between the two may not be cause for concern. For all practical purposes in industry the two indexes move very similarly and in the same direction in virtually every year. However, it would not be advisable to switch the indexes used for comparisons on year to year changes. The most accurate results can be found by remaining consistent with using the same indexes for comparisons.

5.4 Results of Testing All Fresh at the Elasticities of -0.54 and -0.64

When comparing the two indices graphically, (Figure 4 located in the Appendix), it does appear visually that they may be statistically different. In years 2001 through 2007 the difference between demand values is around one, but after 2007 the two indices seem to diverge. In 2008 the difference in demand values is 2.02 and each year after the difference between them increases. In the year 2012 the difference between the two indices is 3.89, which is considerably more than the differences during the time period of 2001 through 2007. Another observation from the graphics is the All Fresh Demand at elasticity -0.64 is always greater than the All Fresh Demand at elasticity -0.54. Again, it is important to note if the two indexes are moving in the same direction between year to year changes. The two indexes in this comparison move in the opposite direction in two years out of 12, however the two years with opposite directional movements saw close to constant demand between the two years. Specifically, from 2006 to 2007 the All Fresh at -0.54 decreased from 106.33 to 106.19, and the All Fresh at -0.64 increased from 107.14 to 107.27. From 2011 to 2012 the All Fresh at -0.54 decreased from 95.84 to 95.44 and the All Fresh at -0.64 increased from 99.27 to 99.33. These results would suggest the two indexes move in the same direction in all years other than when demand remains virtually constant. The regression analysis will determine further if the two indices are statistically different.

The estimates of the test of All Fresh Beef Demand at the elasticities -0.54 and -0.64 can be found in Table 4 in the Appendix. Model 1, which tested $B_0 = 0$ along with $B_1 = 1$, rejected the null hypothesis at the p-value of 0.0006. The results of this joint test would suggest the two indexes are statistically different from one another. Model 2, which tested the coefficient equal to one, rejected the null hypothesis at a p-value of 0.0006. This would imply the Choice Beef

Demand Index at the elasticity of -0.54 does not have one for one movements with the Choice Beef Demand Index at the elasticity of -0.64. Even though Model 2 rejected the null, the parameter estimate on the coefficient was 0.98595. This parameter estimate is close to one and this suggests the two indices might not be that much different. This parameter estimate also indicates a downward shift in the All Fresh Index at the elasticity of -0.54. Model 3, which tested the intercept equal to zero, also rejected the null hypothesis at a p-value of 0.0009. This would suggest there is a bias between the two All Fresh Indices at the different elasticities. Model 1 and Model 3 suggest the two All Fresh Indices are statistically different at the elasticities of -0.54 and -0.64, but again Model 2 is less sure of the difference between the two. Model 2 did reject the null hypothesis, but with a parameter estimate so close to one it does not appear the two are that different from each other. Overall, graphical and econometrical analysis indicates these two indices may be statistically different from one another. These results suggest it may matter which elasticity is chosen, even if this point elasticity is chosen from an accepted range of elasticities from previous research. With all three regression models rejecting the null, it may be relevant to use a range of elasticities when constructing demand indices for the sake of accuracy. However, for all practically purposes in industry it would appear the two indexes move similarly and in the same direction. Thus it does not appear to matter which index is chosen in this comparison, but one should remain consistent with which index is used for year to year comparisons.

5.5 Results of Testing All Fresh at the Elasticities of -0.54 and -0.44

Graphically comparisons were made about the All Fresh Demand Indices at elasticities of -0.54 and -0.44 from Figure 5 located in the Appendix. The graphics related to this comparison

have some similarities when compared to the other tests regarding elasticity sensitivity. Specifically, between the years of 2001 through 2007 the difference between the two indices demand value is around one. However after 2007, the difference between the two indices increases each following year. The difference between the two indices begins to increase between years 2007 and 2008, where these differences are 1.53 and 2.79, respectively. In 2012 the difference from the All Fresh Index at -0.54 and the All Fresh Index at -0.44 is 5.14. The graphics also show similarities to previous comparisons, Figures 2 through 4, in that more elastic elasticity is higher in magnitude in each year. Graphically it would appear that the two indices could be statistically different. It is also important to look at the direction of change between the two indexes for year to year comparisons. The two indexes in this comparison move in the same direction in every year in this comparisons, and this would suggest the two indexes are not different for all practical purposes. The regression analysis will further analyze this possibility.

The results of the test of All Fresh Beef Demand at the elasticities of -0.54 and -0.44 are located in Table 5 in the Appendix. Model 1 rejected the null hypothesis at a p-value of <.0001 and this joint test would suggest the two indexes are statistically different. Model 2, which tested the coefficient equal to one, also rejected the null hypothesis at a p-value of 0.0017. This result would imply the two Choice Demand Indexes do not have one for one movements. However, the parameter estimate for the coefficient in Model 2 is 1.02, which is not that much different from the value of one that the coefficient was tested against. This would suggest that the two indices are not that different from each other and would also suggest an upward shift for the All Fresh Index at -0.54. Model 3, which essentially tested to see if the average means of the two indices were equal, rejected the null hypothesis at the p-value of 0.0007. This would suggest there is bias between the two indexes. Graphically the two indices do appear to be different as

they diverge from each other after year 2007. All three models rejected the null hypothesis, but Model 2 is less sure on the difference between the two indices. Overall the All Fresh Indices at elasticities -0.54 and -0.44 may be statistically different. The results show that it may matter which estimated point elasticity is chosen, even if the elasticity chosen is from a range of estimated elasticities from previous research. The results from Model 2 might suggest the magnitude of this difference is negligible and not worthy of concern, but Model's 1 and 3 suggest it may be pertinent to use a range of estimated elasticities during index construction. Even though the two indexes appear econometrically different, it would appear for all practical purposes in industry that it does not matter which index is used for comparisons. However, it is advisable to remain consistent with which index is chosen for the most accurate results when comparing year to year changes.

5.6 Results of Testing World Wholesale and U.S. Wholesale at -0.54

When visually analyzing the World Wholesale Index versus the U.S. Wholesale Index graph, Figure 6, it would appear the two indices are similar. The range in the yearly demand values goes from a difference of 0.38 to 3.86. With the difference in demand values being small it would appear that these two indices might not statistically different from one another. In each year the U.S. Wholesale Index is larger in demand values than the World Wholesale Index at the elasticity of -0.54. It is also important to note the direction of change in demand from year to year when making comparisons. The two indexes in this comparisons move in the same direction in every year except for one, from 2006 to 2007. Again, the demand change from the year in which the two indexes move in opposite directions saw virtually constant changes in

demand. This would suggest the two indexes in this comparison are not different for all practical purposes. Further regression analysis will determine if the two indices are truly different.

The results from testing World Wholesale Beef Demand with U.S. Wholesale Beef Demand at the elasticity of -0.54 can be found in Table 6 in the Appendix. Model 1, which was a paired F-test, rejected the null hypothesis at a p-value of 0.0012 and this would suggest the two indexes are statistically different. Model 2, which tested the coefficient equal to one while removing the intercept from the model, rejected the null hypothesis at a p-value of 0.0006. This result would suggest the World Wholesale Index does not have one for one movements with the U.S. Wholesale Index. The parameter estimate on the coefficient from Model 2 is 0.97992 and this would suggest a downward shift in demand values for the World Wholesale Index. The parameter estimate is also very close to the value of one and this would suggest that the two indices might not be that different. Model 3, which tested the intercept equal to zero while fixing the coefficient to one, also rejected the null hypothesis at a p-value of 0.0004. This would imply that there is a bias between the World Wholesale Demand Index and the U.S. Wholesale Demand Index. Models 1 and 3, as well as graphical evidence, would suggest excluding U.S. export data during index creation does matter and statistically affects the results. Model 2, with the parameter estimate close to one, would suggest the magnitude of the difference between the two indices might not be cause for concern. It would also appear that excluding the U.S. export data incorrectly upwardly biases domestic beef demand for the U.S. However, for all practical purposes it would not appear to matter which index is chosen when comparing year to year changes in demand. It would not be advisable remain consistent with the index used, rather than switching from an index using U.S. export data to an index that omits export data.

5.7 Results of Testing World Wholesale at the Elasticities of -0.54 and -0.64

This comparison was made to again determine the impact of estimated elasticities on the demand index results. This graphical evidence can be found in the Appendix as Figure 7. Graphically the two indices appear that they may be different from each other. There is not a large divergence between the two indices and the range of difference in demand values is from 1.5 to 3.35. In each year the World Index with elasticity -0.64 is larger in demand value than the World Index at elasticity -0.54. It is again important to note if the direction of change between years is consistent between the two indexes. The two indexes in this comparison move in the same direction in every year, and this would suggest the two indexes are the same for all practical purposes. Visually it would appear that the two indices may be different, but further regression analysis will confirm or deny this point.

The results from testing the category of World Wholesale Beef Demand at the elasticities of -0.54 and -0.64 are located in Table 7 in the Appendix. Model 1, which jointly tested $B_0 = 0$ and $B_1 = 1$, rejected the null hypothesis at a p-value of <.0001. This test would suggest the two indexes are statistically different. Model 2, which tested $B_1 = 1$ while fixing the intercept to zero, rejected the null hypothesis at a p-value of <0.0001. This test would imply that changing the elasticity from -0.54 to -0.64, or vice versa, does make the indexes statistically different. Model 2 suggest the two World Wholesale Indices do not have one for one movements. The parameter estimate on the coefficient in Model 2 is 0.97705 and this would indicate a downward shift for the World Index at elasticity -0.54. However, the parameter estimate in Model 2 is close to the value of one and might suggest the two indices are not that different from one another. Model 3, which tested the intercept equal to zero while fixing the coefficient to one, also rejected the null hypothesis at a p-value of <0.0001 and this would imply there is bias between the two

indexes. Visually it would appear that these indices may be different than each. Econometrically it would also appear they are different as each of the three models suggests the two indexes are significantly different from one another. The implications of these results are that it does matter which estimated point elasticity is chosen during index creation, even if the elasticity chosen is within an accepted range of estimated elasticities from previous research. These results show that using a range of elasticities during index creation may improve the accuracy of index results, however the magnitude of the difference, suggested by Model 2, between the two indices may suggest that the estimated elasticity chosen is not of concern. Even though the two indexes appear econometrically different, it would appear that for all practical purposes in industry that it does not matter which index is used for comparison. Again, it would be advisable to remain consistent with which index is chosen for yearly comparisons.

5.8 Results of Testing World Wholesale at the Elasticities of -0.54 and -0.44

This study will continue the analysis on the World Wholesale Index by graphically examining the differences in the index at the elasticities -0.54 and -0.44. Visually it would appear that the two indices may be different than each other. Figure 8, which shows the graphics of testing the World Wholesale Indices at elasticities -0.54 and -0.44 can be found in the Appendix as Figure 8. The two indices do not have any years of extreme divergence, but the range of difference in demand values is from 2.1 to 4.49. The Wholesale Index at -0.54 is larger in magnitude for the every year for the time period of 2000 through 2012. Again, it is important to note if the direction of change in demand index values is consistent between years for the two indexes. The two indexes in this comparison move in the same direction between every year except for one, from 2011 to 2012. Again, the demand change between these years is virtually

constant, and this would suggest the two indexes move in the same direction for all practical purposes. Visually it would appear the two indices may be different, but the two indexes move in the same direction in virtually every year. Further regression analysis will determine if the two indices are statistically different from each other.

The estimates from testing the World Wholesale Beef Demand Indexes with the elasticities of -0.54 and -0.44 are located in Table 8 in the Appendix. Model 1 rejected the null hypothesis with a p-value of <.0001 and this joint test would imply the two indexes are statistically different. Model 2, which tested $B_1 = 1$ while fixing B_0 to the value of zero, also rejected the null hypothesis at a p-value of <0.0001. The parameter estimate on the coefficient in this model is 1.0327 and this would indicate an upward shift in the Wholesale Index at -0.54. This parameter estimate is close to the value of one might suggest the magnitude of difference between the two indices might not be cause for concern. Model 3, which fixed the coefficient to 1 while testing the intercept equal to 0, rejected the null hypothesis at a p-value of <0.0001. This would imply the two indexes are statistically different and there is a bias present between the two World Wholesale Demand Indexes. Graphically it appears the two indices may be different from one another. All three regression models rejected the null hypothesis and would suggest the indices are statistically different from each other. The results imply that it does matter which estimated point elasticity is chosen during index creation. The econometric results of Model 2 might suggest the magnitude of difference might not be cause for concern. Even though Model 2 is less clear on the statistical difference, using a range of estimated elasticities during index creation may improve accuracy of demand index results. However, for all practical purposes it does not appear to matter which index is chosen as long as one remains consistent with which index is chosen for comparisons.

5.9 Results of Testing U.S. Wholesale at the Elasticities of -0.54 and -0.64

Comparing the U.S. Wholesale Indices at elasticities of -0.54 and -0.64 graphically it would appear the two may be different from one another. The graph for this comparison can be found in the Appendix as Figure 9. The U.S. Index at -0.64 is larger in value than the U.S. Index at -0.54 for each year in the time period of 2000 through 2012. The range of differences in indices goes from 1.42 to 3.02, with no extreme divergence in any year. Again, it is important to determine if the two indexes move in the same direction for yearly comparisons. The two indexes in this comparisons move in the same direction in every year, and this would suggest the two indexes are the same for all practical purposes. It would appear the two indices may be different and further regression analysis will be done to confirm or deny this hypothesis.

