Assessing Beef Demand Determinants

Prepared for the Cattlemen's Beef Board

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I. Executive Summary

This project's objective was to provide a multi-faceted assessment of factors impacting domestic beef demand. The project provides a multitude of insights using diverse data sets and information sources that vary across time periods, levels of product aggregation, and socio-economic factors considered. The use of multiple methods reflects realities of the diverse set of demand information sources and complexities around beef demand assessment.

Several key findings are of elevated importance:

1. Over the past decade, the quantity of beef consumers purchase has become less sensitive to changes in beef prices yet more sensitive to consumer incomes. This could be a result of record high retail beef prices in recent years that resulted in loyal beef consumers, who are less price sensitive, having the strongest presence in the market. As consumer incomes have grown, more consumers who might have been priced out of the beef market, have allocated some of that income growth to purchase beef again thus increasing beef demand response to growing income.

2. The relative impact of pork and chicken prices on beef demand is economically small relative to other factors. This does not imply individual beef, pork, and chicken products are not substitutes, rather the substitutability in aggregate is just not as strong as traditionally thought.

3. Print media and medical journal coverage of topics around beef changes notably over time in areas of focus and volume of coverage. Certain types of media coverage are found to affect meat demand, and an emerging area of negative impact focuses on climate change. Having an impactful presence in the media is immensely important as it shapes perceptions.

4. Some demographic trends are favorable for beef demand including anticipated growth of Hispanic and African-American populations within the U.S.

The main recommendations we offer from this study are:

1. We recommend ongoing focus on beef quality aspects such as taste, appearance, convenience, and freshness. These innate product quality attributes were identified as top priorities in past beef demand studies and they remain key for sustaining and growing beef demand. This reflects declining price sensitivity, increasing impact of consumer incomes, and broader recognition of U.S. beef's comparative advantages to other proteins both domestically and abroad. Going further, persistent importance of these foundational beef quality traits should be noted to avoid over-reacting to "hot topics of the day" in a manner which is counterproductive to building upon these more traditional, yet essential beef quality attribute perceptions held by consumers.

2. External coverage of "hot topics" is likely to continue to be dynamic for the beef industry. We recommend systematic re-assessment of which topics are changing the most with a focus on topics having the largest net impact on beef demand. Factors that drive long term perceptions are likely to be most impactful over time including food safety, nutritional content and healthiness (e.g., fat type and content), and overall quality of the eating experience. Loyal beef consumers have been immensely important in maintaining beef demand and any efforts to build new consumer demand or respond to "hot topics" are advised to not adversely impact loyal beef consumer interests or beef eating experiences.

3. We recommend increasingly collaborative approaches to the U.S. pork and chicken industries. Given limited cross-price sensitivity and a host of common challenges and opportunities a more cohesive approach may better utilize the industry's limited demand enhancing and monitoring resources. This is further true given recent increases in competition from plant-based protein sources.

4. We recommend additional targeting of beef product development, messaging, and marketing to consumers with particular attention to race, income, age, political ideology, and product type considerations.

5. We recommend systematic evaluation of information sources available to gain beef demand insight. An example in this study was extending demand insights offered by the Consumer Beef Index survey. More broadly, multiple data sources and methods were used to gain a more complete understanding of beef demand determinants. Combined, as related opportunities arise we encourage elevated focus on leveraging existing industry investments to regularly assess beef demand.

II. Objectives, Process, and Report Overview

Market developments in 2017 highlight the critical role of beef demand in the U.S. beef-cattle industry. In short, both beef supplies and cattle prices increased in 2017 relative to 2016 – an outcome only possible with demand growth. A perpetual industry priority is to better understand and monitor beef demand, and to inform stakeholders because demand directly influences overall industry success. Accordingly, this project's overriding objective was to provide a multi-faceted assessment of factors impacting domestic beef demand.

The process followed in this project can be summarized in five main steps:

1. First, we gained initial demand determinant insights from targeted preliminary assessments. This included leveraging the Oklahoma State University based FooDS consumer survey, partnering with NCBA, a contractor to the beef checkoff, in extending the Consumer Beef Index survey, and evaluating social statements on web pages for major retailers and food service establishments.
2. At the 2017 Cattle Industry Summer Business meeting in Denver, CO the CBB Evaluation Committee was presented a summary of these preliminary assessments and invited to provide feedback guiding the remainder of the project.
3. We proceeded forward given the interim feedback received. This included conducting an extensive assessment of media and medical journal coverage of several topics suspected to impact beef demand. This information was used in a broader set of economic models designed to identify factors most impacting beef demand in recent years.
4. A condensed set of recommendations was generated reflecting a combination of findings from the multi-faceted assessments conducted and the authors' judgements.
5. Lastly, starting with presentations at the 2018 Cattle Industry Annual Convention in Phoenix, AZ, we will collaborate with CBB staff to widely disseminate findings and implications to industry stakeholders, so the project can have the most impact feasible.

Combined this process provides a multitude of insights into beef demand building upon diverse data sets that vary across time periods, levels of product aggregation, and socio-economic factors considered. The use of multiple methods to assess demand is intentional to maximize use of existing datasets and reflects realities of the diverse set of demand information sources.

Given the use of multiple data sets and research methods employed, the remainder of this report is organized as follows. A summary of analyses conducted using time-series data and methods are first provided to gain insights on demand determinants over a long horizon, multi-decade period. Then analyses using shorter-horizon, nationally representative survey data are summarized yielding additional insights specific to recent years. Finally, a separate summary synthesis and recommendations section is provided. An Appendix is also included containing additional details.

III. Aggregate Beef Demand Elasticities Update

To gain updated estimates of how consumers respond to changes in beef, pork, and chicken prices multiple meat demand models were estimated similar to the 2007 Beef Demand Determinants Study (Tonsor, Mintert, and Schroeder, 2010). This model includes separate equations for beef, pork, chicken, other food, and non-food goods allowing own-price, cross-price, and expenditure effects to be estimated. The model is estimated with seasonality controls but omits other possible non-price demand shifters to retain model robustness.

While the same general model framework was maintained, models were estimated separately using the USDA ERS Choice Beef and USDA ERS All-Fresh Beef prices. The All-Fresh series began in 1988 resulting in any models covering earlier periods to use the Choice series. Quarterly data from Q1.1970 to Q3.2017 was composed for use in these models. Models were estimated for different time periods to assess how elasticities in more recent years compare with those prevalent in the literature from prior decades.[1]

Table 2.1 shows main elasticity results from the models estimated.[2] To aid interpretation, consider the first row of elasticities corresponding to the 1988-2017 period and use of the All-Fresh beef price. These estimates suggest a 1% rise in beef price will decrease per capita beef consumption by 0.479%. Meanwhile, a 1% increase in pork price, chicken price, and total consumer expenditure will increase beef demand by 0.087%, 0.023%, and 0.803%, respectively.

Several key take-aways follow from table 2.1 when comparing more recent years with prior periods. First, beef demand is becoming less own-price elastic. That is, the quantity of beef consumers purchase is less sensitive to own-price changes. To appreciate this, note that a more elastic estimate of -0.645 for 1988-2007 suggests that a 10% increase in price (perhaps reflecting production cost increases) reduced the quantity of beef demanded by 6.45%. Conversely, an estimate of -0.479 for the 2008-2017 period indicates the same 10% price increase would reduce demand by 4.79%. Since beef has an inelastic demand, industry total revenue increases when prices rise as there comparatively is a limited reduction in volume purchased. Going further, a reduction in own-price sensitivity indicates, indirectly given observed demand variation, other factors have gained in their relative impact on beef demand – a critical finding which motivates other sections of this report. While not directly researched for confirmation, this may reflect success in decades of beef advertising in rotating the beef demand curve which over time makes consumers in aggregate less price sensitive (Rickard et al., 2011).

Second, beef demand is becoming more sensitive to consumer expenditures as elasticity estimates are increasing towards 1.0. This may reflect the 2008-2017 period being impacted by the Great Recession and associated recovery (leading to more variation in consumer incomes) while the earlier period of 1988-2007 did not experience equivalent magnitudes of income

[1] Pragmatically, models estimated with quarterly data cover a fairly long period of time to be estimated.
[2] Underlying model coefficients are available upon request.

variation. A key implication of this is beef demand being increasingly sensitive to macroeconomic conditions and consumer willingness to spend their earnings. In aggregate this also suggests beef (or at least some beef products like steak) is becoming more of a luxury good where consumer groups experiencing income growth are the largest sources of additional demand growth.

Third, the impact of competing proteins is shifting and compared to own-price and expenditure effects is small. Pork is becoming less of a beef substitute compared to the past. This may reflect the well-documented growth of bacon demand and parallel impacts for ground beef. Some individual beef and pork products may be complements making the net relationship for aggregated beef and pork measures being one of less substitution than in the past. Given higher meat prices in recent years, this is consistent with Lusk and Tonsor (2016) who found cross-price elasticities of disaggregated meat products shrink as prices increase. The impact of chicken prices remains low but has marginally increased. Combined, this indicates both pork and chicken prices are not economically important market determinants of beef demand.

While we believe beef demand indeed has become less elastic over time, we also highlight that underlying data quality may also be part of this empirical finding. Specifically, the aggregate meat demand models rely upon per capita disappearance (an aggregated proxy for consumption) and prices (sourced from BLS and USDA-ERS efforts) that may not fully reflect changes in prevalence in food-at-home (vs. away-from-home), retail featuring (e.g., buy-one-get-one-free sales), or product development (e.g., changes in processed product offerings) over time. This point builds upon the spread in BLS and IRI prices over the January 2011-November 2016 period noted by Tonsor and Schroeder (2017).

Combined, updated elasticity estimates - specifically the finding of beef demand being influenced less by its own-price - motivates the subsequent report sections.

Table 2.1. Aggregate Meat Demand Elasticities Summary

		Beef Demand				Pork Demand		Chicken Demand	
Period	Beef Price Used	Own-Price	Pork Cross-Price	Chicken Cross-Price	Exp.	Own-Price	Exp.	Own-Price	Exp.
1988-2017	All-Fresh	-0.479	0.087	0.023	0.803	-0.307	0.141	-0.339	0.425
1988-2007	All-Fresh	-0.645	0.145	0.026	0.790	-0.229	-0.262	-0.345	0.371
2008-2017	All-Fresh	-0.450	-0.032	0.083	0.959	-0.089	1.231	-0.378	0.856
1970-2017	Choice	-0.593	0.120	0.041	0.118	-0.973	-0.170	-0.133	0.218
1988-2017	Choice	-0.490	0.085	0.021	0.781	-0.313	0.146	-0.345	0.430
1970-1994	Choice	-0.594	0.138	0.039	0.118	-0.924	-0.004	-0.159	0.003
1995-2017	Choice	-0.468	0.049	-0.044	0.867	-0.287	0.634	-0.469	0.960

Note: “Exp.” is Expenditure abbreviated. All Rotterdam models were estimated using iterative three-stage least squares.

IV. Media and Medical Information Effects

Given the multitude of topics outside of price and consumer income effects that may impact beef demand, and the CBB Evaluation Committee's feedback provided in the July 2017 Summer Business meeting, media and medical journal coverage on several subjects for the Jan. 1980 – Nov. 2017 period was gathered. The purposes of this analyses were to 1) document the magnitude of changes occurring in information consumers are being exposed to over time and 2) to assess how this information is impacting beef demand. Specifically, keyword based searches of Lexis-Nexis and Medline databases were conducted following the process used by Tonsor, Mintert, and Schroeder (2010). Table 3.1 outlines the specific key words and associated database used in generating 12 "counts" used in this analysis.

Table 3.1. Definition of Media and Medical Information Counts

Abbreviated Name	Expanded Name	Keywords	Database
Animal Welfare	*Animal Welfare, Well-Being, Care*	*((animal welfare) or (animal well-being) or (animal friendly) or (animal care) or (animal handling) or (animal transportation))*	*Lexis-Nexis*
Atkins	*Atkins, High Protein, Low Carbohydrate*	*(Atkins or high protein or low carbohydrate)*	*Lexis-Nexis*
Cancer	*Cancer*	*(cancer)*	*Lexis-Nexis*
Climate	*Climate, Environment*	*(climate change or greenhouse gas or global warming or water or environment)*	*Lexis-Nexis*
Convenience	*Convenience*	*(preparation or prepare or cook or bake or grill) and (ease or easy or short or quick or fast)*	*Lexis-Nexis*
Fat	*Fat*	*(fat)*	*Medline*
FCHA	*Fat, Cholesterol, Heart Disease, Arteriosclerosis*	*(fat or cholesterol) and (heart disease or arteriosclerosis)*	*Medline*
Safety	*Safety*	*(safety or recall)*	*Lexis-Nexis*
Sustain	*Sustainability*	*(sustainable or sustainability or sustain)*	*Lexis-Nexis*
TTF	*Taste, Tender, Flavor*	*(taste or tasty or tender or juicy or flavor or savor)*	*Lexis-Nexis*
Vegan	*Vegan, Vegetarian, Meatless*	*(vegan or vegetarian or meatless)*	*Lexis-Nexis*
ZIP	*Zinc, Iron, Protein*	*(zinc or iron or protein)*	*Medline*

Note: Each search was conducted with keywords also including "and (beef or cattle)" to derive measures specific to the beef-cattle industry.