The results from testing the U.S. Wholesale Beef Demand Indexes at the elasticities of -0.54 and -0.64 can be found in Table 9 in the Appendix. Model 1 rejected the null hypothesis at a p-value of <0.0001 and this joint test would imply the two indexes are statistically different. Model 2, which tested the coefficient equal to one while fixing the intercept at zero, also rejected the null hypothesis at a p-value of <0.0001. The parameter estimate for the coefficient in Model 2 is 0.97937 and this would indicate a downward shift for the U.S. Index at -0.54. This result would suggest the two indexes do not move one for one at the elasticities of -0.54 and -0.64. However, the parameter estimate in Model 2 being close to the value of one might suggest the magnitude of difference is not cause for concern. Model 3 rejected the null hypothesis with a p-value of <0.0001 and this would suggest a bias between the two indexes at the elasticities of -0.54 and -0.64. All three models suggest the U.S. Wholesale Beef Demand Indexes at the elasticities of -0.54 and -0.64 are statistically different. Comparing these regression results with the graphics it would appear the two indices may be different. These econometric results imply

that the estimated point elasticity chosen matters and may affect the demand index results. The magnitude of the difference in indices may not be worthy for concern, however these results suggest that the index does differ with even slight changes in elasticities chosen. Demand index accuracy may improve if a range of estimated elasticities from previous research is used during index creation. However, for all practical purposes it would appear that the two indexes are the same, as they move very similarly and in the same direction in every year. This would suggest that it does not matter which index is chosen, as long as one stays consistent with which index is used for yearly comparisons.

5.10 Results of Testing U.S. Wholesale at the Elasticities of -0.54 and -0.44

Graphically it would appear the U.S. Wholesale Indices at elasticities -0.54 and -0.44 follow each other in movements, but there is some difference in magnitude. The graph of this comparison can be found in the Appendix as Figure 10. In each year from 2000 through 2012 the U.S. Index at -0.54 is larger in value than the other index in this comparison. The range of difference between indices is 1.99 to 4.07, with no extreme divergence in values. Visually it appears the two indices may be similar, but there is some difference in demand values. It is also important to note the direction of change in demand values between years in the two indexes. The indexes in this comparison move in the same direction in every year, and this would suggest that the two indexes are the same for all practical purposes. Further regression analysis will determine if the two indices are statistically different.

The estimates from testing the U.S. Wholesale Beef Demand Indexes at the elasticities of -0.54 and -0.44 are located in Table 10 that can be found in the Appendix. Model 1 rejected the

null hypothesis at the p-value of <.0001. This result would suggest the two indexes are statistically different from each other. Model 2, which tested the coefficient equal to one while fixing the intercept at zero, rejected the null hypothesis at a p-value of <0.0001. This would imply the two indexes do not move one for one. The parameter estimate on the coefficient in Model 2 is 1.02949 and this would indicate a slight upward shift in demand for the U.S. Index at -0.54. The parameter estimate in Model 2 is close to the value of one and suggests the magnitude of difference between indices might not be worthy of concern. Model 3 also rejected the null hypothesis at a p-value of <0.0001. This would suggest a bias between the two indexes and that the two indexes are statistically different at the two elasticities. Graphically the two indices appear to follow the same movements. Econometrical results would all suggest the U.S. Wholesale Index at -0.54 is different from the U.S. Wholesale Index at -0.44. These results imply that the elasticity chosen does matter and the magnitude of difference between the two indices indicates it may be cause for concern. A range of estimated elasticities used during index creation may correct for this problem. However, for all practical purposes it does not appear to matter which index is chosen for comparison, as long as one remains consistent with which index is chosen for yearly comparisons.

5.11 Results of Testing between Choice Quantity vs Choice Price at -0.54

The graphics used in this comparison can be found in the Appendix as Figure 11, and analysis of this comparison appears to show the two indices may be different from one another. The Choice Index created in terms of prices is larger in magnitude for the time period of 2001 through 2007. The Choice Quantity Index is larger in magnitude for every year after 2007. The largest divergence in demand value is 5.79 in year 2004, and the range of difference between the

two indices is from .46 to 5.79. Again, it is important to note the direction of change between years for the two indexes. The two indexes in this comparison move in the same direction in every year, and this would suggest that for all practical purposes it does not matter which index is chosen. It would appear graphically that the two indices may be different and further regression analysis will be done to gain a clearer picture.

The results from testing between the Choice Quantity Index and the original Choice Index at the elasticity of -0.54 can be found in Table 11 located in the Appendix. Model 1 rejected the null hypothesis at the p-value of <.0001. This result would suggest the two indices are statistically different from one another. Model 2, which tested the coefficient equal to one while removing the intercept, failed to reject the null hypothesis at the p-value of 0.1151. This result would suggest the two indices have one for one movements. The parameter estimate in Model 2 is 0.98931 and this would suggest the indices are not that different than each other in that they have virtually one-for-one movements. Model 3, which tested the intercept equal to zero while restricting the coefficient to one, failed to reject the null hypothesis with a p-value of 0.1832. This would suggest the two indices are not different than one another. Graphically it would appear that the two indices may be different, with the differences in demand values. However, econometric analysis would suggest the two indices move similarly and are not that different from each other. Model 1 rejected the null hypothesis, but Model 2 and Model 3 failed to reject the null and this result would imply that it does not matter whether indices are created in terms of prices or in terms of quantities. When looking at the direction of change in demand values between years, it also appears to not matter which index is chosen for all practical purposes. Again, it would be advisable to remain consistent with the index chosen for yearly comparisons.

5.12 Results of Testing Choice Quantity Indices at Elasticities -0.54 and -0.64

Analyzing the graphics, Figure 12 located in the Appendix, between this comparison would suggest the two indices may follow similar movements. There are no extreme differences in demand values between the two indices. The range of differences in demand values in this comparison goes from .76 to 2.51. The Choice Quantity Index at elasticity -0.64 is higher in magnitude than the Choice Quantity Index at elasticity -0.54 in every year in this comparison. Again, the Choice Quantity Index was created with elasticities while the other indices in this study used flexibilities, which is one over the elasticity. When looking at the direction of change in demand values between the two indexes, it would appear that for all practical purposes the two indexes are the same. Only one year saw opposite movements in the direction of change, however the change in demand was virtually constant between these two years. This would suggest that it does not matter which index is chosen for yearly comparisons. Visually it would appear the two indices are similar, but further analysis will determine if the two indices are statistically different.

The results from testing the Choice Quantity Indices at elasticities -0.54 and -0.44 are located in Table 12 in the Appendix. Model 1, which was a paired F-test, rejected the null hypothesis at the p-value 0.0002. This result would suggest the two indices are statistically different from one another. Model 2, which tested $B_{1=}1$ while restricting $B_0=0$, rejected the null hypothesis with the p-value of <.0001. This would suggest the two indices do not have one for one movements. However, the parameter estimate in Model 2 is 0.98568 and this would imply the two indices are not that much different in magnitude. Model 3, which tested $B_0=0$ while restricting $B_1=1$, rejected the null hypothesis at the p-value of <.0001. This would also suggest

the two indices have bias and are statistically different from each other. Graphically it would appear the two indices have one for one movements. All three regression models rejected the null hypothesis and would suggest the two indices may be statistically different from each other. However, Model 2's parameter estimate would suggest the magnitude of difference between indices is not worthy of concern. For all practical purposes it does not appear to matter which index is chosen for yearly comparisons, but it is advisable to remain consistent with which index is chosen.

5.13 Results of Testing the Choice Quantity Indices at Elasticities -0.54 and -0.44

Analyzing this comparison using the graph, Figure 13 located in the Appendix, it would appear the two indices may have one for one movements. The Choice Quantity Index at -0.54 is larger in magnitude than the Choice Quantity Index at -0.44 in every year from 2000 to 2012. There are no major differences in demand values between the two indices and the range of differences is from 0.76 to 2.39. Again, it is important to note the direction of change between the two indexes for industry use. The two indexes in this comparison move in the opposite direction twice, from 2006 to 2007 and 2010 to 2011. Again the two times the indexes move in the opposite directions saw virtually no change in demand between the two years in question. This would suggest that the two indexes move in the same direction and it would not appear to matter which index is chosen for yearly comparisons. It would appear graphically the two indices move one for one, but further regression analysis will determine if the indices are statistically different from each other.

The results of testing the Choice Quantity Indices at the elasticities of -0.54 and -0.44 can be found in Table 13 located in the Appendix. Model 1, which was a paired F-test, rejected the null hypothesis at the p-value of 0.0002. This would suggest the two indices are statistically different from one another. Model 2 rejected the null hypothesis at the p-value of <.0001 and this would suggest the two indices do not move one for one. However, the parameter estimate for Model 2 is 1.0141 and this would suggest the magnitude of difference between indices might not be worthy of concern. Model 3 also rejected the null hypothesis at the p-value of <.0001 and this would suggest there is bias between the two indices. All three regression models rejected the null hypothesis and would suggest the two indices are statistically different from one another. However, the parameter estimate in Model 2 being close to one would suggest the magnitude of difference between the two indices might not be worthy of concern. For all practical purposes in industry, it would not appear to matter which index is chosen due to the indexes moving in the same direction in virtually every year. However, it would be advisable to remain consistent with the index chosen for yearly comparisons.

Results of Testing Choice vs US Wholesale

Analyzing this comparison with the graphics shows some major divergence between the two indexes. This difference in index values would make sense because this test compared to separate data sets. It is also important to note the change in direction between the two indexes in this comparison. The Choice Index and the U.S. Wholesale Index move in opposite directions in four out of the ten years. This result, along with the large difference in index values, would suggest the two indexes are different from one another. Further regression analysis will determine if the two indexes are statistically different.

The estimates from testing the Choice Index with the U.S. Wholesale Index at the elasticity of -0.54 are located in Table 14 in the Appendix. Model 1 failed to reject the null hypothesis with a p-value of 0.2237 and this joint test would imply the two indexes are not statistically different. Model 2, which tested $B_1 = 1$ while fixing B_0 to the value of zero, also failed to reject the null hypothesis at a p-value of 0.3283. The parameter estimate on the coefficient in this model is 1.027 and this would indicate the two indexes have similar movements. This parameter estimate is close to the value of one might suggest the magnitude of difference between the two indices might not be cause for concern. Model 3, which fixed the coefficient to 1 while testing the intercept equal to 0, failed to reject the null hypothesis at a p-value of 0.2885. This would imply the two indexes are not statistically different and there is no bias present between the two indexes. Graphically it appears the two indices may be different from one another, as the two indexes in this comparison had large variations between them and moved in opposite directions in numerous years. However, all three regression models failed to reject the null hypothesis and would suggest the indices are not statistically different from each other. Overall, the two indexes have a similar downward trend throughout the years in this test and it would appear for all practical purposes the two indexes are not different. However, it would be advisable to stay consistent with which index is chosen for comparisons.

Results of Testing Choice vs World Wholesale

When analyzing this comparison graphically it is easy to see the large variation between the two indexes. This difference in index values would make sense due to the different price data used in the two indexes. Again, it is also important to note the direction of change between years of the two indexes in this comparison. The Choice Index and the World Wholesale Index

move in opposite directions in five out of the ten years. These yearly changes, along with the graphics, would suggest the two indexes may be different from one another. Further regression analysis will determine if the two indexes are statistically different.

The estimates from testing the Choice Index with the World Wholesale Index at the elasticity of -0.54 are located in Table 15 in the Appendix. Model 1 failed to reject the null hypothesis with a p-value of 0.0892 and this joint test would imply the two indexes are not statistically different. Model 2, which tested $B_1 = 1$ while restricting B_0 to the value of zero, also failed to reject the null hypothesis at a p-value of 0.0884. The parameter estimate on the coefficient in this model is 1.048 and this would indicate the two indexes have one for one movements. This parameter estimate is close to the value of one might suggest the magnitude of difference between the two indices might not be cause for concern. Model 3, which fixed the coefficient to 1 while testing the intercept equal to 0, failed to reject the null hypothesis at a p-value of 0.0716. This would imply the two indexes are not statistically different and there is no bias present between the two indexes. Graphically it appears the two indices may be different from one another, as the two indexes in this comparison had large variations between them and moved in opposite directions in half of the years in this comparison. However, all three regression models failed to reject the null hypothesis and would suggest the indices are not statistically different from each other. Overall, the two indexes have a general downward trend throughout the years in this test and it would appear for all practical purposes the two indexes are not different. However, it would be advisable to stay consistent with which index is chosen for comparisons.

Chapter 6 Conclusion

The objective of this study was to analyze the effect of changing the major factors that go into demand index construction to determine if the magnitude of change is worthy of concern. This study used simple OLS regression and graphical analysis to determine if demand index results are greatly influenced by changing elasticities, changing retail price data, or constructing the index in terms of quantities rather than in terms of prices. Demand indices have been used throughout many industries, including agriculture, as a measure to compare demand across many years. There are many different beef demand indices in literature that are constructed in different ways and little research has been done to analyze the effects of these different factors of index construction on the demand index results. Accurate information gained from demand index results is extremely important for strategic planning purposes for many different industries and can have serious monetary implications.

6.1 Results and Implications

This study tested five separate factors in the construction of demand indices. These iterations are as follows, changes in retail price data, retail price data versus wholesale price data, changes in elasticities chosen, changes in export data, and changes in construction in terms of quantities instead of prices. This study tested Choice retail beef price data against All-Fresh retail beef price data. It would be reasonable to assume that different retail price data used during index construction could impact demand results. However, the Choice retail beef demand index does not appear to be statistically different from the All-Fresh retail beef demand index constructed in this study. For all practical industry purposes it does not appear to matter which

index is chosen for yearly comparisons, but one should remain consistent with the index chosen. The All-Fresh retail prices are derived from a formula based on the Choice retail beef prices, so it could be possible for future data could be influenced by this. It would be useful to use scanner data in the future to obtain a clearer picture of consumer quality preferences due to the greater transparency this would allow when compared with the USDA's derived All Fresh retail price data.

The Choice Index in this study was compared with the U.S. and World Wholesale Indexes to determine if different indexes should be used for different industry purposes. It would be reasonable to see how one in the business of exporting beef might want to use a wholesale index, instead of an index constructed with retail prices. When looking at the graphics between these two comparisons it would appear that the retail price index is different from the wholesale indexes. However, with further regression analysis it appears that the Choice Index is not statistically different from either of the wholesale indexes. All three models fail to reject that the Choice Index is different from either wholesale index. This would suggest that it would not matter which index is chosen for industry comparisons. However, it would be advisable to stay consistent with which index is chosen for comparisons to maintain accuracy.

The sensitivity analysis in this study had a range of elasticities from -0.44 to -0.64 and these elasticities were well within the range of generally acceptable elasticities estimated from previous literature (Schroeder et al 2000). One main concern from previous literature was estimating the same elasticity across time during index construction. This study shows that even small changes in elasticities causes the demand index results to be statistically different. All estimates in this study where elasticities were changed appear to be different statistically, however the level of concern with this finding may be minimal due to the small increments of

change in magnitudes of difference between indices. This study shows that it may be useful to use a range of elasticities when constructing demand indices as an upper and lower bound for demand index estimates. However, for all practical purposes it does not appear to matter which index is chosen for yearly comparisons due to the indexes moving very similarly and in the same direction. Though, it would be advisable to remain consistent with which index is chosen for yearly comparisons. To reiterate this important point, one must compare the same index from year to year because changing indexes used will effect the demand results obtained. Further research with regards to a larger range of elasticities chosen could determine if the magnitude of change in index results is worthy of concern.

Another concern of index construction is omitting U.S. export data. Some indexes in literature have failed to use the correct populations when U.S. export data is unavailable. This study shows that this error may incorrectly upwardly bias domestic demand for beef. The study shows this to be statistically significant with all three models, but the magnitude of difference between the two indices is small and may not be cause for concern. For all practical purposes in industry it does not appear to matter which index is chosen for yearly comparisons. However, one should remain consistent with the index chosen, as changing indexes used will effect the yearly comparisons in demand.

More than likely indices in the agricultural sector will be constructed in terms of prices instead of in terms of quantities. Again, one creates an index in terms of prices by taking the real beef price and dividing that by the expected real beef price to arrive at the demand index. Creating the index in terms of quantities means taking the real beef quantity and dividing that by the expected real beef quantity to determine the demand index. Graphically these indices in this comparison appear that they might be different, but statistical evidence would state the two

indices to move similarly. Again, for all practical purposes it does not appear to matter which index is chosen, as long as one is consistent with which index is used for comparisons.

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Appendix

Table 1						
Retail Choice vs. Retail All Fresh		**Elasticity -0.54**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	-17.98723	0.0207			-0.60051	0.2262
Retail All Fresh	1.16992	<.0001	0.99472	<.0001	1	<.0001
R2	0.9671		0.9997		0.9467	
Number of Observations	13		13		13	
Root MSE	1.39247		1.71892		1.69738	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-Value	Reject null	0.0349	Fail to Reject Null	0.2876	Fail to Reject null	0.2262

Table 2						
Choice -0.54 vs -0.64		**Testing between Elasticities -0.54 Choice = -0.64 Choice**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	-11.58977	0.027			-1.39804	0.001
Retail Choice at -0.64	1.09883	<.0001	0.98687	<.0001	1	<.0001
R2	0.9827		0.9999		0.9747	
Number of Observations	13		13		13	
Root MSE	1.01157		1.22149		1.16965	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Reject null	0.0007	Reject null	0.0017	Reject null	0.001

Table 3						
Choice -0.54 vs -0.44		**Testing between Elasticities -0.54 Choice = -0.44 Choice**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	17.32953	0.0004			2.10349	0.0006
Retail Choice at -0.44	0.84716	<.0001	1.01993	<.0001	0.0006	<.0001
R2	0.982		0.9997		0.95	
Number of Observations	13		13		13	
Root MSE	1.03159		1.7889		1.6446	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Reject null	<.0001	Reject null	0.0017	Reject null	0.0006

Table 4						
All Fresh -0.54 vs -0.64		**Testing between Elasticities -0.54 All Fresh = -0.64 All Fresh**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	-15.16393	0.025			-1.49682	0.0009
Retail All Fresh at -0.64	1.13164	<.0001	0.98595	<.0001	1	<.0001
R2	0.8735		0.9999			
Number of Observations	13		13		13	
Root MSE	1.05055		1.27675			
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Reject null	0.0006	Reject null	0.0014	Reject null	0.0009

Table 5						
All Fresh -0.54 vs -0.44		**Testing between Elasticities -0.54 All Fresh = -0.44 All Fresh**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	20.44311	0.0004			2.13214	0.0007
Retail All Fresh at -0.44	0.81724	<.0001	1.02024	<.0001	1	<.0001
R2	0.9734		0.9997		0.9247	
Number of Observations	13		13		13	
Root MSE	1.05404		1.82373		1.69683	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Reject null	<.0001	Reject null	0.0017	Reject null	0.0007

Table 6						
World Wholesale vs US Wholesale		**Elasticity -0.54**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	-9.85778	0.1416			-1.95169	0.0004
US Wholesale	1.08281	<.0001	0.97992	<.0001	1	<.0001
R2	0.9695		0.9998		0.9639	
Number of Observations	11		11		11	
Root MSE	1.19867		1.29081		1.23852	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Reject null	0.0012	Reject null	0.0006	Reject null	0.0004

Table 7						
World Wholesale -0.54 vs -0.64		**Testing between Elasticities -0.54 World = -0.64 World**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	-7.81985	0.1047			-2.22574	<.0001
World at Elasticity -0.64	1.05843	<.0001	0.97705	<.0001	1	<.0001
R2	0.9839		0.9999		0.9809	
Number of Observations	11		11		11	
Root MSE	0.87269		0.96606		0.90152	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Reject null	<.0001	Reject null	<.0001	Reject null	<.0001

Table 8						
World Wholesale -0.54 vs -0.44		**Testing between Elasticities -0.54 World = -0.44 World**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	12.46342	0.0117			3.03061	<.0001
World at Elasticity -0.44	0.89575	<.0001	1.0327	<.0001	1	<.0001
R2	0.9791		0.9998		0.9659	
Number of Observations	11		11		11	
Root MSE	0.99267		1.36537		1.20413	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Reject null	<.0001	Reject null	<.0001	Reject null	<.0001

Table 9						
U.S. Wholesale -0.54 vs -0.64		**Testing between Elasticites -0.54 U.S. Wholesale = -0.64 U.S. Wholesale**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	-5.85353	0.2329			-2.0295	<.0001
US Wholesale at Elasticity -0.64	1.03922	<.0001	0.97937	<.0001	1	<.0001
R2	0.982		0.9999		0.9806	
Number of Observations	11		11		11	
Root MSE	0.83741		0.86363		0.82477	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Reject null	<.0001	Reject null	<.0001	Reject null	<.0001

Table 10						
U.S. Wholesale -0.54 vs -0.44		**Testing between Elasticties -0.54 U.S. Wholesale = -0.44 U.S. Wholesale**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	11.29164	0.0342			2.78309	<.0001
US Wholesale at Elasticity -0.44	0.9082	<.0001	1.02949	<.0001	1	<.0001
R2	0.9747		0.9999		0.9648	
Number of Observations	11		11		11	
Root MSE	0.99258		1.22469		1.11193	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Reject null	<.0001	Reject null	<.0001	Reject null	<.0001

Table 11						
Choice Quantity vs Choice Price		**Testing between Choice Quantity = Choice Price at Elasticity -.54**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	31.75492	<.0001			-0.93482	0.1832
US Wholesale at Elasticity -0.44	0.67864	<.0001	0.98931	<.0001	1	<.0001
R2	0.9958		0.9995		0.7725	
Number of Observations	13		13		13	
Root MSE	0.33941		2.31347		2.38588	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Reject null	<.0001	Fail to Reject	0.1151	Fail to Reject Null	0.1832

Table 12						
Choice Quantity -0.54 vs -0.64		**Testing between Elasticities -0.54 Choice Quantity = -0.64 Choice Quantity**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	2.40729	0.6154			-1.45818	<.0001
US Wholesale at Elasticity -0.44	0.96219	<.0001	0.98568	<.0001	1	<.0001
R2	0.976		0.9999		0.9745	
Number of Observations	13		13		13	
Root MSE	0.80927		0.78417		0.79877	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Reject null	0.0002	Reject null	<.0001	Reject null	<.0001

Table 13						
Choice Quantity -0.54 vs -0.44		**Testing between Elasticities -0.54 Choice Quantity = -0.44 Choice Quantity**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	2.28373	0.6253			1.40646	<.0001
US Wholesale at Elasticity -0.44	0.99117	<.0001	1.0141	<.0001	1	<.0001
R2	0.9772		0.9999		0.9771	
Number of Observations	13		13		13	
Root MSE	0.78946		0.76447		0.75713	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Reject null	0.0002	Reject null	<.0001	Reject null	<.0001

Table 14						
Choice vs US Wholesale		**Testing between Choice and US Wholesale at -0.54**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	61.434	0.1593			2.49776	0.2885
US Wholesale	0.38582	0.92	1.02708	<.0001	1	<.0001
R2	0.0862		0.9935		.	
Number of Observations	11		11		11	
Root MSE	7.84447		8.35888		8.28412	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Fail to Reject Null	0.2237	Fail to Reject Null	0.3283	Fail to Reject Null	0.2885

Table 15						
Choice vs World Wholesale		**Testing between Choice and World Wholesale at -0.54**				
	Model 1		**Model 2**		**Model 3**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Intercept	52.14331	0.1594			4.75146	0.0716
World Wholesale	0.49322	0.207	1.04836	<.0001	1	<.0001
R2	0.1704		0.9941		.	
Number of Observations	11		11		11	
Root MSE	7.47435		7.96382		7.82204	
Test	B0=0 & B1=1		B1=1 no intercept		B0=0	
Test Result P-value	Fail to Reject Null	0.0892	Fail to Reject Null	0.0884	Fail to Reject Null	0.0716

Table 16 – Choice Index Spreadsheet

	choice				Assumed Beef Price Elast		**-0.54**	1980=100			
					Assumed Beef Price Flexi		**-1.85**	Constant Demand			
Year	Beef	Year to Yea	Nominal	CPI	(82-84 $)	Year to Yea	1980=100	Expected	Beef Demand Index		Beef Demand Index
	Consumption	% change in consump	Beef Price		Real Beef Price	Actual % change	Demand Year to year	(1982-84 $)	1980=100		2000=100
	(lbs/capita)		(cents/lb)		(cents/lb)	in real price	Expected % change in Real Quantities	Real Beef Price (cents/lb)			
1980	76.6		233.6	82.4	283.46				100		
1981	78.3	2.16	234.7	90.9	258.09	-8.95	-4.01	272.09	94.85		
1982	77.1	-1.52	238.4	96.5	247.00	-4.29	-1.14	280.23	88.14		
1983	78.6	1.91	234.1	99.6	235.02	-4.85	-4.70	270.13	87.01		
1984	78.5	-0.11	235.5	103.9	226.67	-3.55	-4.50	270.70	83.74		
1985	79.3	0.99	228.6	107.6	212.54	-6.23	-6.37	265.40	80.08		
1986	78.9	-0.45	226.8	109.6	206.90	-2.66	-5.51	267.85	77.24		
1987	73.9	-6.33	238.4	113.6	209.80	1.40	6.56	302.04	69.46		
1988	72.7	-1.62	250.3	118.3	211.69	0.90	9.46	310.26	68.23		
1989	69.0	-5.06	265.7	124.0	214.30	1.23	18.34	335.45	63.88		
1990	67.8	-1.82	281.0	130.7	215.08	0.36	21.38	344.05	62.51		
1991	66.8	-1.43	288.3	136.2	211.71	-1.57	23.71	350.67	60.37		
1992	66.5	-0.47	284.6	140.3	202.83	-4.19	24.47	352.82	57.49		
1993	65.1	-2.09	293.4	144.5	203.13	0.15	27.83	362.34	56.06		
1994	67.0	2.92	282.9	148.2	190.84	-6.05	23.24	349.32	54.63		
1995	67.5	0.67	284.3	152.4	186.59	-2.23	22.15	346.23	53.89		
1996	68.2	1.08	280.2	156.9	178.66	-4.25	20.39	341.25	52.35		
1997	66.9	-1.91	279.5	160.5	174.15	-2.53	23.53	350.16	49.73		
1998	68.1	1.77	277.1	163.0	170.00	-2.38	20.66	342.03	49.70		
1999	69.1	1.49	287.8	166.6	172.76	1.62	18.22	335.10	51.55		
2000	67.8	-1.91	306.4	172.2	177.94	3.00	21.40	344.13	51.71		100.00
2001	66.3	-2.15	337.7	177.1	190.73	7.19	24.93	354.11	53.86		103.08
2002	67.7	2.15	331.5	179.9	184.32	-3.36	21.48	344.34	53.53		103.49
2003	65.0	-4.05	374.6	184.0	203.59	10.45	28.11	363.14	56.06		106.35
2004	66.2	1.85	406.5	188.9	215.23	5.72	25.20	354.89	60.65		115.97
2005	65.6	-0.90	409.1	195.3	209.47	-2.67	26.65	358.99	58.35		111.13
2006	65.9	0.42	397.0	201.6	196.94	-5.98	25.97	357.08	55.15		105.24
2007	65.2	-0.98	415.8	207.3	200.56	1.83	27.54	361.51	55.48		105.40
2008	62.5	-4.25	432.5	215.3	200.86	0.15	34.24	380.51	52.79		98.57
2009	61.1	-2.16	426.0	214.5	198.55	-1.15	37.50	389.76	50.94		94.40
2010	59.6	-2.49	439.4	218.1	201.53	1.50	41.18	400.17	50.36		92.56
2011	57.3	-3.81	482.7	224.9	214.60	6.49	46.66	415.71	51.62		93.81
2012	55.4	-3.30	502.3	229.6	218.77	1.94	51.23	428.67	51.03		91.94