Table 3.2 includes summary statistics for the full 1980-2017 period as well as two more recent periods (1990-2007 and 2008-2017) of elevated interest for comparison. Additional statistics on variability are included for the more recent periods. Figures 3.1, 3.2, and 3.3 shows trends of information flow visually for the same periods.

Several topics tracked by the counts are relatively new and were largely not discussed prior to 2000. In particular, beef and *Climate*; *Taste, Tender, and Flavor*; *Safety*; and preparation *Convenience* all became much more prevalent media information consumers are exposed to in recent years. As such, the impacts of certain information factors besides prices and consumer incomes have changed motivating analyses for different time periods. The *FCHA* count has a persistent, low volume and hence not further used.

Focusing on the 2008-2017 period, the counts exhibiting the most variation in volume in order of coefficients of variation, are *Atkins*, *Animal Welfare*, *Sustain*, *Safety*, and *Cancer*. If average 5-month percentage changes are alternatively used, this order changes to *Atkins*, *Animal Welfare*, *Sustain*, *Safety*, and *Fat* suggesting both measures of variation provide a similar indication of which information counts have experienced the most change within the 2008-2017 period.

Table 3.2. Summary Statistics of Monthly Media and Medical Information Counts

	Jan. 1980 to Nov. 2017					Jan. 1990 to Dec. 2007									Jan. 2008 to Nov. 2017								
Abbreviated Name	Mean	25th Percentile	Median	75th Percentile	COV	Mean	25th Percentile	Median	75th Percentile	Inner Quartile Range	Maximum	Max Month	COV	Average 5-Month % Change	Mean	25th Percentile	Median	75th Percentile	Inner Quartile Range	Maximum	Max Month	COV	Average 5-Month % Change
Animal Welfare	24.0	0.0	2.0	47.5	1.50	11.19	1.0	2	8.0	7.0	113	4/2007	1.82	29.24	71.05	52.5	68	81.0	28.5	331	2/2008	0.47	15.09
Atkins	4.8	0.0	1.0	9.0	1.40	3.56	0.0	1	3.3	3.3	26	1/2007	1.68	21.30	11.73	8.0	10	14.5	6.5	44	1/2016	0.52	28.46
Cancer	33.8	1.0	4.0	75.0	1.33	19.04	2.0	4	13.3	11.3	141	10/2007	1.72	34.97	94.00	77.0	93	104.0	27.0	264	3/2010	0.28	3.24
Climate	213.7	9.0	25.0	508.0	1.28	112.55	15.0	25.5	81.5	66.5	732	8/2007	1.62	20.88	606.38	525.5	587	695.5	170.0	873	3/2015	0.18	2.13
Convenience	75.0	3.0	7.0	182.0	1.28	41.97	4.0	7	36.0	32.0	281	1/2007	1.67	34.83	208.45	183.5	205	229.5	46.0	289	3/2015	0.15	1.64
Fat	20.3	11.0	18.0	29.0	0.56	18.62	14.0	18	23.0	9.0	41	10/2007	0.33	10.58	34.88	30.0	34	39.0	9.0	56	2/2017	0.22	3.64
FCHA	0.3	0.0	0.0	1.0	1.82	0.35	0.0	0	1.0	1.0	4	7/2004	1.79	-53.44	0.35	0.0	0	1.0	1.0	2	10/2008	1.71	-69.70
Safety	111.7	3.0	12.0	250.0	1.31	64.78	6.0	12	58.5	52.5	407	1/2005	1.59	38.75	306.93	251.5	286	338.5	87.0	791	7/2014	0.30	6.08
Sustain	35.7	0.0	2.0	77.0	1.49	11.74	1.0	2	9.0	8.0	95	5/2007	1.85	16.11	114.45	84.5	104	137.5	53.0	233	8/2014	0.33	6.42
TTF	160.5	6.0	14.0	396.5	1.28	87.72	8.0	14	70.3	62.3	570	1/2007	1.63	27.10	449.77	404.5	439	485.0	80.5	858	7/2014	0.16	1.36
Vegan	35.4	0.0	3.0	83.5	1.34	16.80	1.0	3	15.0	14.0	115	5/2006	1.72	26.81	104.70	86.5	104	117.0	30.5	155	3/2015	0.19	3.17
ZIP	186.8	149.0	198.0	225.0	0.26	210.85	195.0	211	231.0	36.0	279	9/1996	0.12	1.37	207.42	190.5	216	232.0	41.5	270	10/2012	0.19	-2.14

Note: "COV" is coefficient of variation abbreviated. Presented average, 5-month % changes are calculated omitting months with no counts to mitigate the effect of extreme effects.

Figure 3.1. Beef Industry, Monthly Media and Medical Counts: Jan. 1980 – Nov. 2017

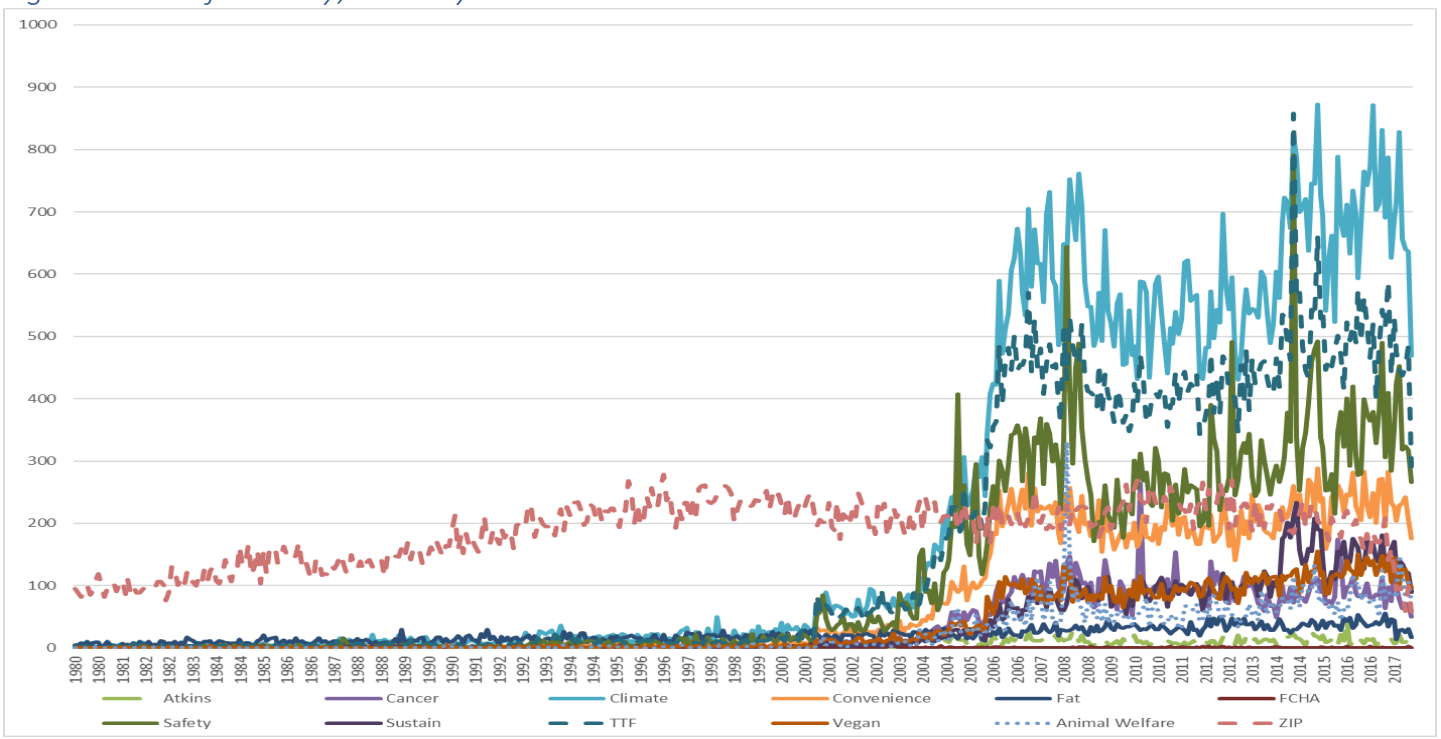


Figure 3.2. Beef Industry, Monthly Media and Medical Counts: Jan. 1990 – Dec. 2007

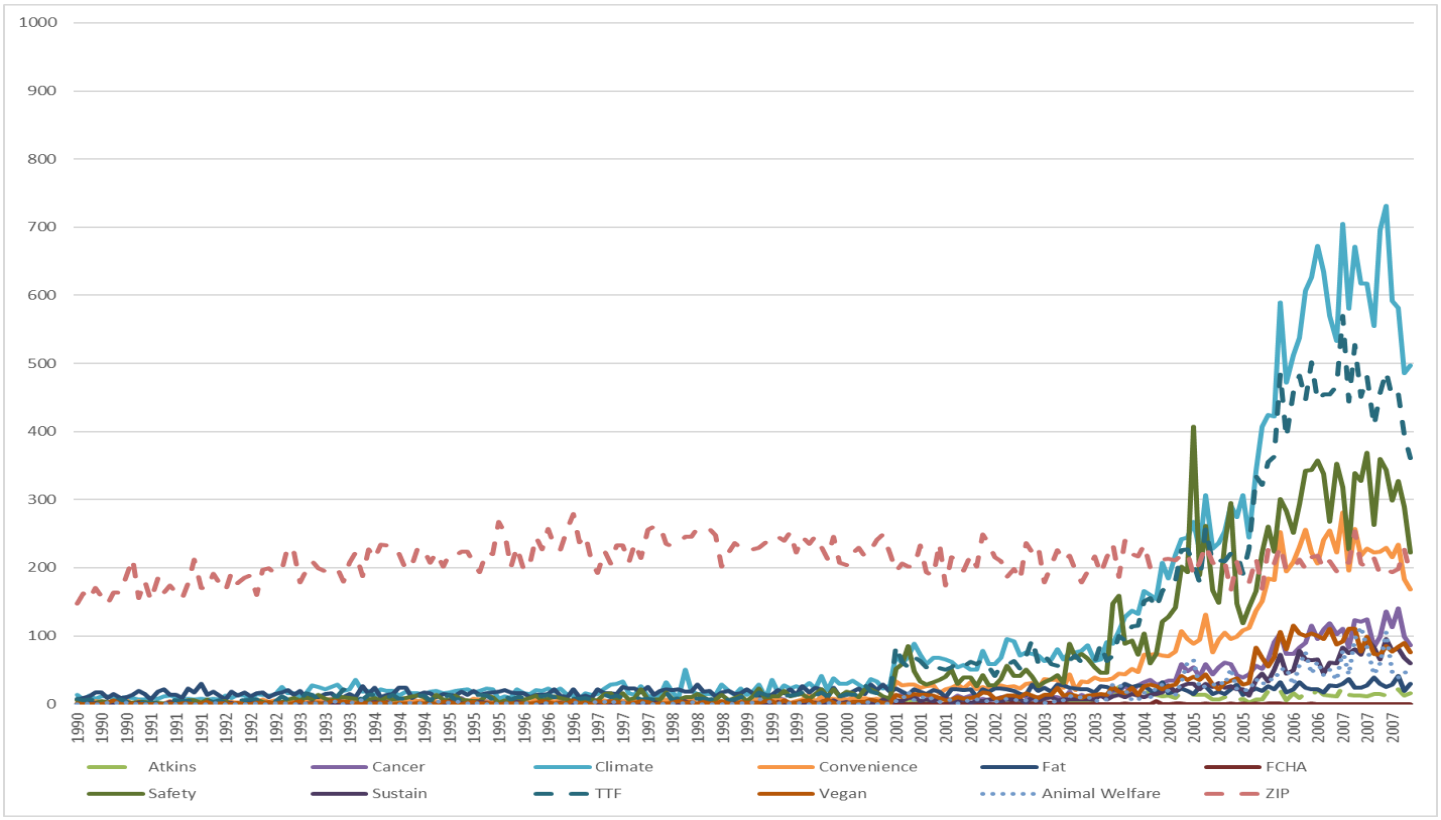
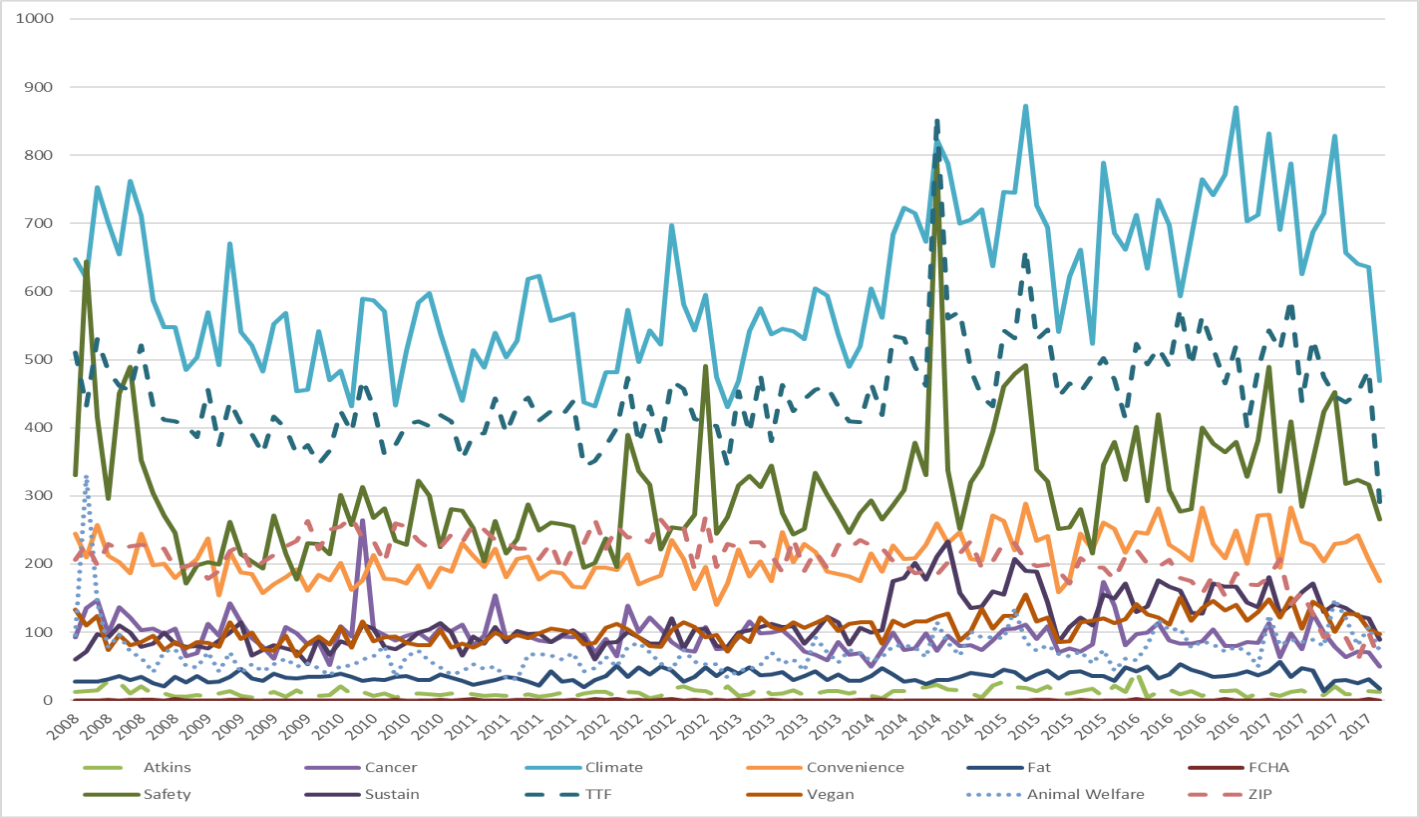