Table 17- All Fresh Index Spreadsheet

Year	Beef		ALL FRESH		Assumed Beef Price Elasticity		**-0.54**	1990=100				
	Consumption				Assumed Beef Price Flexibility		**-1.85**	Constant Demand				
	(lbs/capita)	Year to Year	Nominal	CPI		Year to Year	1990=100	Expected	Beef Demand Index		Beef Demand Index	
		% change in consump	Beef Price	(82-84)	Real Beef Price	Actual % change	Constant Demand Year to year	(1982-84 $)	1990=100		2000=100	
			(cents/lb)		(cents/lb)	in real price	Expected % change in quantity	Real Beef Price (cents/lb)				
1990	67.8		262.48	130.66	200.89							
1991	66.8	-1.43	271.06	136.19	199.03	-0.93	2.63	206.18	100.00			
1992	66.5	-0.47	266.42	140.32	189.87	-4.60	3.49	207.90	96.53			
1993	65.1	-2.09	271.45	144.46	187.91	-1.03	7.27	215.50	91.33			
1994	67.0	2.92	265.02	148.23	178.80	-4.85	2.10	205.10	87.20			
1995	67.5	0.67	259.42	152.38	170.24	-4.79	0.87	202.64	87.17			
1996	68.2	1.08	252.44	156.85	160.95	-5.46	-1.11	198.66	84.01			
1997	66.9	-1.91	253.76	160.52	158.09	-1.77	2.43	205.77	81.01			
1998	68.1	1.77	253.30	163.01	155.39	-1.71	-0.80	199.29	76.83			
1999	69.1	1.49	260.52	166.58	156.40	0.65	-3.55	193.75	77.97			
2000	67.8	-1.91	276.10	172.20	160.34	2.52	0.03	200.96	80.72		100.00	
2001	66.3	-2.15	300.59	177.07	169.76	5.88	4.00	208.93	79.79		101.84	
2002	67.7	2.15	305.21	179.88	169.68	-0.05	0.12	201.13	81.25		105.74	
2003	65.0	-4.05	331.04	184.01	179.91	6.03	7.59	216.13	84.36		104.32	
2004	66.2	1.85	361.20	188.88	191.23	6.30	4.31	209.55	83.24		114.38	
2005	65.6	-0.90	364.41	195.29	186.60	-2.42	5.94	212.82	91.26		109.89	
2006	65.9	0.42	361.37	201.59	179.26	-3.93	5.18	211.29	87.68		106.33	
2007	65.2	-0.98	377.42	207.34	182.03	1.55	6.94	214.83	84.84		106.19	
2008	62.5	-4.25	396.68	215.30	184.24	1.22	14.49	230.00	84.73		100.39	
2009	61.1	-2.16	389.29	214.54	181.46	-1.51	18.17	237.39	80.10		95.80	
2010	59.6	-2.49	402.13	218.06	184.42	1.63	22.30	245.70	76.44		94.07	
2011	57.3	-3.81	444.01	224.94	197.39	7.03	28.48	258.10	75.06		95.84	
2012	55.4	-3.30	469.37	229.59	204.43	3.57	33.62	268.44	76.48		95.44	

Table 18- U.S. Wholesale Index Spreadsheet

Wholesale beef demand US			elasticity	**-0.54**									
			flex	-1.85									
Year	total prod	Beginning Stocks- Ending Stocks	Total Production Net Beginning and Ending Stocks	US Estimated Population	Wholesale per Capita Consumption in US	Year to Year % Change in Consumption	Weighted Annual Wholesale Cutout Nominal Value	PPI Base Year 82-84	Wholesale Real Cutout Value	Yearly Change in Real Price	Constant Demand Yearly Expected % Change in Real Price	Demand Expected (82-84 $) Real Wholesale Cutout Value	U.S. Wholesale Demand Index
	in million lbs		in million lbs	in July	(lbs/person)	(%)	in (cents/lb)		in (cents/lb)	(%)	2002=100	cents/lb	2002=100
2002	27396.7	-86	27482.7	287625193	0.0001	n/a	111.22	138.9	80.07	n/a	n/a	100	100
2003	26540.6	175	26365.6	290107933	0.0001	-4.89	134.88	143.3	94.13	17.56	9.05	87.31	107.80
2004	24825.8	-118	24943.8	292805298	0.0001	-6.26	136.29	148.5	91.78	-2.50	20.08	96.15	95.45
2005	24951.8	64.9	24886.9	295516599	0.0001	-1.14	140.20	155.7	90.05	-1.88	21.97	97.66	92.20
2006	26411.5	-59.9	26471.4	298379912	0.0001	5.35	139.51	160.4	86.98	-3.41	13.24	90.67	95.93
2007	26668.8	-1	26669.8	301231207	0.0001	-0.20	145.66	166.6	87.43	0.52	13.59	90.95	96.13
2008	26815.3	-14	26829.3	304093966	0.0001	-0.35	151.19	177.1	85.37	-2.36	14.19	91.43	93.37
2009	26214.8	77	26137.8	306771529	0.0001	-3.43	139.49	172.5	80.87	-5.28	20.05	96.13	84.12
2010	26558.6	-15	26573.6	309349689	0.0001	0.82	154.11	179.5	85.86	6.17	18.70	95.04	90.34
2011	26444.8	-14	26458.8	311587816	0.0001	-1.15	178.58	190.5	93.74	9.19	20.61	96.57	97.07
2012	26149.60	-10.00	26159.6	313914040	0.0001	-1.86	187.95	194.2	96.78	3.24	23.68	99.03	97.73

Table 19- World Wholesale Index Spreadsheet

Year	Total Production	Difference in Beginning and Ending Stocks	Total Producion Net Beg. And End Stocks	World Population Annual Estimate	Wholesale per Capita Consumption in World	Year to Year % Change in Consumption	Average Annual Wholesale Cutout Nominal Value	PPI Base Year 82-84	Wholesale Real Cutout Value	Yearly Change in Real Price	Constant Demand Yearly Expected % Change in Real	Demand Expected (82-84 $) Real Wholesale Cutout Value	World Wholesale Demand Index
	in million lbs		in million lbs	in july	(lbs/person)	(%)	in (cents/lb)		in (cents/lb)	(%)	2002=100	cents/lb	2002=100
2002	27396.7	-86	27482.7	6243351444	0.000004	n/a	111.57	138.90	80.32	n/a	n/a	100.00	100.00
2003	26540.6	175	26365.6	6319822330	0.000004	-5.23	135.61	143.30	94.63	17.81	9.68	88.10	107.42
2004	24825.8	-118	24943.8	6396726866	0.000004	-6.53	136.41	148.50	91.86	-2.93	21.14	97.30	94.40
2005	24951.8	65	24886.9	6473525274	0.000004	-1.41	140.71	155.70	90.38	-1.61	23.45	99.16	91.14
2006	26411.5	-60	26471.4	6551256997	0.000004	5.10	139.75	160.40	87.12	-3.60	15.20	92.53	94.16
2007	26668.8	-1	26669.8	6629668134	0.000004	-0.44	145.96	166.60	87.61	0.56	15.95	93.13	94.07
2008	26815.3	-14	26829.3	6708196774	0.000004	-0.58	151.05	177.10	85.29	-2.64	16.93	93.92	90.81
2009	26214.8	77	26137.8	6786381274	0.000004	-3.70	139.53	172.50	80.88	-5.17	23.16	98.92	81.77
2010	26558.6	-15	26573.6	6863770931	0.000004	0.52	154.24	179.50	85.93	6.24	22.31	98.24	87.47
2011	26444.8	-14	26458.8	6940712355	0.000004	-1.54	178.71	190.50	93.81	9.17	24.81	100.25	93.58
2012	26149.6	-10	26159.6	7017543964	0.000004	-2.21	187.95	194.20	96.78	3.16	28.36	103.10	93.87

Table 20- Choice Quantity Index Spreadsheet

	Choice Quantity				Assumed Beef Price Elasticity		-0.54	1980=100			
					Assumed Beef Price Flexibility		-1.85	Constant Demand			
Year	Beef	Year to Year	Nominal	CPI	(82-84 $)	Year to Year	1980=100	Expected	Beef Demand Index		Beef Demand
	Consumption	% change in	Beef Price		Real Beef Price	Actual % change	Constant Demand Year	(1982-84 $)	1980=100		2000=100
	(lbs/capita)		(cents/lb)		(cents/lb)	in real price	Expected % change in Real price	Real Quanity			
1980	76.62		233.59	82.41	283.46			100.00			
1981	78.28	2.16	234.67	90.93	258.09	-8.95	4.85	80.33	97.44		
1982	77.09	-1.52	238.36	96.50	247.00	-4.29	6.97	81.96	94.06		
1983	78.56	1.91	234.08	99.60	235.02	-4.85	9.26	83.71	93.85		
1984	78.48	-0.11	235.48	103.88	226.67	-3.55	10.86	84.94	92.40		
1985	79.25	0.99	228.63	107.57	212.54	-6.23	13.56	87.01	91.09		
1986	78.90	-0.45	226.78	109.61	206.90	-2.66	14.64	87.83	89.82		
1987	73.91	-6.33	238.38	113.63	209.80	1.40	14.08	87.41	84.55		
1988	72.71	-1.62	250.34	118.26	211.69	0.90	13.72	87.13	83.44		
1989	69.03	-5.06	265.66	123.97	214.30	1.23	13.22	86.75	79.57		
1990	67.77	-1.82	281.02	130.66	215.08	0.36	13.07	86.64	78.23		
1991	66.81	-1.43	288.33	136.19	211.71	-1.57	13.72	87.13	76.68		
1992	66.49	-0.47	284.61	140.32	202.83	-4.19	15.42	88.43	75.19		
1993	65.10	-2.09	293.44	144.46	203.13	0.15	15.36	88.39	73.66		
1994	67.00	2.92	282.88	148.23	190.84	-6.05	17.71	90.19	74.30		
1995	67.46	0.67	284.33	152.38	186.59	-2.23	18.52	90.81	74.28		
1996	68.18	1.08	280.23	156.85	178.66	-4.25	20.04	91.97	74.13		
1997	66.88	-1.91	279.53	160.52	174.15	-2.53	20.90	92.63	72.20		
1998	68.07	1.77	277.12	163.01	170.00	-2.38	21.69	93.24	73.00		
1999	69.08	1.49	287.77	166.58	172.76	1.62	21.17	92.84	74.41		
2000	67.76	-1.91	306.42	172.20	177.94	3.00	20.18	92.08	73.59		100.00
2001	66.31	-2.15	337.73	177.07	190.73	7.19	17.73	90.20	73.51		101.82
2002	67.73	2.15	331.54	179.88	184.32	-3.36	18.96	91.14	74.31		101.93
2003	64.99	-4.05	374.62	184.01	203.59	10.45	15.27	88.32	73.58		104.03
2004	66.19	1.85	406.53	188.88	215.23	5.72	13.05	86.61	76.42		110.20
2005	65.59	-0.90	409.09	195.29	209.47	-2.67	14.15	87.46	75.00		107.08
2006	65.87	0.42	397.02	201.59	196.94	-5.98	16.54	89.29	73.77		103.18
2007	65.23	-0.98	415.84	207.34	200.56	1.83	15.85	88.76	73.48		103.38
2008	62.45	-4.25	432.45	215.30	200.86	0.15	15.79	88.72	70.39		99.08
2009	61.10	-2.16	425.97	214.54	198.55	-1.15	16.23	89.06	68.61		96.21
2010	59.58	-2.49	439.44	218.06	201.53	1.50	15.67	88.62	67.23		94.73
2011	57.31	-3.81	482.72	224.94	214.60	6.49	13.17	86.71	66.10		95.21
2012	55.42	-3.30	502.28	229.59	218.77	1.94	12.37	86.10	64.37		93.41

Figure 1

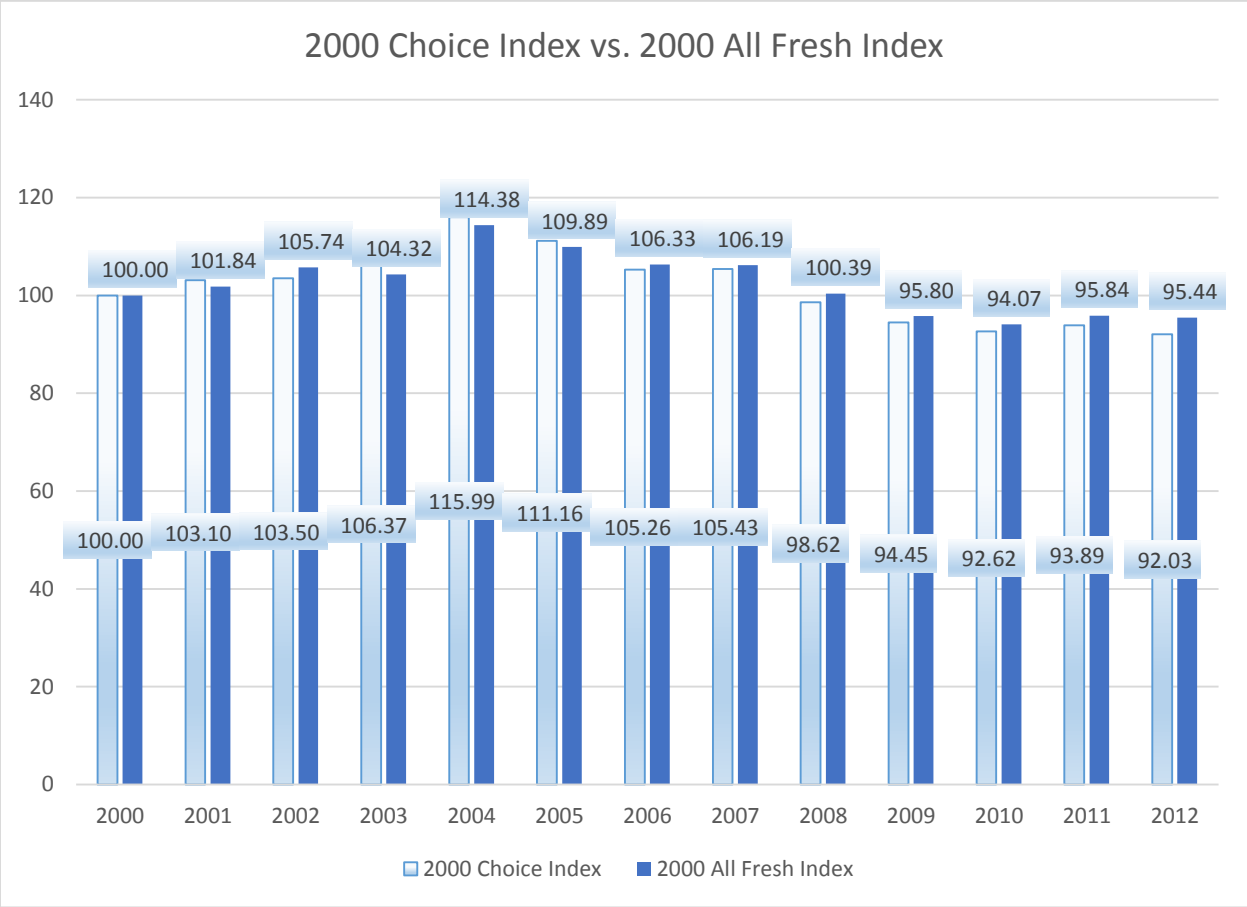
2000 Choice Index vs. 2000 All Fresh Index
140
120
100
80
60
40
20
0
100.00
101.84
105.74
104.32
114.38
109.89
106.33
106.19
100.39
95.80
94.07
95.84
95.44
100.00
103.10
103.50
106.37
115.99
111.16
105.26
105.43
98.62
94.45
92.62
93.89
92.03
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2000 Choice Index
2000 All Fresh Index