Figure 3.3. Beef Industry, Monthly Media and Medical Counts: Jan. 2008 – Nov. 2017



Rather than estimating a full meat demand system as in the prior chapter that attempted to identify the effect of each individual index, we alternatively built demand indices for direct assessment. Specifically, we built monthly beef, pork, and chicken demand indices beginning in 1988 (reflecting available monthly trade data). This approach uses own-price elasticities of -0.48 for beef, -0.31 for pork, and -0.34 for chicken consistent with Table 3.1 in the past section. This approach follows procedures currently used at KSU in regularly posted quarterly demand indices (Tonsor, 2010). The main adjustment is to use a quantity-based demand index which compares expected quantities with realized quantities, rather than expected and realized prices which facilitates a viable chicken demand index (Brester, Bekkerman, and Tonsor, 2017).[3]

The resulting beef index based upon the All-Fresh retail price is shown in Figure 3.4 and broadly follows the same time pattern of existing demand indices.[4] Consistent with existing indices, Figure 3.4 indicates beef demand largely eroded between 1988 and 1998, recovered with an intermediate peak in 2004-2006, declined through the Great Recession, and has improved since 2010. The October 2017 demand index value of 83 suggests per capita beef consumption was 17% lower than it would have been if beef demand was at its January 1988 level. The two main

[3] Correlation of price- and quantity-based indices are 0.92, 0.92, 0.89, and -0.01 for Beef (Choice), Beef (All-Fresh), Pork, and Chicken suggesting the selection of approach has limited impact for beef and pork but substantial impact on Chicken demand conclusions.

[4] A parallel index was built using the Choice beef price which was highly correlated (0.98) with the presented All-Fresh based index.

periods of demand reduction underlying this are the 1990s and the more recent Great Recession. To more clearly see this and appreciate importance of demand growth in recent years, note the February 2010 index of 65 suggests individual consumption was 28 percentage points higher in October 2017 then it would have been without demand improvement since February 2010.

Figure 3.4. Monthly Beef Demand Indices, Jan. 1988 – Oct. 2017.

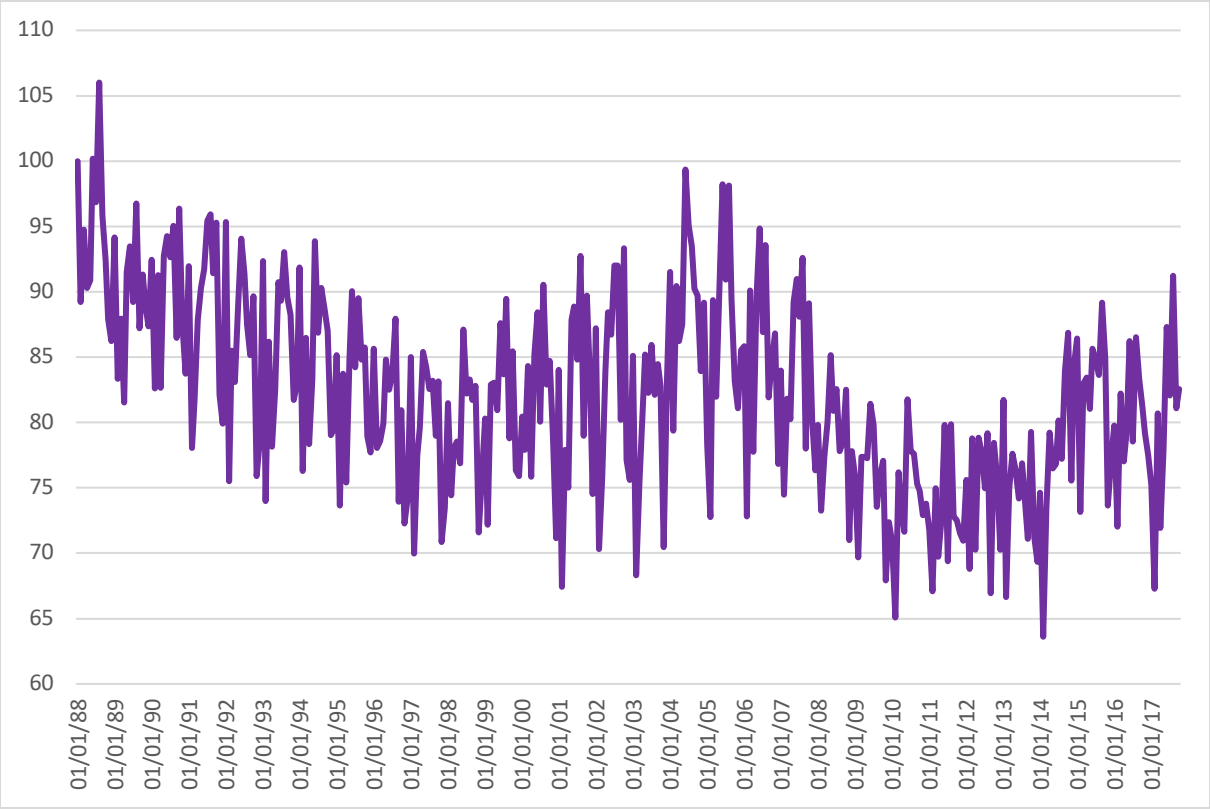
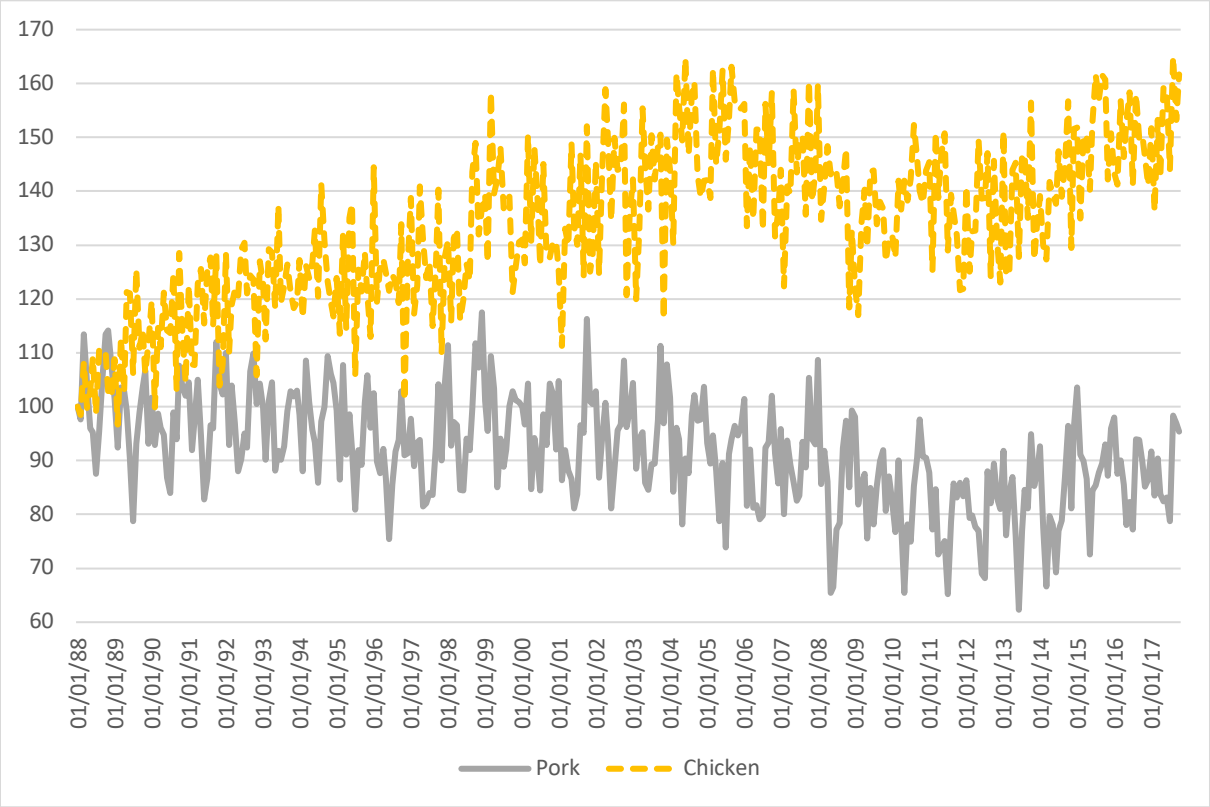


Figure 3.5 reveals that pork demand has followed a similar pattern to beef. Conversely, chicken demand gained notably over the 1988-2004 period before declining during the Great Recession and strengthening since 2009. While analyses comparing relative determinants of demand for beef versus pork or chicken are possible, the limited cross-price effects noted in the past section reduce importance.

Figure 3.5. Monthly Pork and Chicken Demand Indices, Jan. 1988 – Oct. 2017.



Our main interest is not demand index values themselves, but rather which factors explain observed variation in beef demand. Given high levels of correlation in the media and medical information counts, combined with probable lagged effects of some counts the number of explanatory variables associated with 11 counts expands rapidly (n=66 if contemporaneous up to 5-month lagged effects are considered), a variable selection approach was used to aid in final model identification. Specifically, a stepwise regression approach (Cohen, 2006) was employed using 0.15 entry and retention levels to identify a subset of initially considered demand determinants to retain in the model. To succinctly summarize, this process identifies a model comprised of explanatory variables (eliminating others) that provide the best statistically significant relationship with the demand measure of key interest.[5]

Table 3.3 shows results of this process separately for models considering the 1990-2007 and 2008-2017 periods to highlight changes in the most recent 10-year period. Here demand index models were estimated in log-log format such that the effect of information count variables and other continuous variables (e.g. competing meat prices) are presented in table 3.3 in elasticity or percentage change format.[6]

[5] The Appendix contains additional regression details including duration of impact for each information count.
[6] Seasonality coefficients reflect dummy variable rather than natural log specification and are not elasticity estimates.