Figure 2

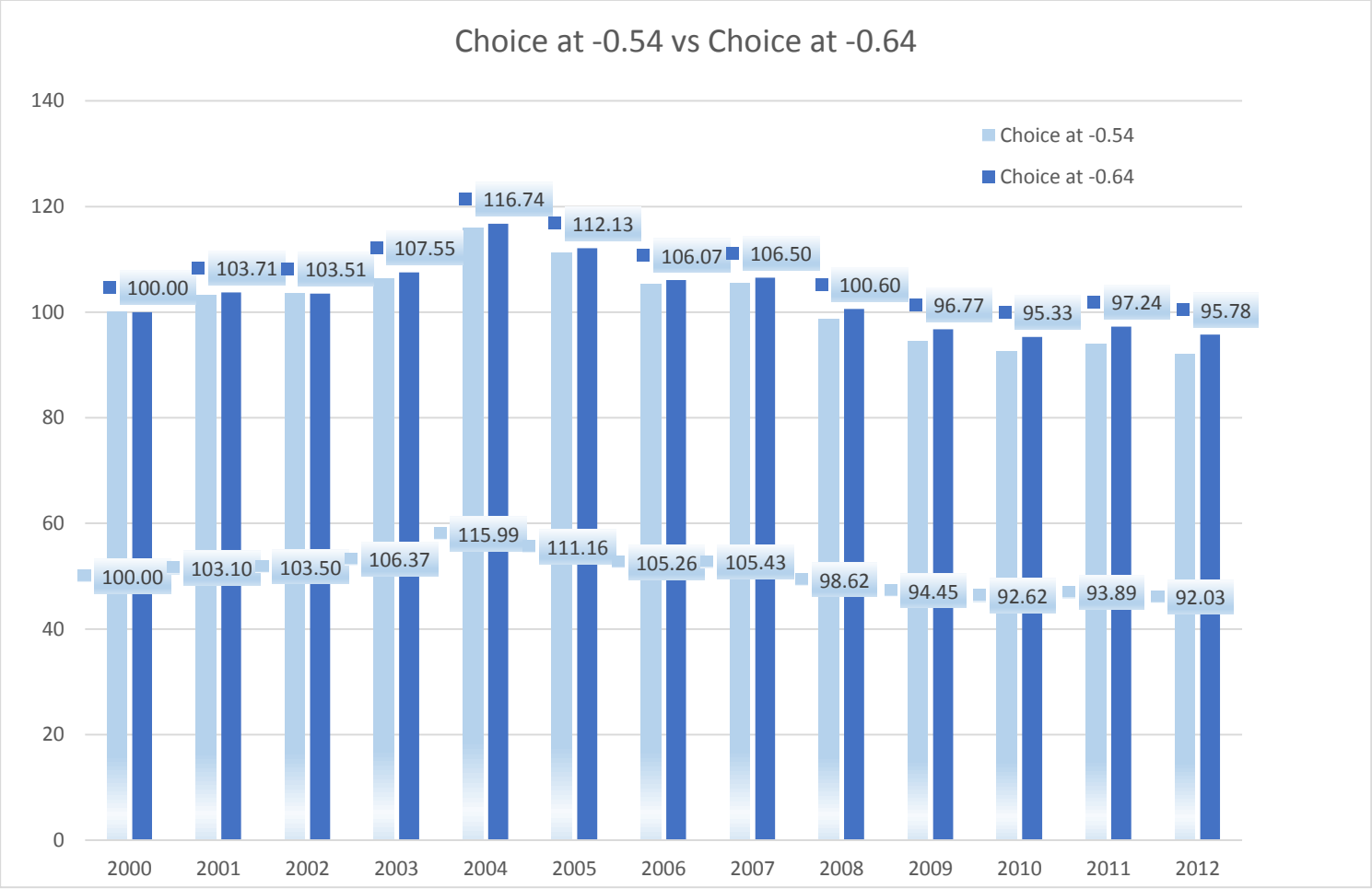
Choice at -0.54 vs Choice at -0.64
140
120
100
80
60
40
20
0
Choice at -0.54
Choice at -0.64
100.00
103.71
103.51
107.55
116.74
112.13
106.07
106.50
100.60
96.77
95.33
97.24
95.78
100.00
103.10
103.50
106.37
115.99
111.16
105.26
105.43
98.62
94.45
92.62
93.89
92.03
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Figure 3

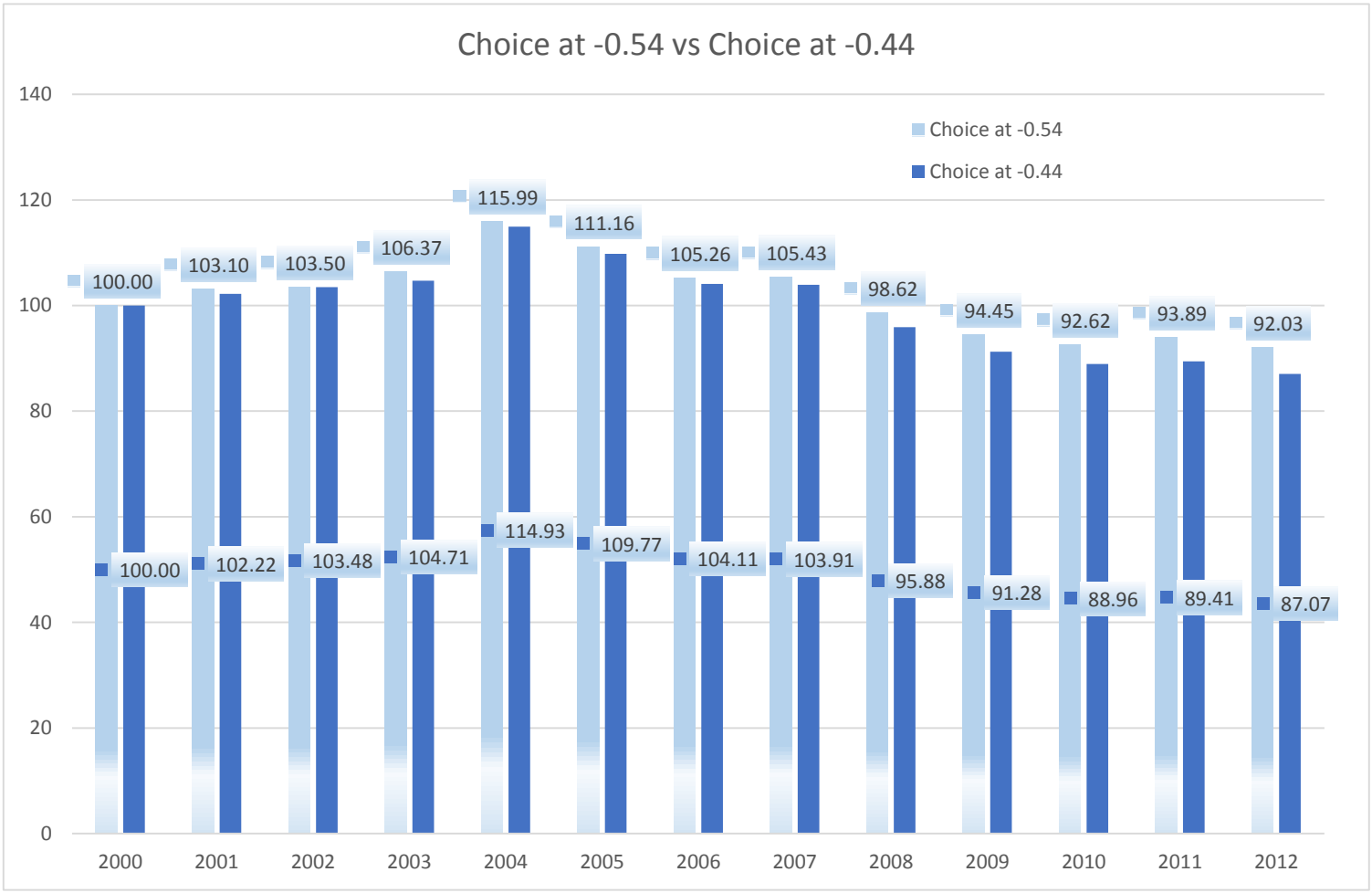
Choice at -0.54 vs Choice at -0.44
Choice at -0.54
Choice at -0.44
140
120
100
80
60
40
20
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
100.00
103.10
103.50
106.37
115.99
111.16
105.26
105.43
98.62
94.45
92.62
93.89
92.03
100.00
102.22
103.48
104.71
114.93
109.77
104.11
103.91
95.88
91.28
88.96
89.41
87.07

Figure 4

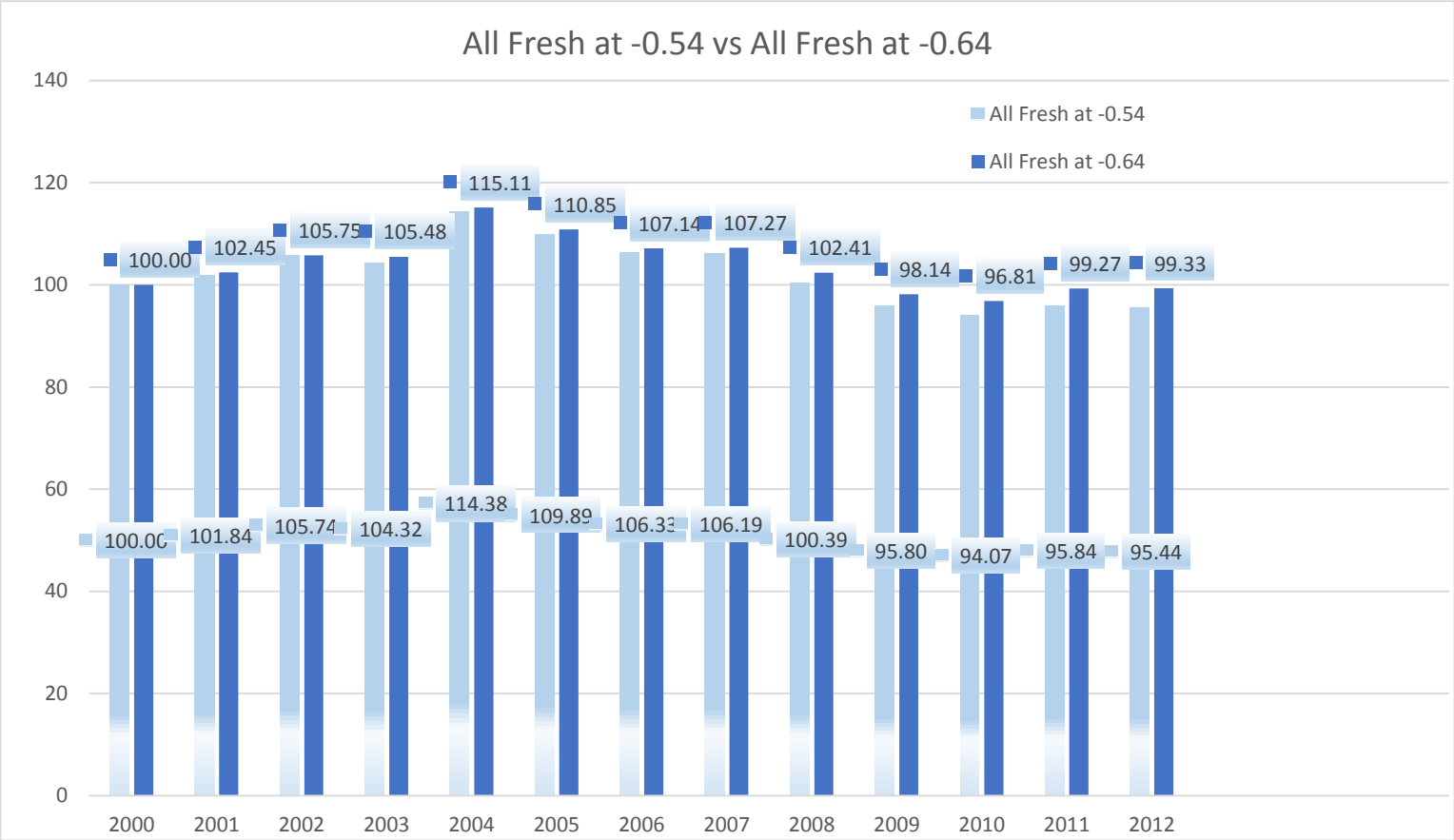
All Fresh at -0.54 vs All Fresh at -0.64
All Fresh at -0.54
All Fresh at -0.64
140
120
100
80
60
40
20
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
100.00
102.45
105.75
105.48
115.11
110.85
107.14
107.27
102.41
98.14
96.81
99.27
99.33
100.00
101.84
105.74
104.32
114.38
109.89
106.33
106.19
100.39
95.80
94.07
95.84
95.44

Figure 5

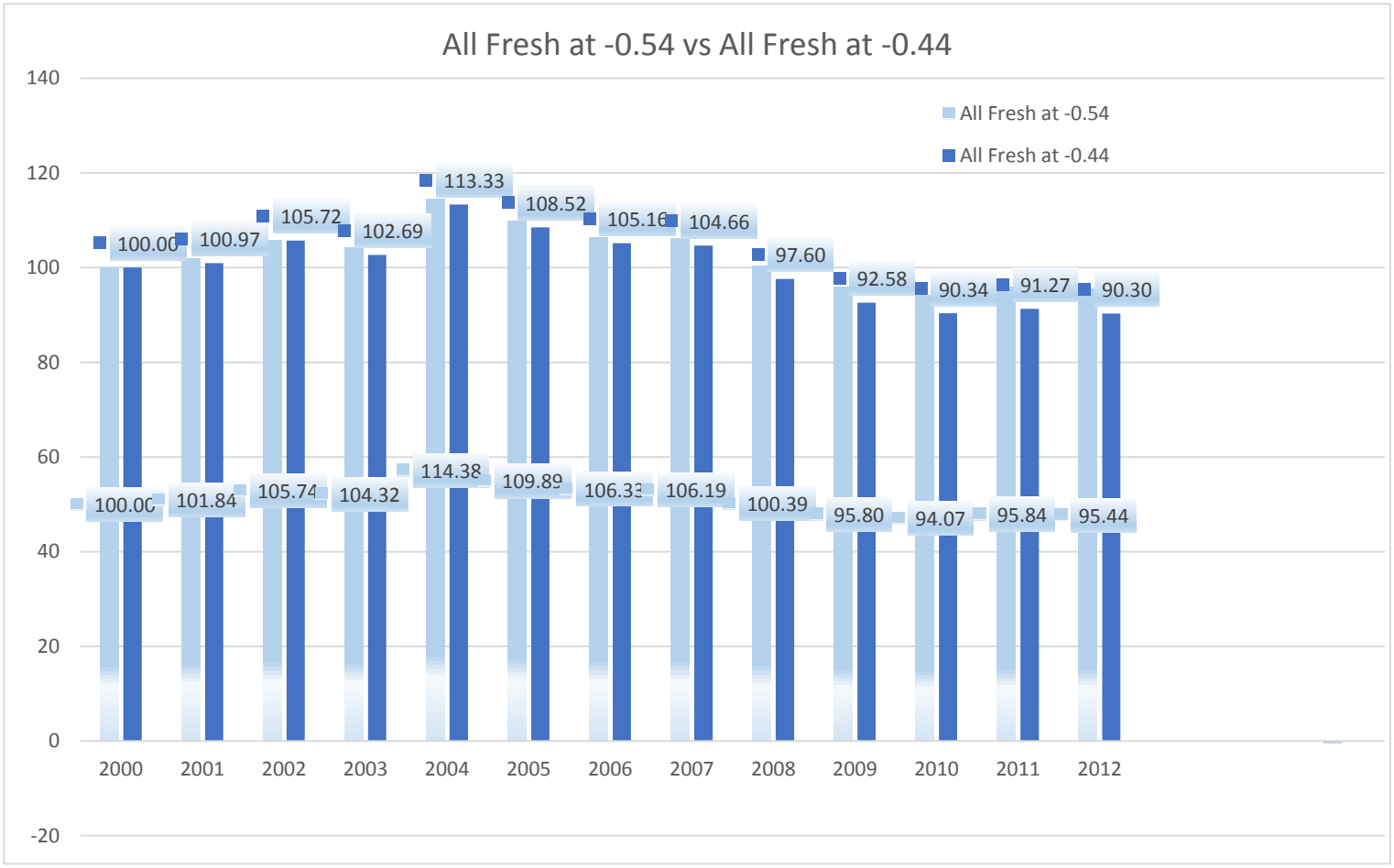
All Fresh at -0.54 vs All Fresh at -0.44
All Fresh at -0.54
All Fresh at -0.44
140
120
100
80
60
40
20
0
-20
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
100.00
100.97
105.72
102.69
113.33
108.52
105.16
104.66
97.60
92.58
90.34
91.27
90.30
100.00
101.84
105.74
104.32
114.38
109.89
106.33
106.19
100.39
95.80
94.07
95.84
95.44

Figure 6

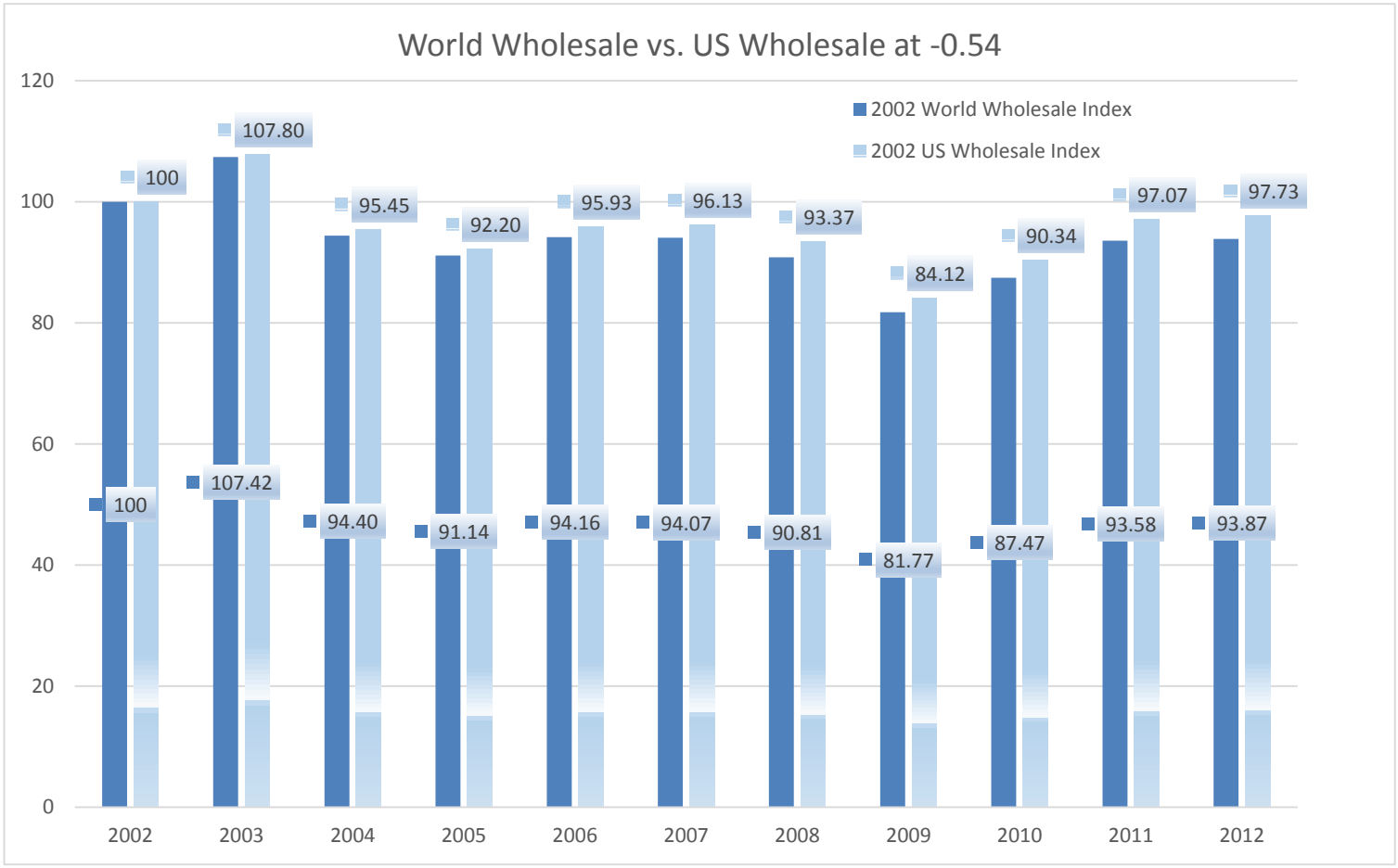
World Wholesale vs. US Wholesale at -0.54
2002 World Wholesale Index
2002 US Wholesale Index
120
100
80
60
40
20
0
100
107.80
95.45
92.20
95.93
96.13
93.37
84.12
90.34
97.07
97.73
100
107.42
94.40
91.14
94.16
94.07
90.81
81.77
87.47
93.58
93.87
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Figure 7

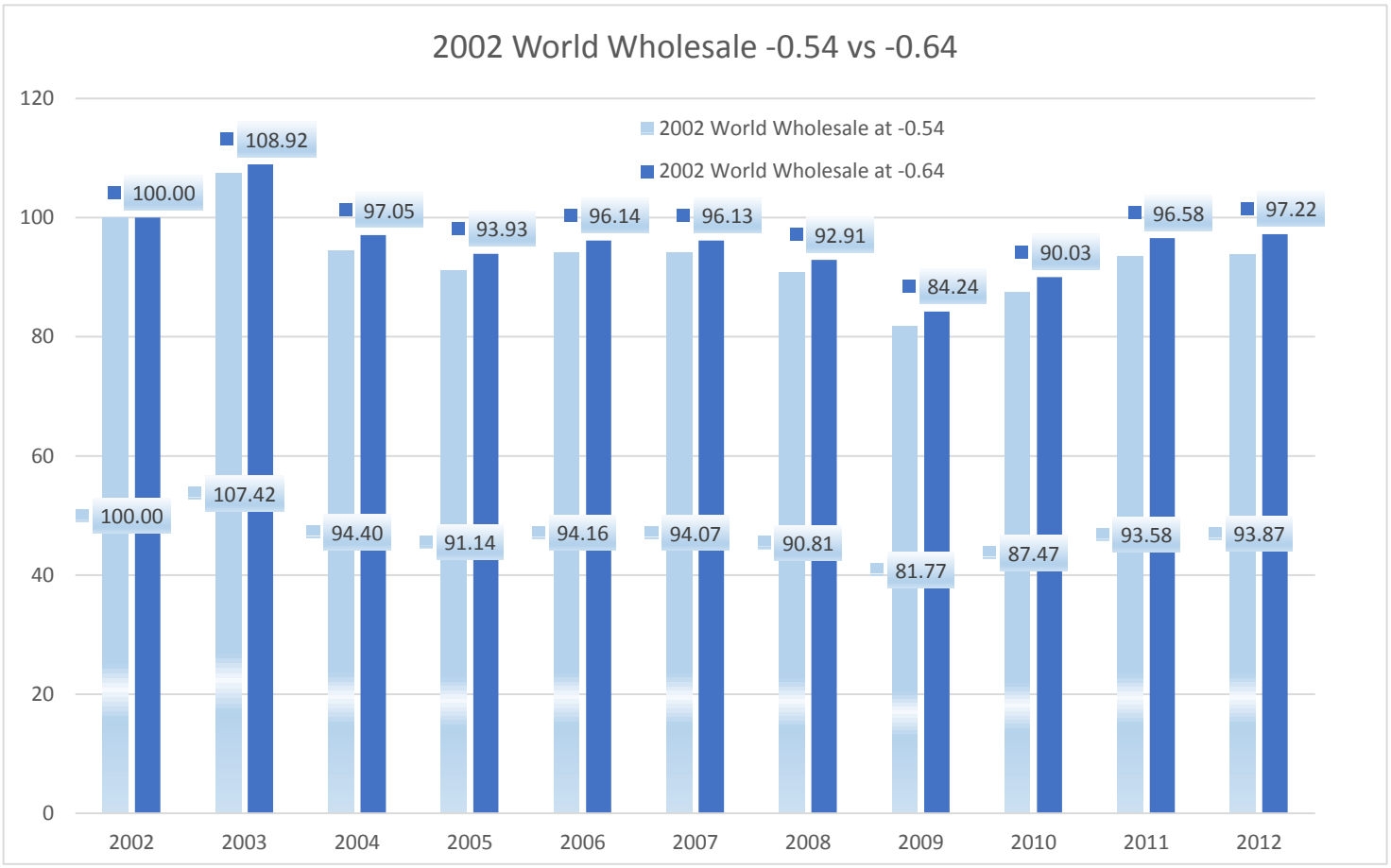
2002 World Wholesale -0.54 vs -0.64
2002 World Wholesale at -0.54
2002 World Wholesale at -0.64
120
100
80
60
40
20
0
100.00
108.92
97.05
93.93
96.14
96.13
92.91
84.24
90.03
96.58
97.22
100.00
107.42
94.40
91.14
94.16
94.07
90.81
81.77
87.47
93.58
93.87
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Figure 8