Table 3.3 shows notably different beef demand drivers were at play for the 1990-2007 and 2008-2017 periods.[7] Several results are consistent with expectations. Beef demand is higher in June and lower in February than December, consistent with grilling and holiday seasonality. The absolute value of each monthly seasonality coefficient being lower for the 2008-2017 period indicates seasonality on balance has declined. Beef demand is stronger when the University of Michigan's Consumer Sentiment index is improving. This is consistent with consumers being more comfortable spending when their general views on their economic situation are improving. Specifically, a 1% increase in consumer sentiment increases beef demand by 0.11%.

The information variable which stands out in Table 3.3 is our proxy for taste, tenderness, juiciness, and flavor (*Taste, Tender, Flavor* or *TTF*). Increasing media discussion of TTF topics has a supportive impact on beef demand as expected. This marginal impact is two or more times (e.g. 9 times as influential as *Sustain*) greater than each of the other information effects examined. A 1% increase in TTF media volume corresponds with a cumulative 0.48% increase in beef demand over five months.

While media coverage of Atkins, High Protein, or Low Carbohydrate (*Atkins*) topics remains supportive, the marginal benefit for beef demand is lower in the 2008-2017 period. Increasing medical journal coverage of Fat topics (*Fat*) had a negative impact in 1990-2007, perhaps consistent with books like *Big Fat Surprise* and related changes of "tune," this impact turned positive during the 2008-2017 period.

As expected, when issues of preparation ease or time (*Convenience*), safety (*Safety*), climate change/environment (*Climate*), or meatless diets (*Vegan*) are more prevalent in the media beef demand declines. Beef demand is stronger given increasing coverage on the topics of Cancer (*Cancer*), Sustainability (*Sustain*), and Animal Welfare, Well-Being, Care, etc. (*Animal Welfare*). While initially surprising, perhaps this reflects the "tone" of these discussions being more positive for the beef-cattle industry than anticipated. Finding coverage of zinc, iron, or protein topics (*ZIP*) to reduce beef demand is not expected and hard to reconcile. Perhaps this reflects the separate consideration of *Atkins* and *Fat* topics.

Consistent with the last section's remarks regarding limited impacts from changes in pork and chicken prices, the lack of significance of both pork and chicken prices here is noteworthy.

It is important to go further than simply highlighting marginal effects summarized in table 3.3 and incorporate the previously noted (table 3.2) variation in information counts to jointly consider marginal effects and magnitudes of variation in information counts. Recall the counts exhibiting the most variation are *Atkins*, *Animal Welfare*, *Sustain*, *Safety*, *Cancer*, and *Fat*. Table 3.3. suggests small (less than 0.05) marginal effects for *Atkins* and *Fat*. Accordingly, while coverage of *Atkins* and *Fat* topics is supportive of beef demand, the net effect is small.

[7] In the 1990-2007 model, multicollinearity issues led to removal of Cancer, Climate, and Vegan variables while no variables were removed from the 2008-2017 model for multicollinearity reasons.

Conversely, the marginal effects of *Animal Welfare*, *Sustain*, *Safety*, and *Cancer* are larger (greater than 0.05) suggesting these four topics are areas of high impact.

The count variable *Climate* is also worth additional discussion. While exhibiting less relative variability within the 2008-2017 period, it has the highest mean volume (table 3.2) and second-most negative marginal impact on beef demand (table 3.3). Within 2017, this measure also experienced a notable decline which could be monitored going forward in assessing future relevance for beef demand. Combined with broader and often divisive discussions around climate change, greenhouse gas emissions, water use, etc. elevated attention to volume, "tone," and beef demand impact would be prudent.

Table 3.3. Monthly Beef Demand Index Models, Final Results

	1990-2007	2008-2017
Information Elasticities		
Atkins	0.021	0.014
Cancer		0.197
Climate		-0.209
Convenience		-0.054
Fat	-0.024	0.031
Safety		-0.072
Sustain	-0.012	0.058
Taste, Tender, Flavor		0.479
Vegan		-0.240
Welfare	0.004	0.098
Zinc, Iron, Protein	-0.160	-0.198
Other Elasticities		
Prior Month Demand	0.323	
Pork Price		
Chicken Price		
Per Capita Disposable Income		
Consumer Sentiment		0.112
Seasonality Coefficients		
January	0.085	0.002
February	-0.095	-0.083
March	0.064	0.020
April		
May	0.074	0.019
June	0.103	0.037
July	0.050	0.002
August	0.100	0.011
September		
October	0.078	0.036
November	-0.040	-0.030

V. Food Demand Survey Insights

To better understand beef demand drivers, this research utilizes nationwide survey data collected from 48,358 individual responses to the Food Demand Survey (FooDS) over a four-year time period from June 2013 to May 2017. The research focuses on socio-economic and demographic drivers of steak and ground beef demand, and also analyzes the impact of food values (Lusk and Briggeman, 2009) on beef demand. As discussed by Lusk (2011), the relationship between food values and beef demand can reveal information about consumers' beliefs about the relative tastiness, healthiness, etc. regarding beef, which can provide valuable information in deciding where to target promotional resources. The primary focus of this analysis is to uncover individual heterogeneity in beef demand, to link this heterogeneity with identifiable characteristics, and to determine the extent to which demand has changed over time.

This analysis makes use of the individual-level data collected as a part of the Food Demand Survey (FooDS) from Oklahoma State University. FooDS is an online survey that has been conducted every month with over 1,000 consumers since May 2013. The analysis in this report relies on 48,358 responses to the Food Demand Survey (FooDS) over a four-year time period from June 2013 to May 2017.[8] Table 4.1 shows the characteristics of the individuals included in this study.

[8] We did not use May 2013 results because of a change in the way we asked the meat demand questions after that point.

Table 4.1. Characteristics of the Sample Used in the Analysis (N=48,358)

Household Income	
<$20K	15.7%
$20K-$39K	18.4%
$40K-$59K	16.0%
$60K-$79K	15.2%
$80K-$99K	12.1%
$100K-$119K	7.9%
$120K-$139K	4.5%
$140K-$159K	4.3%
≥$160K	5.9%

Age	
<25	11.4%
25-34	21.5%
35-44	19.1%
45-54	17.0%
55-64	15.1%
65-74	12.8%
≥75	3.1%

Household Size	
1	18.1%
2	33.4%
3	20.0%
4	18.6%
≥5	9.89%

Race	
White	77.1%
Black	13.2%
Asian + Other	6.7%
Indian	3.0%
Hispanic	13.0%

Region of Residence	
Northeast	21.7%
Midwest	20.1%
South	35.8%
West	22.3%

Primary shopper?	78.7%
Children under age 12?	31.8%

Gender	
Male	47.7%
Female	52.3%

Education	
High School Degree or lower	56.7%
Some College	20.9%
BS or BA degree or higher	22.3%

Political Ideology	
1=very liberal; 5=very conservative	2.94

As a measure of beef demand, this analysis relies on consumers' responses to a series of discrete choice questions like the one below.

Each person answered nine choice questions, like the one above. Preceding the questions was the verbiage: "Imagine you are at the grocery store buying the ingredients to prepare a meal for

you or your household. For each of the following nine questions that follow, please indicate which meal you would be most likely to buy."

Each of the questions was identical except the prices varied across each question. Each question had nine options (two beef, two pork, two chicken, two non-meat, and one "no purchase") and the price of each option was varied at three levels. The price of hamburger varied between $2 and $5; steak varied between $5 and $8; pork chop varied between $2.25 and $5.25; ham varied between $1.15 and $4.15; chicken breast varied between $1.75 and $4.75; chicken wing varied between $0.25 and $3.25; rice and beans varied between $0.5 and $3.5; and pasta varied between $2.5 and $5.5. The third price levels for each option were set to the mid-point of the aforementioned ranges. The prices appearing in each choice were determined by a main effects orthogonal fractional factorial design. A perfectly orthogonal design (in which prices of each choice alternative were uncorrelated with each other alternative) required 27 choices. The 27 choices were blocked into three sets of nine, and each person was randomly assigned to one of the three blocks. The order of the questions was randomly varied across individuals and the order of the presentation of the choice options was varied across blocks.

To simplify the analysis, this report focuses on the number of times an individual chose steak or ground beef (out of the nine total choices made). This is a viable option as the set of presented prices has not changed over the 4-year history of FooDS. Table 4.2 below shows the summary statistics associated with the 9*48,358=435,222 choices made by the respondents in our sample. Overall, steak was chosen on average 0.9 times out of 9 (or (0.9/9)*100 = 10% of the time) and ground beef was chosen 1.32 times out of 9 (or (1.32/9)*100 = 14.7% of the time). Chicken breast was chosen most frequently, having been chosen 26.9% of the time.

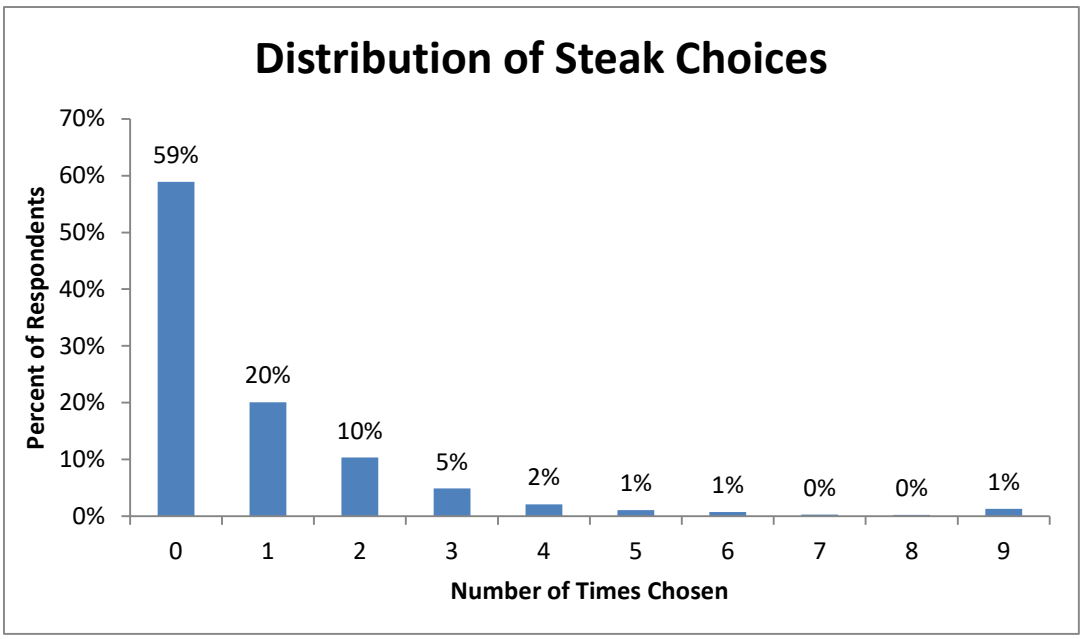
The fact that steak was infrequently chosen might be mistakenly interpreted as suggesting steak is not highly preferred. However, note that steak was higher priced than all the other alternatives consistent with actual grocery-store prices. As the monthly FooDS reports make clear, consumer willingness-to-pay for steak is higher than all the other food options presented in the survey. While this report could utilize steak (and ground beef) willingness-to-pay as the key variables of interest, such an approach would require estimating a multinomial choice models that require numerous statistical assumptions, and for which incorporating individual heterogeneity is comparatively challenging. As such, this analysis focuses on the count of the numbers of times steak and ground beef was chosen. While this might seem to present a challenge insofar as ignoring the role of prices, note that in the experimental design, the prices of all options are essentially constant across individuals and over time. As such, changes in the number of times ground beef or steak was chosen by individual A vs. individual B or at time t vs. time t+1 *cannot* be explained by changing prices and are thus due to differences or changes in preferences for beef.

Table 4.2. Summary Statistics Associated with Consumer Choices (N = 435,222)

Item	Mean Number of Times Chosen	Percent of Times Chosen
Steak	0.90	10.0%
Ground Beef	1.32	14.7%
Pork Chop	0.80	8.9%
Ham	0.66	7.3%
Chicken Breast	2.42	26.9%
Chicken Wing	0.89	9.9%
Non-Meat (Pasta or Beans and Rice)	1.40	15.5%
None	0.61	6.8%
Total	9.00	100.0%

While table 4.2 provides useful summary statistics on the mean number of choices for each food item, the data masks a great deal of heterogeneity across respondents over time. Figure 4.1 reports the distribution of choices across the 48,358 respondents. As the figure shows, about 59% of respondents never chose steak, about 20% chose steak once out of nine times, and 1% chose steak every time it was presented. For ground beef, only 36% never chose the option, 26% chose ground beef once, 21% chose it two times, and 0.48% (rounded to 0%) chosen it all nine times.