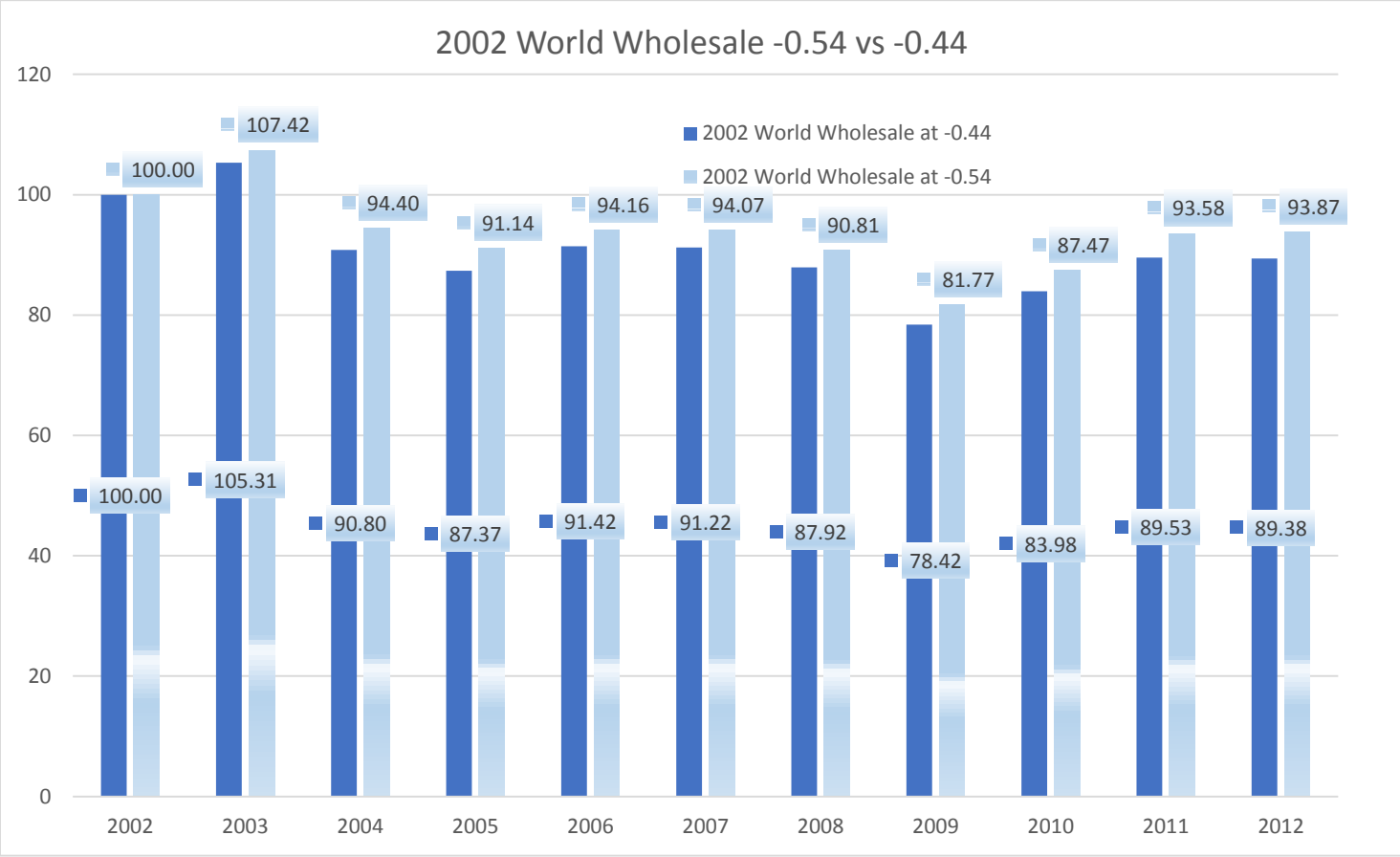
2002 World Wholesale -0.54 vs -0.44
2002 World Wholesale at -0.44
2002 World Wholesale at -0.54
120
100
80
60
40
20
0
100.00
107.42
94.40
91.14
94.16
94.07
90.81
81.77
87.47
93.58
93.87
100.00
105.31
90.80
87.37
91.42
91.22
87.92
78.42
83.98
89.53
89.38
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Figure 9

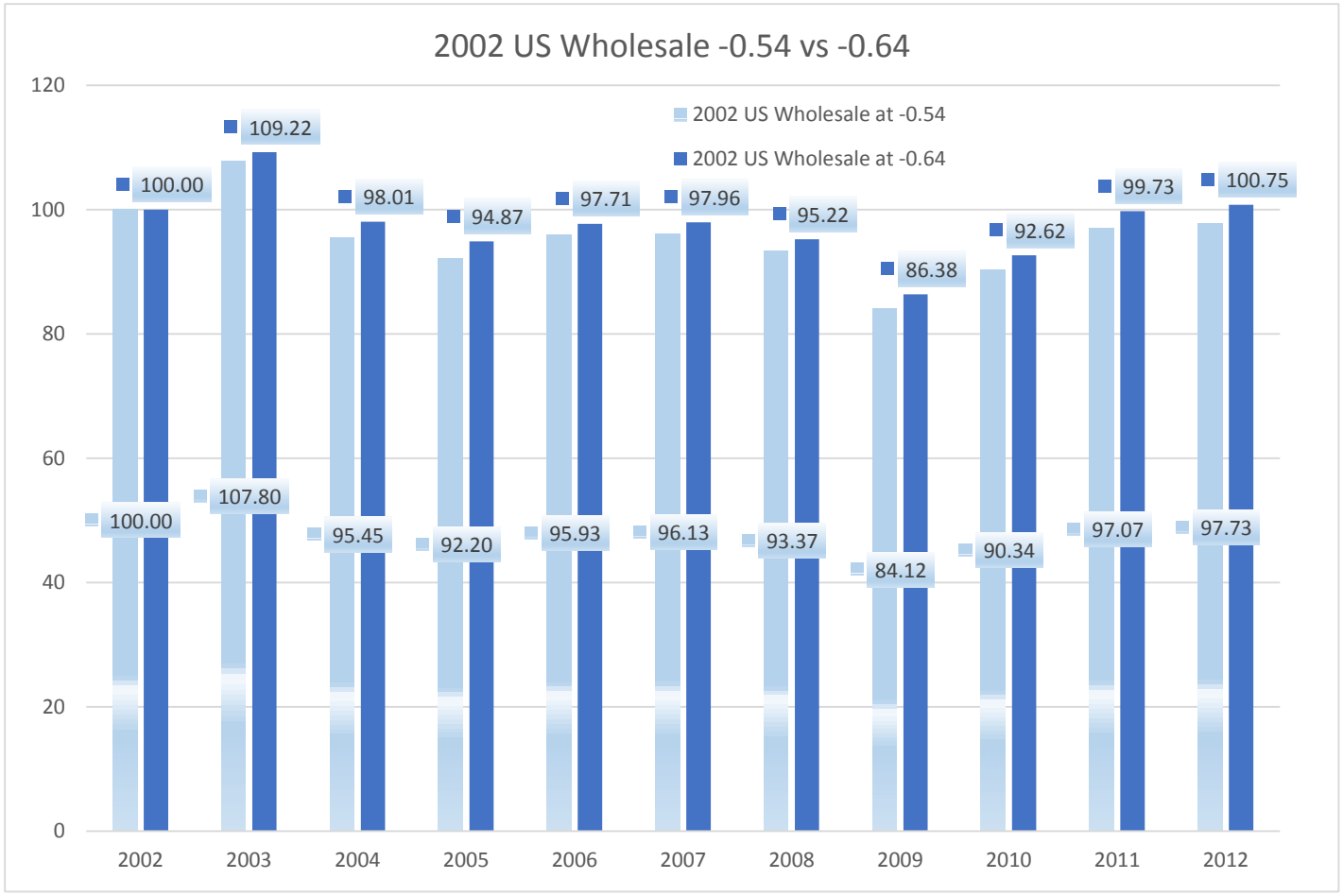
2002 US Wholesale -0.54 vs -0.64
2002 US Wholesale at -0.54
2002 US Wholesale at -0.64
120
100
80
60
40
20
0
100.00
109.22
98.01
94.87
97.71
97.96
95.22
86.38
92.62
99.73
100.75
100.00
107.80
95.45
92.20
95.93
96.13
93.37
84.12
90.34
97.07
97.73
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Figure 10

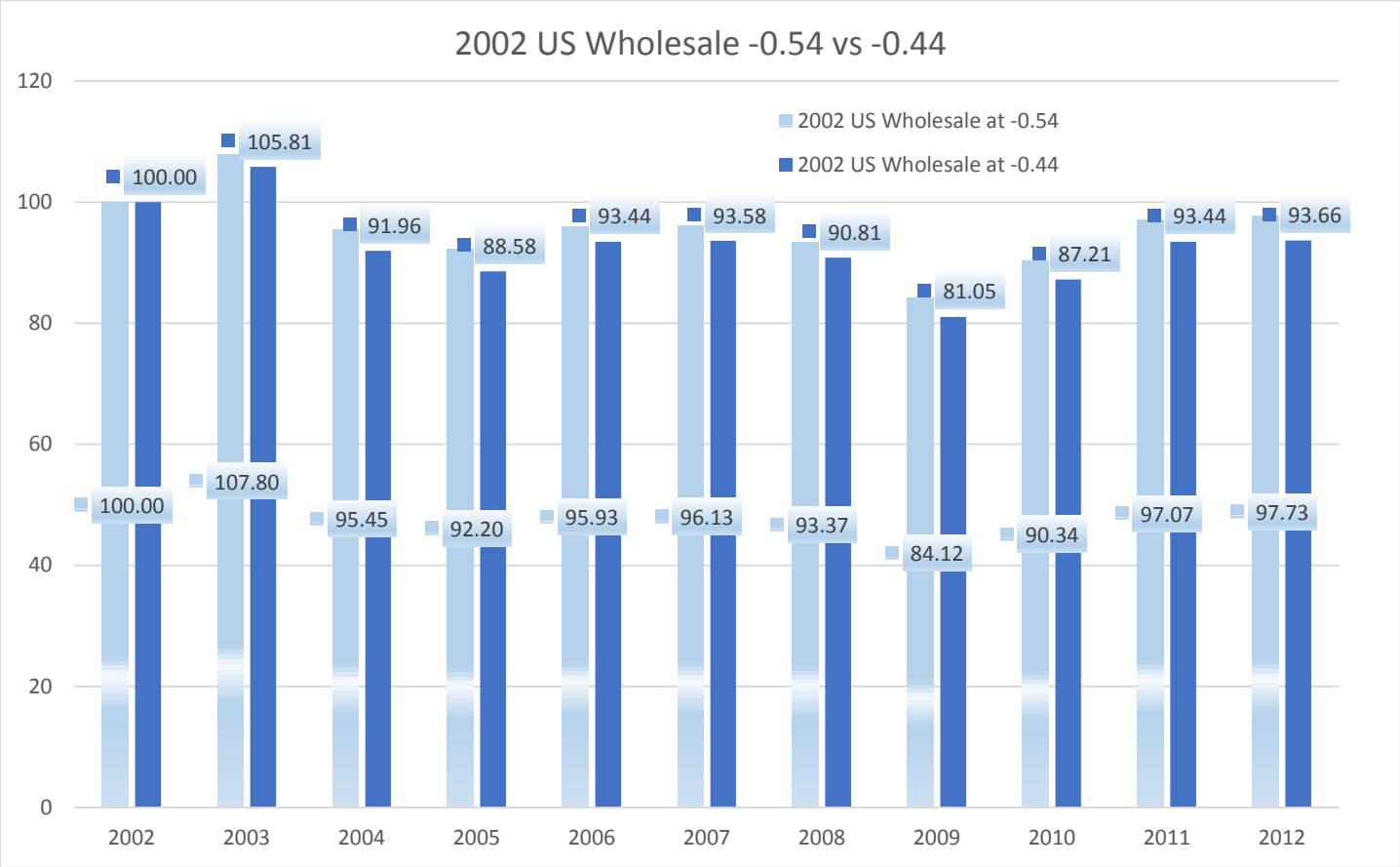
2002 US Wholesale -0.54 vs -0.44
2002 US Wholesale at -0.54
2002 US Wholesale at -0.44
120
100
80
60
40
20
0
100.00
105.81
91.96
88.58
93.44
93.58
90.81
81.05
87.21
93.44
93.66
100.00
107.80
95.45
92.20
95.93
96.13
93.37
84.12
90.34
97.07
97.73
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Figure 11

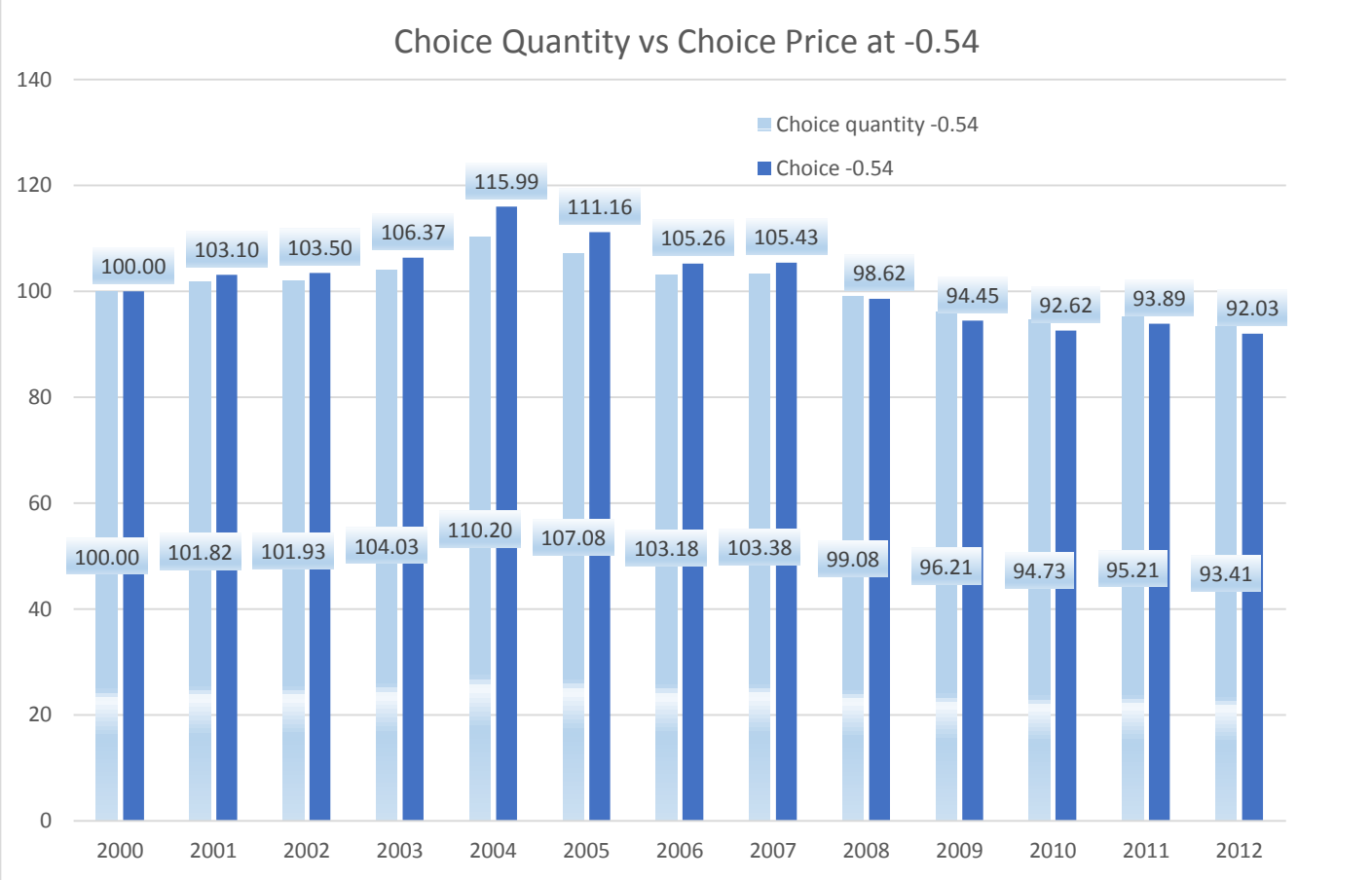
Choice Quantity vs Choice Price at -0.54
Choice quantity -0.54
Choice -0.54
140
120
100
80
60
40
20
0
100.00
103.10
103.50
106.37
115.99
111.16
105.26
105.43
98.62
94.45
92.62
93.89
92.03
100.00
101.82
101.93
104.03
110.20
107.08
103.18
103.38
99.08
96.21
94.73
95.21
93.41
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Figure 12