Because the choice experiment used in FooDS requires respondents to make a choice among nine items, it is useful to explore choices for beef *relative to* other items that could have been chosen because a choice for another item implies beef has not been chosen. As it turns out, our analysis reveals that models focused on *relative* demand determinants provides a better fit to the data and more intuitive results. Figure 4.3 shows the distribution of the primary variables used in our analysis, which are the number of times steak is chosen minus the number of times non-meat items (tomato pasta or beans and rice) is chosen and the number of times ground beef is chosen minus the number of times non-meat items (tomato pasta or beans and rice) is chosen. Because each option could be chosen a minimum and maximum of 0 and 9 times, these variables range from -9 to +9. A score of -9 would imply a respondent who never chose steak and who always chose beans and rice or pasta. A score of +9 would imply a respondent who always chose steak and never chose beans and rice or pasta.



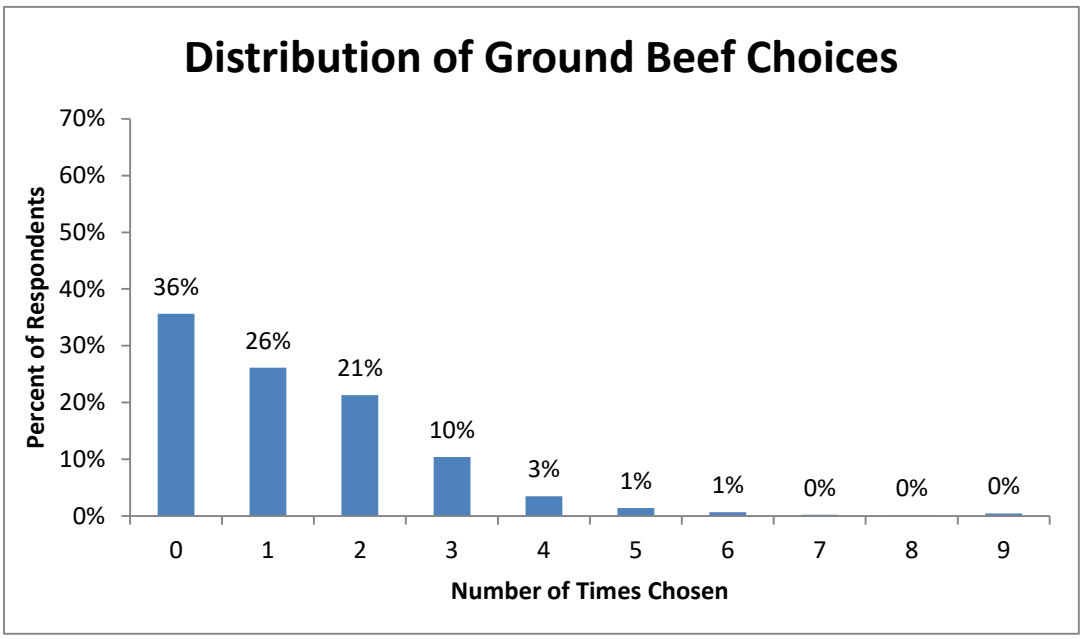
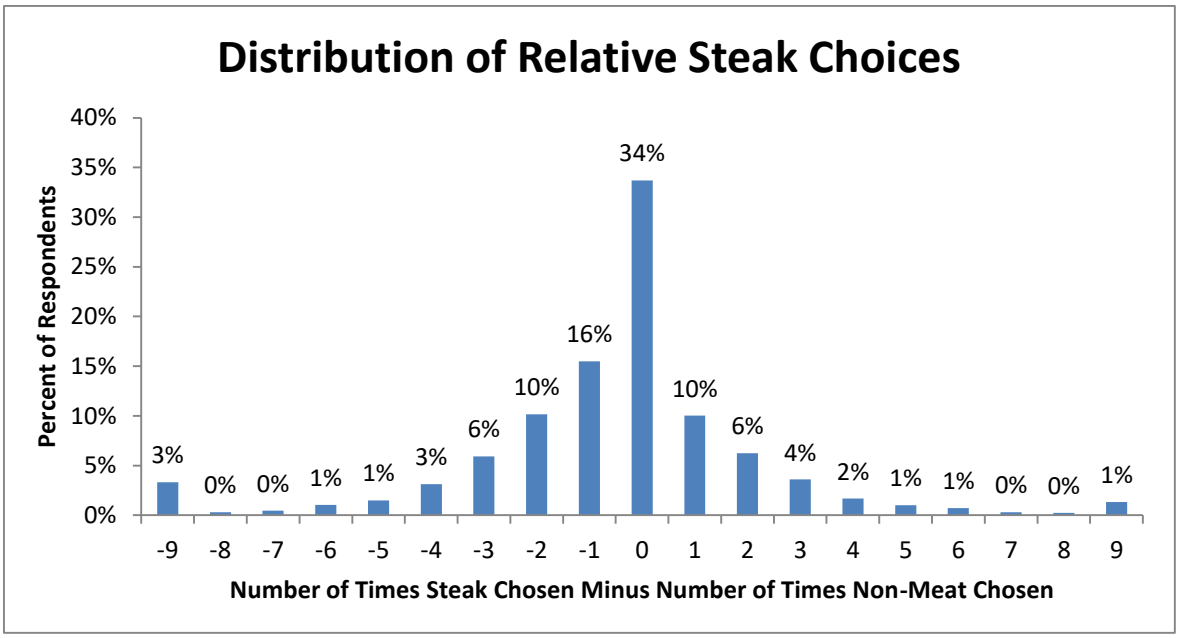


Figure 4.1. Distribution of Choices for Steak and Ground Beef (out of 9 possible choices)



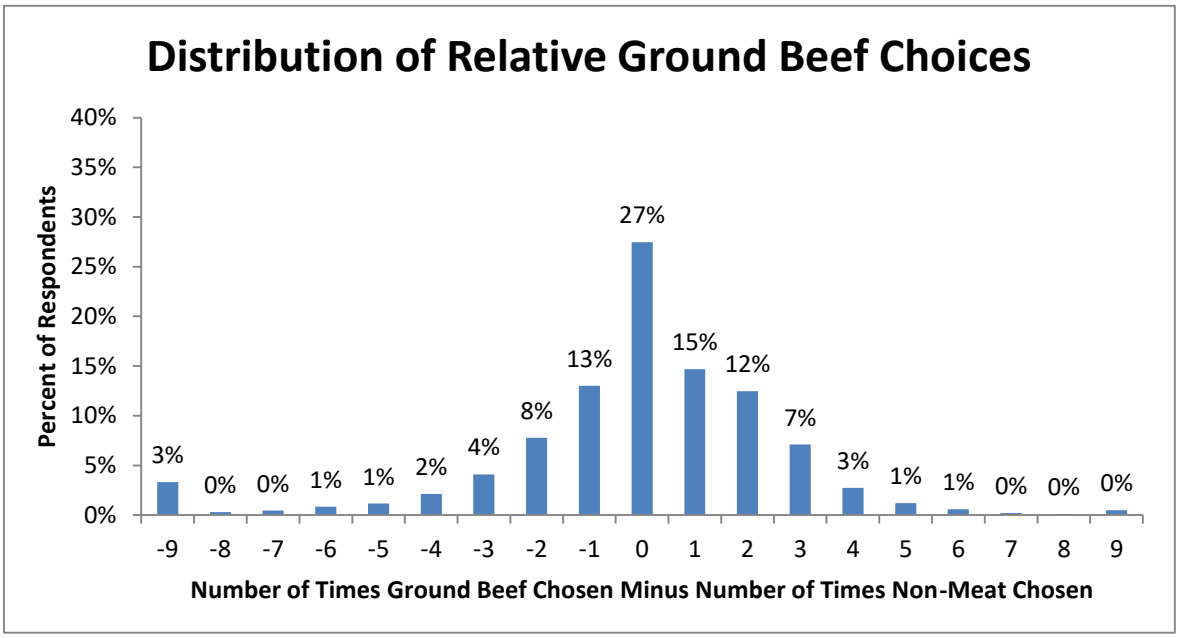


Figure 4.2. Distribution of Choices for Steak and Ground Beef Relative to Choices for Pasta and Beans and Rice (out of 9 possible choices)

One of the main explanatory variables explored in this study are food values. Respondents were shown a list of 12 issues they confront when purchasing food as shown in the following figure. Respondents were asked to place four (and only four) items in the "most important" box and four (and only four) items in the "least important" box. The task is accomplished by clicking on the various items and dragging them into the associated boxes. Note that the order of the food values was randomly varied across respondents. These food values trends provide insights into the relative importance of multiple factors such as Novelty (perhaps proxying a desire for more variety in diet) and Fairness that are very hard to quantify in existing, traditional public data sets.

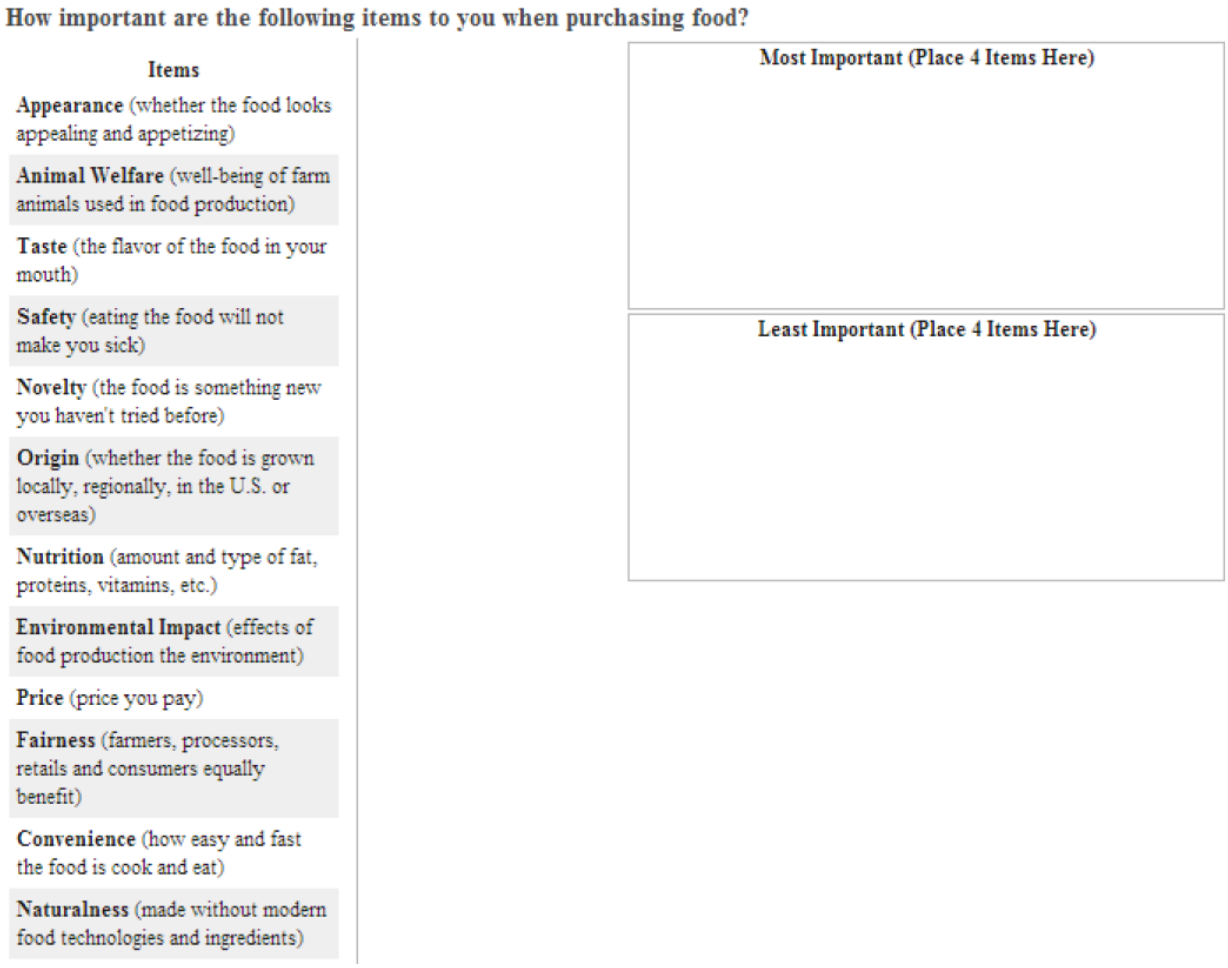


Figure 4.3 shows the percent of times each of the 12 items was placed in the most and least important boxes. The value of taste was placed in the most important box by 70% of respondents but was placed in the least important box by only 8% of respondents. On the other end of the spectrum, the value of novelty was placed in the most important box by only 6% of respondents but in the least important box by 71%. For some values, such as appearance and naturalness, there was disagreement; appearances was placed in the most important box

at about the same rate (32%) as it was placed in the least important box (31%), implying that appearance was placed in neither box 100%-32%-31%=37% of the time.

It is also worth noting that a related assessment of food values by Lister et al. (2017) used a very similar approach but slightly different set of 12 values. Inclusion of *Freshness* is noteworthy as it was the most important value in steak purchasing decisions and second highest for ground beef. The FooDS based insights on food values are shared as they are monitored over a multi-year period, while the Lister et al. (2017) study was only conducted one time yet has insights specific to beef products. It is likely that both *Taste* and *Safety* are elevated in the FooDS findings in part as consumers may embed freshness into these attributes.

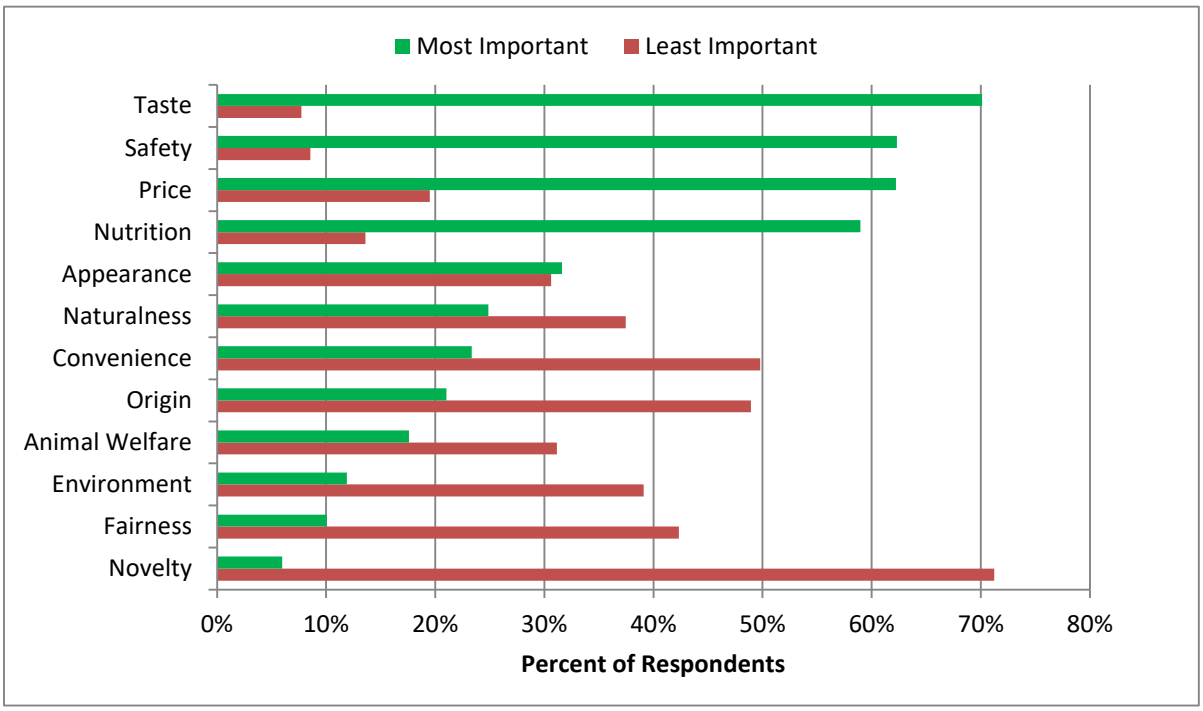


Figure 4.3. Food Values Considered Most and Least Important

A scale of importance can be created by calculating the percent of times (across the entire sample) a food value appeared in the most important box minus the percent of times it appeared in the least important box. Thus, the range of possible values is -100% to 100%, where a higher number implies more importance. Figure 4.4 shows each of the food values on this scale and indicates the four most important food values are taste, safety, nutrition, and price followed, after a sharp drop by appearance, naturalness, and animal welfare. The least important food values were environment, origin, fairness, and novelty.

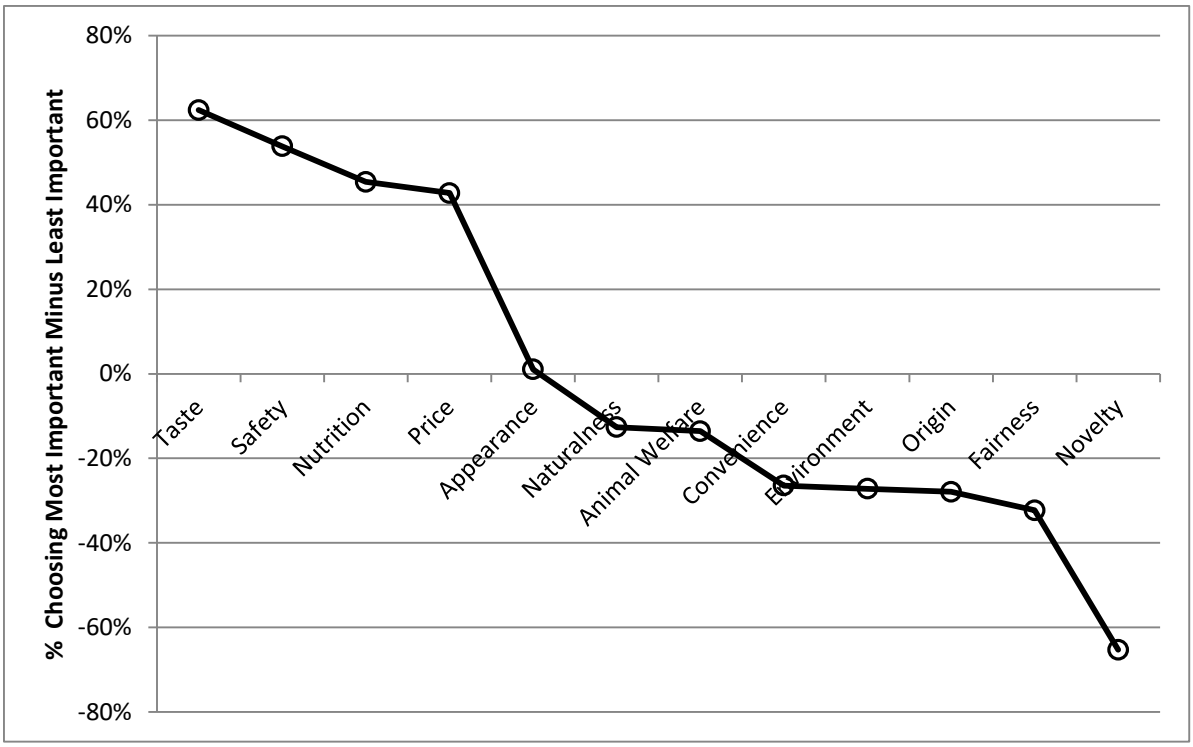


Figure 4.4. Relative Importance of 12 Food Values

Overall, the relative importance of the various food values has remained relatively stable over time. However, to explore the potential temporal impacts of changes in values, a trend was fitted against each of the food values, and we calculated the implied change that occurred over the 48-month period studied here. The following values have declined in importance over time price (-18.2% over 48 months), safety (-12.4%), nutrition (-7.2%), taste (-6.9%), and appearance (-2.2%). The following values have increased in importance over time convenience (3.3%), novelty (6.1%), origin (6.3%), environment (6.5%), animal welfare (7.2%), fairness (8.2%), and naturalness (9.2%). Finally, it should be noted that these food value trends apply broadly to a diverse bask of food items – exactly how they relate to beef demand is examined in the next section. However, the declining importance of price is worth note as being consistent with chapter 2's points on declining impact of own- and pork-prices on beef demand.

To investigate the impacts of food values and socio-economic and demographic variables, multiple regression models were estimated where the dependent variables were the number of times steak was chosen minus the number of times non-meat items were chosen and the number of times ground beef was chosen minus the number of times non-meat items were chosen. Each of these dependent variables range from -9 to +9 as shown in figure 2 and the respective means are -0.49 and -0.07, respectively. Henceforth, these variables are simply referred to as steak demand and ground beef demand, respectively.

Regression Results

The underlying regression results are fully reported in the appendix. In the main body of the report, these results are utilized to draw out the primary implications.

To ascertain the relative importance of different variables or factors on beef demand, the regression coefficients were inspected and compared in terms of relative magnitude. We then determined, for each factor, a score that is calculated as the maximum possible change in demand that would occur if one moved from the most deleterious impact on demand to the most favorable impact on demand. The results are given in table 4.3.

For both steak and ground beef, the most determinative factor of demand are food values. This is important as it suggests unobservable perceptions and beliefs held by consumers are key demand determinants. The results indicate that an individual with the four least favorable food values for steak demand were replaced with an individual with the four most favorable food values, then steak demand would increase by 2.49 (again, out of a total possible range from -9 to +9). Next most important for both steak and ground beef demand is race. Income and gender are the third and fourth most important factors for steak demand whereas month/season and political ideology are for ground beef. For both steak and ground beef, the least impactful factors (out of the factors considered here) were overall trend (suggesting minor changes in demand over the 4-year period explored here) and participation in SNAP (aka food stamps).

Table 4.3. Relative Importance of Various Factors on Beef Demand

Steak Demand			Ground Beef Demand	
Factor	**Score**		**Factor**	**Score**
Food Values	2.49		Food Values	2.91
Race	1.10	↑	Race	0.94
Income	0.86		Month/Season	0.72
Gender	0.68	Highest	Political Ideology	0.62
Month/Season	0.65	demand impacts	Education	0.47
Political Ideology	0.47		Gender	0.45
Children	0.35		Household Size	0.39
Primary Shopper	0.34		Age	0.34
Age	0.27	Lowest demand	Region	0.33
Household Size	0.26	impacts	Income	0.27
Education	0.24	↓	Primary Shopper	0.24
Day of week	0.21		Day of week	0.22
Region	0.14		Children	0.20
Trend	0.13		Trend	0.13
SNAP	0.10		SNAP	0.10

Given the importance of food values on demand, figures 4.5 and 4.6 illustrate the relative impacts of individual food values. Figure 4.5 shows the impacts on steak demand. Results indicate that if an individual who indicated animal welfare as the least important food value (a score of -1) instead indicated animal welfare as a most important food value (a score of +1), steak would be chosen 0.42 fewer times on average. Similarly for nutrition, results indicate that if an individual who indicated nutrition as the least important food value (a score of -1) instead indicated nutrition as a most important food value (a score of +1), steak would be chosen 0.33 fewer times on average. By contrast, greater importance placed on the food values of taste, appearance, and novelty are associated with increases in steak demand. An individual who indicated the four most deleterious factors (animal welfare, nutrition, environment, and price) as most important food values instead indicated these as least important and instead indicated the four most positive factors (convenience, taste, appearance, and novelty) as most important, then steak demand would increase by 2.49 as indicated in table 4.3 above.

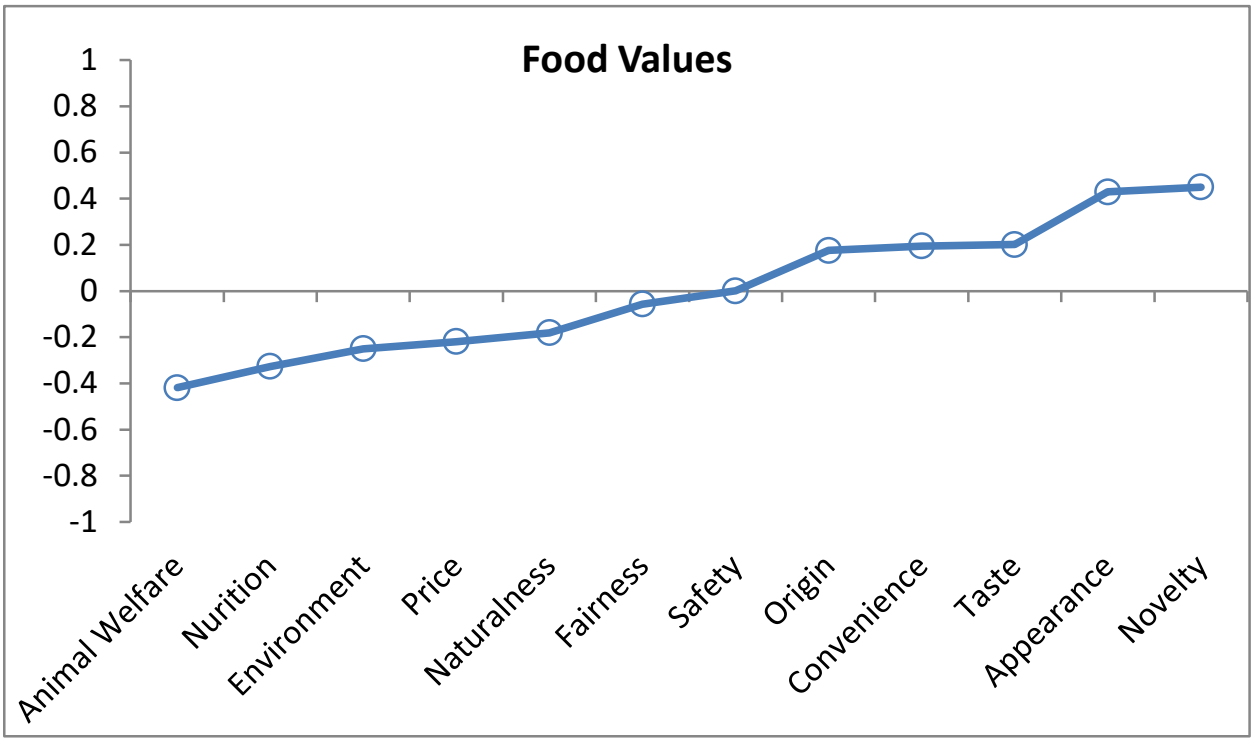


Figure 4.5. Impacts of Food Values on Steak Demand

While it may not be initially obvious, results in figure 4.5 can be interpreted as providing evidence about people's beliefs about (or perceptions of) steak. Suppose an individual highly values taste. Figure 4.5 shows that such an individual will tend to choose more steak. As a result, it must be that steak is perceived to be highly tasty. By this line of reasoning, figure 4.5 suggests that consumers, on average, perceive steak to be convenient, tasty, attractive, and novel but they also perceive steak to be poor for animal welfare, nutrition, and environment while also being expensive.