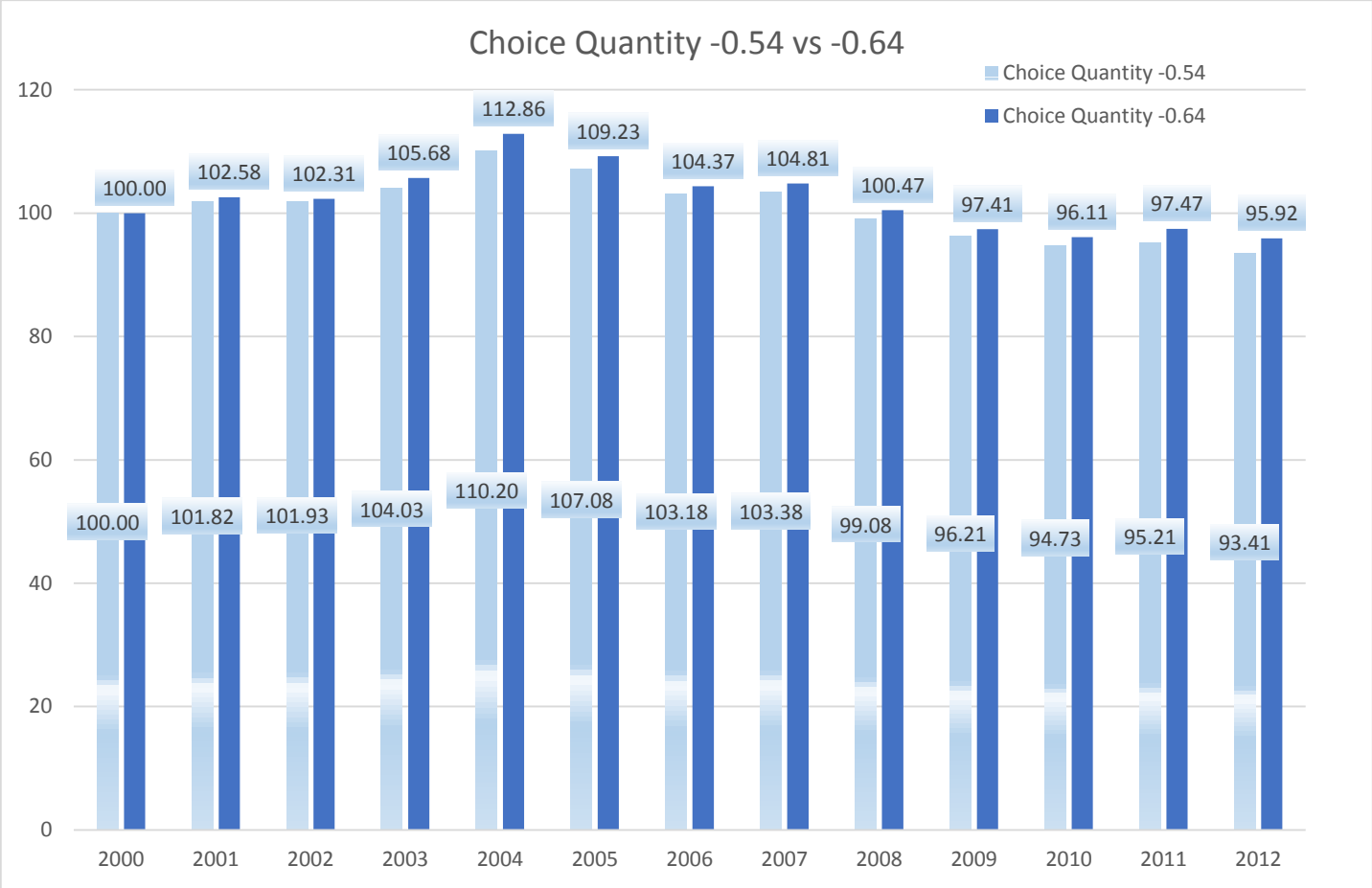
Choice Quantity -0.54 vs -0.64
Choice Quantity -0.54
Choice Quantity -0.64
120
100
80
60
40
20
0
100.00
102.58
102.31
105.68
112.86
109.23
104.37
104.81
100.47
97.41
96.11
97.47
95.92
100.00
101.82
101.93
104.03
110.20
107.08
103.18
103.38
99.08
96.21
94.73
95.21
93.41
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Figure 13

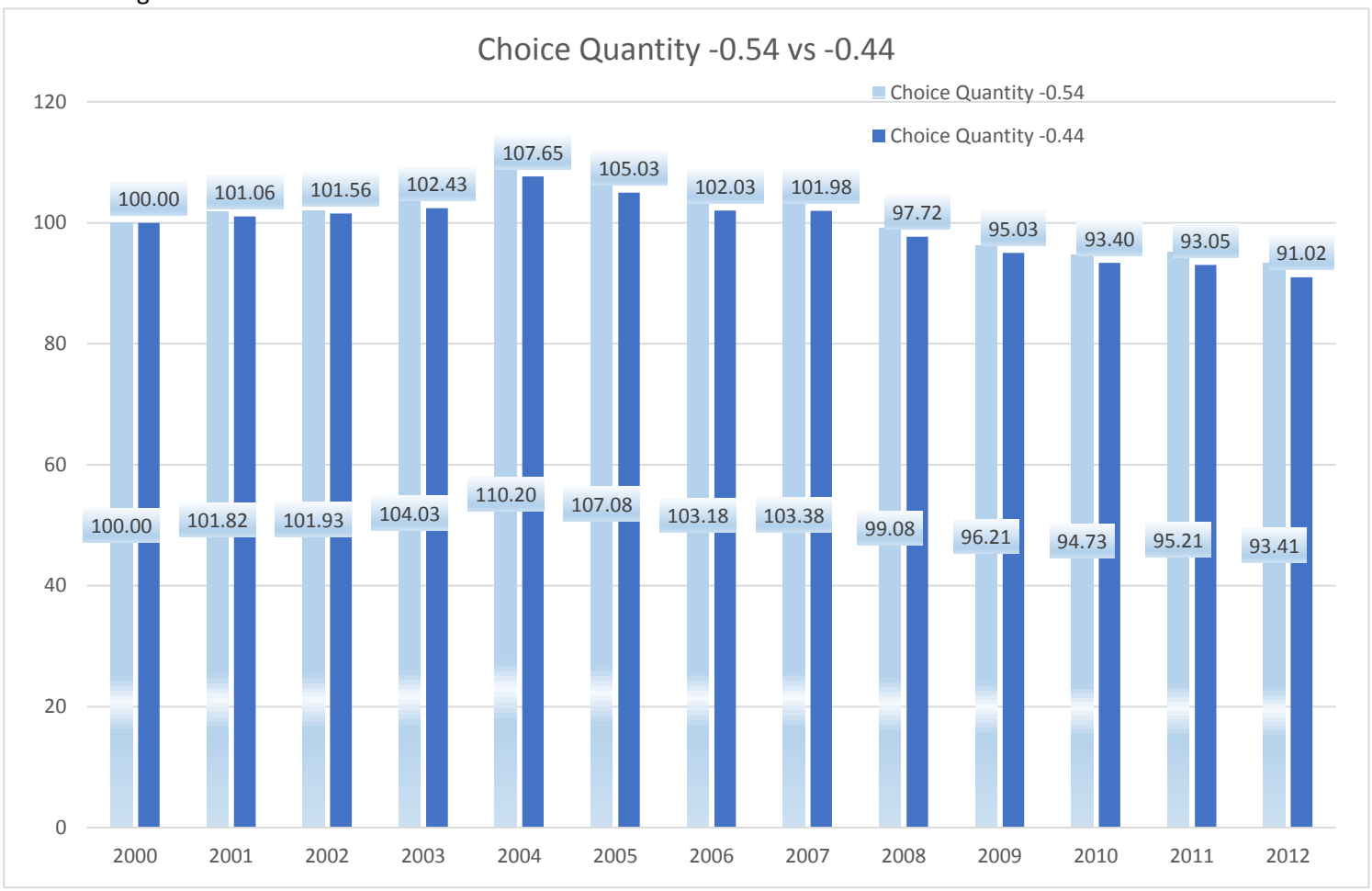
Choice Quantity -0.54 vs -0.44
Choice Quantity -0.54
Choice Quantity -0.44
120
100
80
60
40
20
0
100.00
101.06
101.56
102.43
107.65
105.03
102.03
101.98
97.72
95.03
93.40
93.05
91.02
100.00
101.82
101.93
104.03
110.20
107.08
103.18
103.38
99.08
96.21
94.73
95.21
93.41
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Figure 14

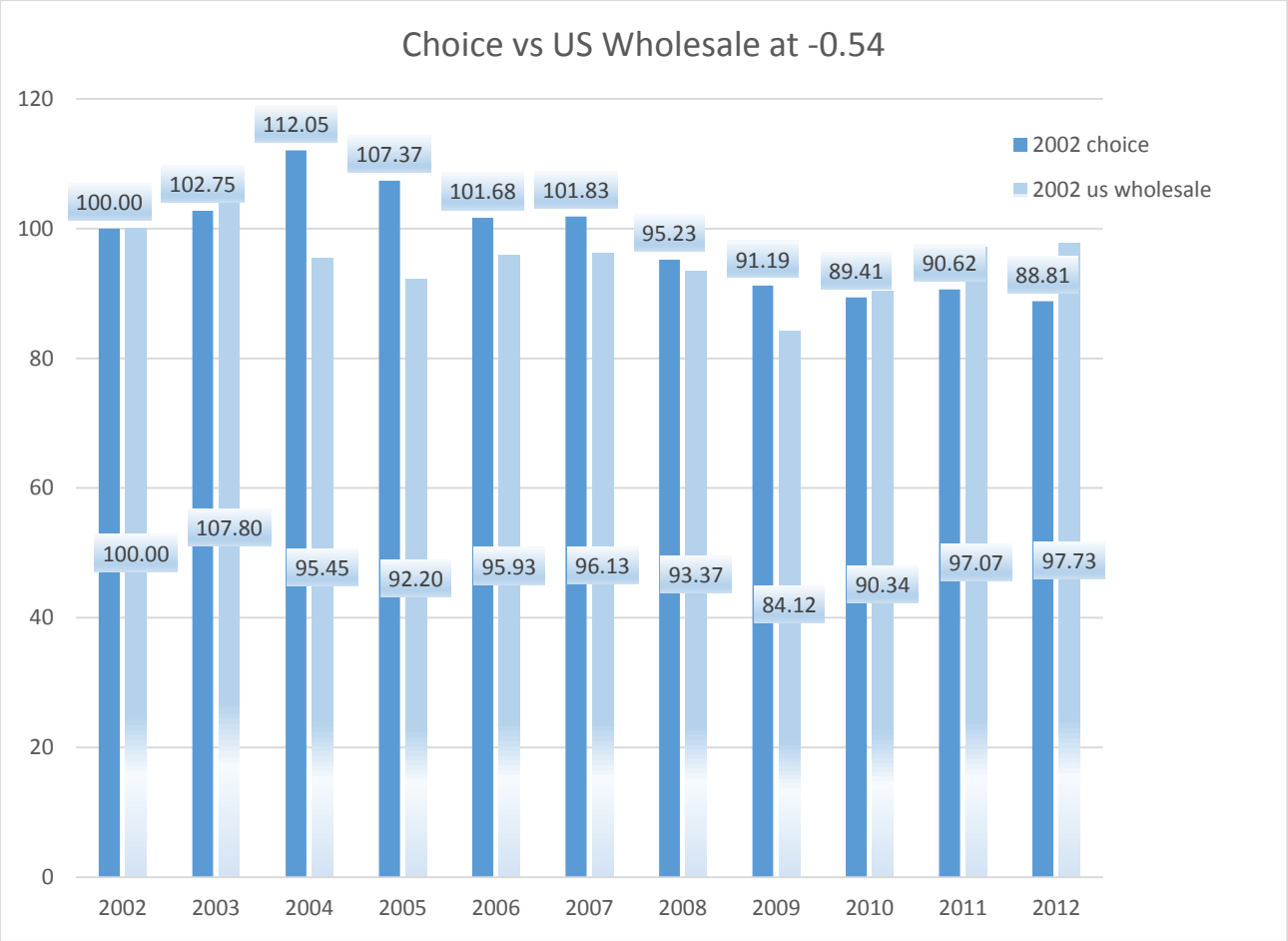
Choice vs US Wholesale at -0.54
120
100
80
60
40
20
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2002 choice
2002 us wholesale
100.00
102.75
112.05
107.37
101.68
101.83
95.23
91.19
89.41
90.62
88.81
100.00
107.80
95.45
92.20
95.93
96.13
93.37
84.12
90.34
97.07
97.73

Figure 15


Choice vs World Wholesale at -0.54
120
100
80
60
40
20
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
100.00
102.75
112.05
107.37
101.68
101.83
95.23
91.19
89.41
90.62
88.81
100.00
107.42
94.40
91.14
94.16
94.07
90.81
81.77
87.47
93.58
93.87
2002 choice
world wholesale