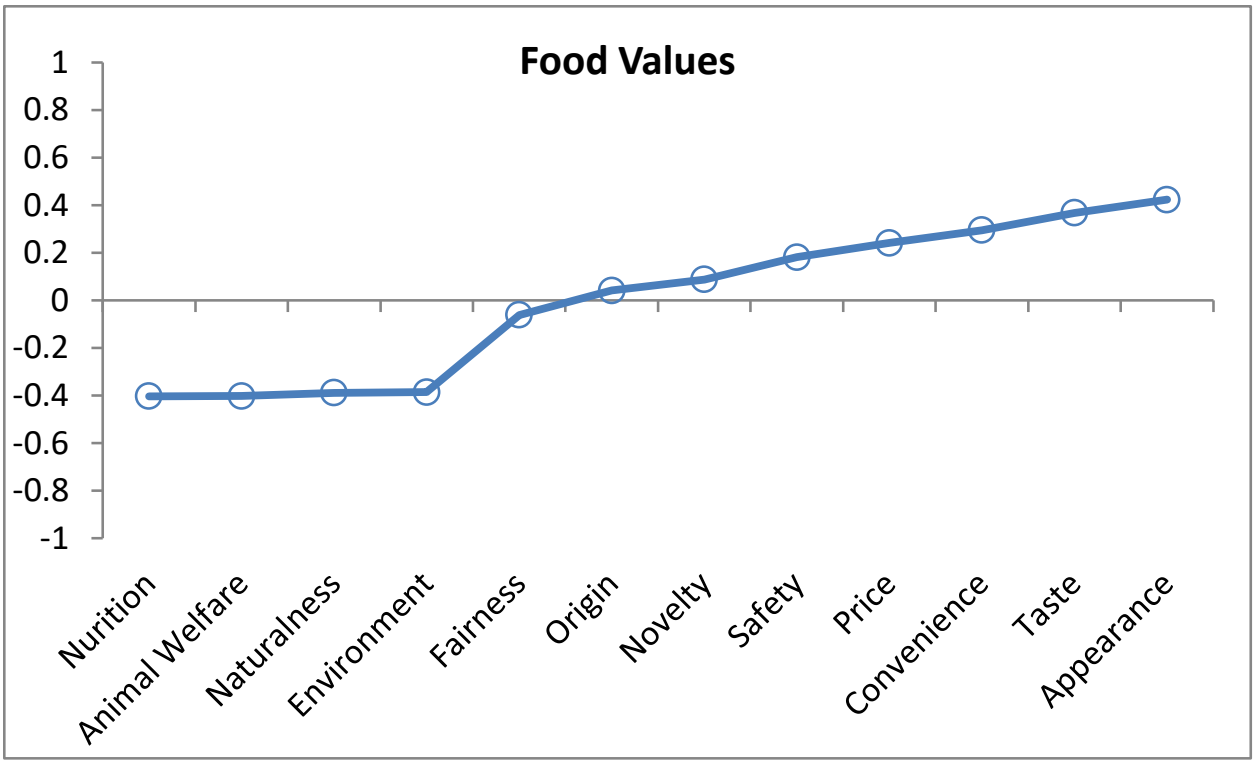


Figure 4.6. Impacts of Food Values on Ground Beef Demand

Figure 4.6 shows the estimated impacts of specific food values on ground beef demand. Some of the most deleterious impacts on ground beef demand are similar to that for steak, such as nutrition, animal welfare, and environment. However, there are also some key differences. For example, price is now one of the most positive demand determinants for ground beef. Figure 4.6 suggests that consumers, on average, perceive ground beef to be affordable, convenient, tasty, and attractive but they also perceive ground beef to be poor for nutrition, animal welfare, and the environment while also being "unnatural." Interestingly, figure 4.6 shows that ground beef is perceived as relatively safe; though safety is not a large determinant of steak or ground beef demand.

Figures 4.5 and 4.6 provide insights into how to improve beef demand. Marketing efforts which improve the perceived nutrition of beef would have a strong impact on both steak and ground beef demand. Improvements in perceptions of environmental impact would also increase overall beef demand. The same is true of perceptions about animal welfare. Moreover, note the results in figure 4.3, showing that 18% of consumers consider animal welfare one of the most important food values and 31% consider it a least important food values. This implies that a majority (100%-18%-31% = 51%) do not consider animal welfare a high or low importance food value. This is the food value with the greatest neutrality or least polarization (followed by environment and animal welfare with 49% and 48% of consumers stating them as neither most nor least important), and as such consumers, as a group, might be most susceptible to persuasion about this value. This situation for animal welfare likely reflects it being one of the least standardized issues, of the food values examined at least, faced by consumers.

Continuing to stress the tastiness of beef would also help maintain beef demand, but note the results in figure 4.3 showing the vast majority of consumers already consider taste an important food, and as such, there may not be much room for positive change. Attractive appearance and convenience are also positive messages for overall beef demand. At a minimum, these positive factors should be kept in mind in demand enhancing strategies as factors that need to be sustained to avoid demand erosion.

Figures 4.7 and 4.8 place the impact of food values on beef demand in the context of impacts of other demand determinants. The figures show the change in steak and ground beef demand that would occur as a result of changes in food values, demographics, and other socio-economic variables.

The figures are constructed so the vertical axis represent changes in demand that occur when moving from the first level for each variable presented on the horizontal axis to one of the other levels on the horizontal axis. To ease comparisons across variables, the vertical axis always ranges from -1 to +1. Also for sake of comparison, figures 4.5 and 4.6 are also imbedded (after rescaling) into figures 4.7 and 4.8, respective.

Figure 4.7 shows that moving from a household income of under $20,000 to an income between $20,000 and $39,000 would increase steak demand by 0.091. Going from under $20,000 to an income above $160,000 would increase steak demand by 0.86. Thus, steak is what economist call a “normal good”, where consumers demand more as their incomes increase. Two other major factors affecting beef demand are race and gender. Compared to Asian consumers, Indians have much lower steak demand (however, note that only about 3% of the sample consists of Indian consumers). Females choose steaks about 0.68 fewer times than males on average.

Figure 4.8 shows the results for ground beef demand. Unlike the case for steak, income has a relatively small impact on ground beef demand. Younger consumers (under 25 years of age) have the lowest ground beef demand but there is not much difference in demand among older age groups. Again, females show lower ground beef demand than males, however the effect isn’t as large as was the case for steak. Similar to steak, Indian consumers had the lowest overall demand. Political ideology had a strong influence on ground beef demand, with the most conservative consumers choosing ground beef about 0.62 times more often than the most liberal consumers.

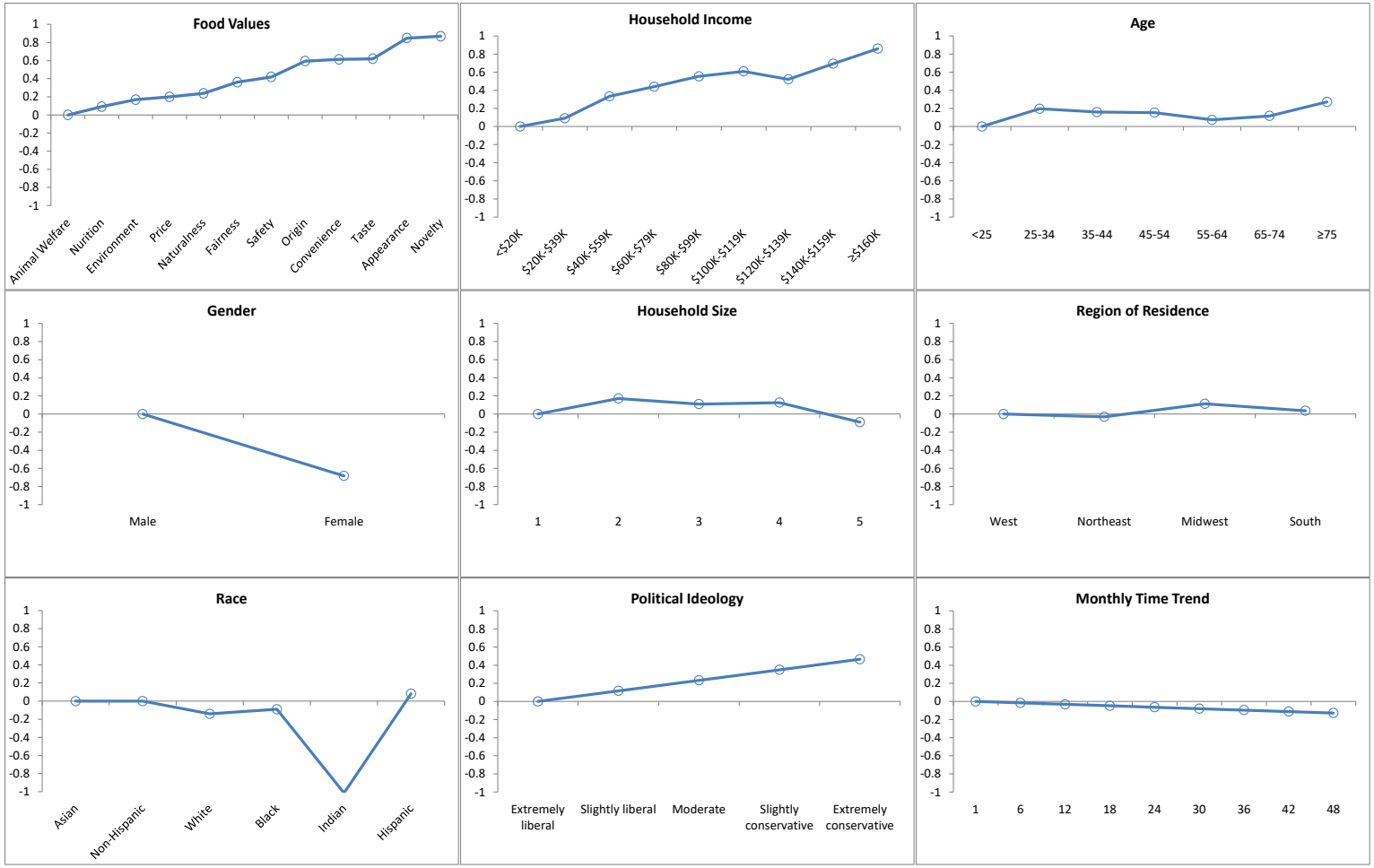


Figure 4.7. Determinants of Steak Demand relative to Demand for Non-Meat Options

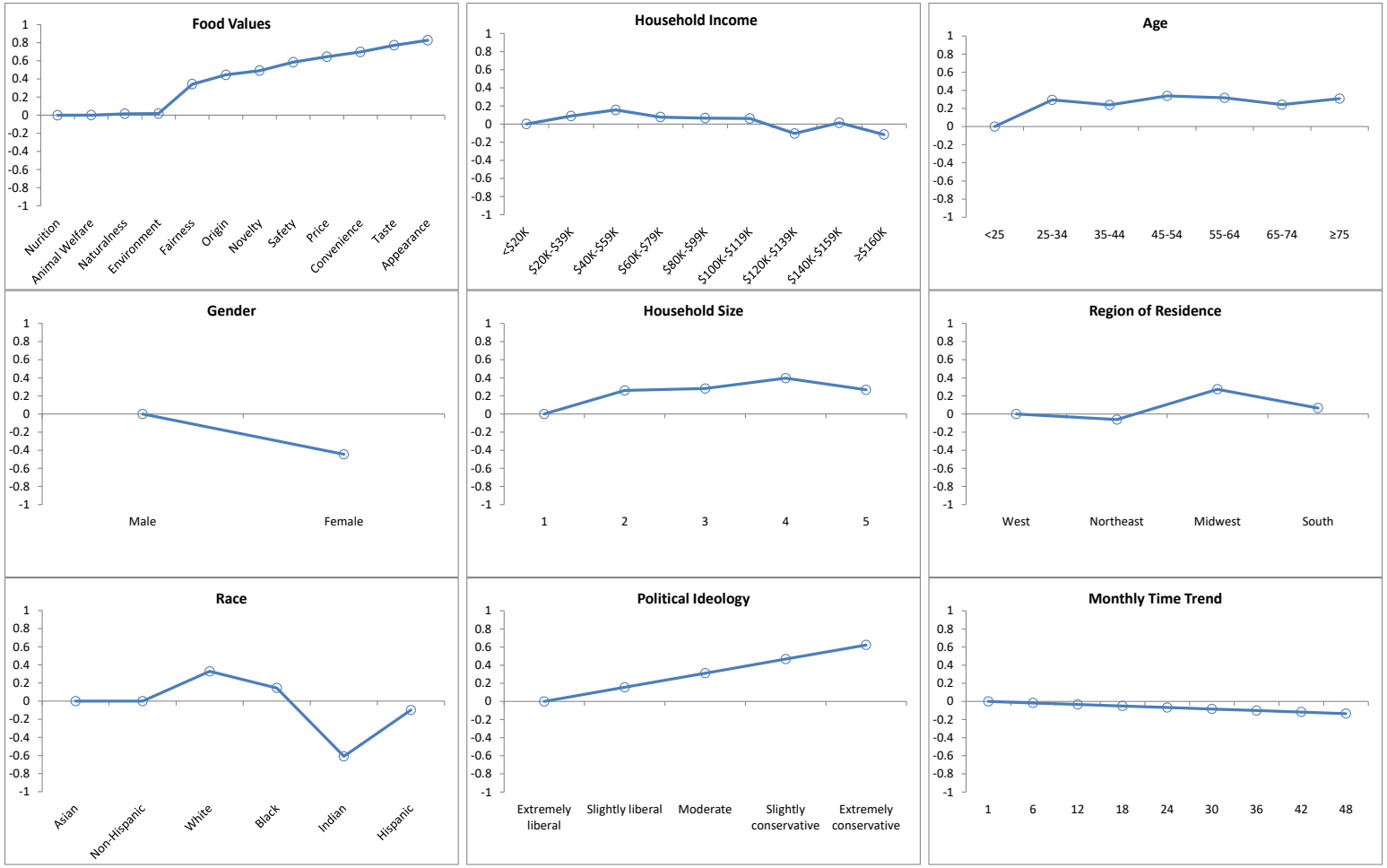


Figure 4.8. Determinants of Ground Beef Demand relative to Demand for Non-Meat Options

VI. Consumer Beef Index Beef Demand Insights

Approximately every 6 months the beef industry currently supports a nationally representative survey of over 1,000 beef consumers referred to as the Consumer Beef Index (CBI) survey. In 2017 in coordination with this project, an addition to this ongoing survey was made to further assess consumer willingness to pay for beef. The general goal is to leverage the existing CBI investment and extend insights by providing ongoing estimates of beef demand over time.

In each survey a contingent valuation approach is implemented where consumers are asked if they would buy beef at a given price. Participants are provided one of the following two initial questions:

"Would you buy 16 oz. (1 lb.) of boneless Ribeye steak if it was priced at [$x] the next time you were shopping?"

"Would you buy 16 oz. (1 lb.) of 80% lean ground beef if it was priced at [$y] the next time you were shopping?"

Depending on their initial Yes(No) response, follow-up questions at Higher(Lower) prices are posed providing insights into consumer price sensitivity by identifying a range of prices that encompasses consumer willingness to pay (WTP).[9]

Interval-censored regression models are estimated using the lower- and upper-bound estimates for each survey participant to provide estimates of mean WTP and an examination of participant characteristics associated with higher or lower WTP amounts. Table 5.1 presents the results of basic WTP models.

In the February wave (data collection spanned March 9th-21st), mean WTP estimates for ground beef and steak of $3.95/lb and $9.88/lb, respectively. The July survey (data collected during August 9th – 17th) yielded mean WTP estimates of $3.97/lb and $9.68/lb indicating ground beef demand was steady between March and August while steak demand slipped moderately (about 2%).

[9] Initial values of $3.49 and $10.49 for ground beef and steak were used in both surveys. In the February CBI, the highest presented prices were $4.99 and $11.99. Given significant upper-end censoring, in the July CBI these values were increased to $5.49 and $12.89. Moreover, given lower-end censoring for steak in the February CBI, the July CBI also reduced the lowest presented value ($8.09 vs. $8.99). Combined July CBI insights are less impacted by data censoring.

Table 5.1. CBI Survey-Based WTP Estimates, March and August 2017

Survey Collection Period	March				August			
Beef Product	*Ground Beef*		*Steak*		*Ground Beef*		*Steak*	
Intercept	**3.946**	**3.728**	**9.882**	**9.345**	**3.967**	**3.942**	**9.680**	**8.597**
Male		**0.134**		0.146		0.019		0.318
Age (Years)		-0.004		**-0.026**		**-0.009**		**-0.022**
Full-Time Worker		0.129		**0.324**		0.090		**0.650**
Income (000s)		0.000		**0.006**		-0.001		**0.009**
College Graduate		-0.008		0.179		0.127		0.188
Northeast		-0.092		0.220		0.093		-0.230
Midwest		**-0.282**		**0.437**		**-0.219**		-0.303
South		-0.152		0.274		-0.015		0.498
African American		**0.493**		**0.604**		**0.312**		0.401
Asian		0.064		0.417		-0.087		-0.250
Hispanic		0.170		**0.559**		0.031		**0.672**
Kids Present		**0.210**		-0.071		**0.208**		0.074
Weekly Beef Consumer		**0.343**		**0.800**		**0.371**		**0.955**
Scale	**0.933**	**0.879**	**1.857**	**1.722**	**0.973**	**0.915**	**2.594**	**2.371**
Completed surveys	537		529		540		528	
Lower-end Censoring (%)	0		33.84		0.74		30.11	
Upper-end Censoring (%)	21.97		21.74		9.26		16.48	

Notes: Variables are dummy values (=1 if yes, =0 otherwise) unless noted.
Bold coefficients indicate statistical significance (0.10 level).

Table 5.1 also includes results of models examining the impact of various socio-economic factors on estimated WTP values. Robust findings across the two 2017 assessments include ground beef demand being lower for Midwest residents and being higher for African Americans, households with children present, and households who consume beef at least once per week. Meanwhile steak demand in both survey waves is lower for older respondents and higher for those working full-time, with higher incomes, Hispanics, and those who consume beef at least once per week.

VII. Summary and Recommendations

The use of multiple analyses, covering different time periods and methods, makes provision of clear-cut rankings of determinants ill-advised. A short-list of key determinants can however be identified without indication of relative order by combining insights across analyses with our own judgement. A *key determinants* list would include beef quality (taste, appearance, convenience, and freshness); consumer incomes; coverage of food safety, animal welfare, sustainability, cancer, and nutrition topics; and shifts in race composition of the U.S. population.

Expounding further, some unifying themes arise when considering the multiple analyses presented above including:

1) Price has become a less important determinant of demand for beef in aggregate. Meanwhile, the opposite is true for income (or total expenditures).

2) Different data sets and methods can provide both consistency and areas of different implications regarding beef demand determinants. This points to the need to utilize multiple data sources and methods to better monitor demand given realities of data collection.

3) Different measures indicate beef demand has increased (per section III) or remained relatively stable (per section IV) over the past 5 or so years. While each measure indicates variation up and down in demand, given the volume of negative media attention related to beef one might have expected strong negative trends. This indirectly indicates other sources of demand support in recent years.

4) Specific topics have changed notably in the 2008-2017 period and increased beef demand including *Animal Welfare*, *Sustain*, *Cancer*, and *Fat*. Coverage of *Climate* and *Safety* topics has decreased beef demand and are among the most prevalent "hot topics" in the media. The "tone" of coverage can change as indicated by *Fat* discussions turning from a beef demand detriment to catalyst. Supportive topics, such as *Atkins* diet conversations, can remain demand supporting yet decline in relative impact. Accordingly, these key topics warrant elevated industry attention and prudent re-assessment is needed as new topics arise and the impact of previously examined topics can change.

5) Household demographic demand determinants differ for different beef products. High income households want steak while lower income households want ground beef. Consumers who demand more beef are driven mainly by taste, appearance, and convenience. Combined this suggests additional focus on target marketing both by beef product and household type.

Given these over-riding findings, a set of recommendations include:

- We recommend ongoing elevated focus on beef quality including taste, appearance, and convenience with possibly less focus on price, especially that of competing meats.
    - Several topics such as consumer income strength, general attitudes toward protein in diets, etc. have common directional impacts on beef and other meat protein industries. Coupling this with limited sensitivity to pork and chicken prices, we recommend the beef industry adopt an increasingly collaborative approach to other industries to leverage industry resources and opportunities.
- Sources of current demand strength should be noted and the industry should work to maintain these favorable conditions.
    - One specific household characteristic of note is how African-American and Hispanic residents exhibit strong desire for beef. As the share of the U.S. population comprised of these two races is projected to grow refined focus on specific desires of these groups is warranted.
- Drivers of weakening demand should be noted and further assessed for viability as opportunities for focused investment and improvement.
    - Issues including safety and climate were found as current demand detriments. Ultimately the feasibility of impacting these areas must be considered before final decisions regarding industry investment are made.
- Periodic updates and new assessments of beef demand determinants are critical.
    - This study revealed own-price elasticities have changed, highlighted key changes in "hot topics," and utilized data sets that were not previously available in past studies. Given ongoing changes in data and research methods, along with inner-industry developments make more frequent assessments prudent to better utilize limited demand enhancing resources.
- Additional effort should target leveraging existing industry investments to expand understanding of beef demand.
    - As an example, this study incorporated recent changes in how the Consumer Beef Index survey is executed providing new estimates of beef willingness-to-pay. Similar opportunities should be pursued.

VIII. Appendix

References

Cohen, R.A. (2006). "Introducing the GLMSELECT Procedure for Model Selection." Available online at: http://www2.sas.com/proceedings/sugi31/207-31.pdf.

Brester, G., A. Bekkerman, and G.T. Tonsor. (2017). "Separating Changes in Demand from Changes in Quantity Demanded: Untangling a Gordian Knot with Demand Indices." Working paper.

Lister, G., G.T. Tonsor, M. Brix, T.C. Schroeder, and C. Yang. (2017). "Food Values Applied to Livestock Products." *Journal of Food Products Marketing*. 23:326-341.

Lusk, J. L. (2011). "External validity of the food values scale." *Food Quality and Preference*, *22*(5), 452-462.

Lusk, J.L. and B.C. Briggeman. (2009). "Food Values." *American Journal of Agricultural Economics*. 91:184-196.

Lusk, J.L. and G.T. Tonsor. (2016). "How Meat Demand Elasticities Vary with Price, Income, and Product Category." *Applied Economic Perspectives and Policy*. 38:673-711.

Rickard, B.J., J. Liaukonyte, H.M. Kaiser, and T.J. Richards. (2011). "Consumer Response to Commodity-Specific and Broad-Based Promotion Programs for Fruits and Vegetables." *American Journal of Agricultural Economics*. 93:1312-1327.

Tonsor, G.T. (2010). Intuition and creation detail of beef demand indices. *AgManager.info Kansas State University*. Available at: http://www.agmanager.info/livestock/marketing/graphs/Meat%20Demand/Index/IndexOverview_09-14-10.pdf.

Tonsor, G.T., J. Mintert, and T.C. Schroeder. (2010). "US Meat Demand: Household Dynamics and Media Information Impacts." *Journal of Agricultural and Resource Economics*. 35:1-17.

Tonsor, G.T. and T.C. Schroeder. (2017). "Creating and Assessing Candidate Food Service and Retail Beef Demand Indices." Available at: https://www.beefboard.org/news/files/FY2017/Demand%20Indices%20Report%20-%20full.pdf

Beef Demand Index Modeling Appendix

Table A.1. 1990-2007 Beef Demand Index Regression

	Estimate	P-Value
Intercept	3.8795	<.0001
Prior Month Demand Index	0.3232	<.0001
Atkins (Current Month)	0.00983	0.0727
Sustain (1-month lag)	-0.0121	0.0123
ZIP (1-month lag)	-0.0673	0.0161
Animal Welfare (2-month lag)	0.00408	0.3364
ZIP (3-month lag)	-0.0925	0.0004
Atkins (4-month lag)	0.0113	0.0557
Animal Welfare (4-month lag)	-0.0005	0.9057
Fat (5-month lag)	-0.0239	0.0078
Sustain (5-month lag)	0.00051	0.9145
Jan	0.0853	<.0001
Feb	-0.0951	<.0001
Mar	0.0643	<.0001
May	0.0742	<.0001
Jun	0.1031	<.0001
Jul	0.0501	<.0001
Aug	0.0995	<.0001
Oct	0.0781	<.0001
Nov	-0.04	0.0013
Autoregressive Term (3-month lag)	-0.2546	0.0002
Autoregressive Term (13-month lag)	0.3487	<.0001

Note: Each information count variable enters the model in natural log format.

Table A.2. 2008-2017 Beef Demand Index Regression

	Estimate	P-Value
Intercept	3.4098	<.0001
Consumer Sentiment	0.1121	0.0057
Cancer (Current Month)	0.0425	0.0197
Convenience (Current Month)	-0.0537	0.1775
TTF (Current Month)	0.1159	0.0189
Vegan (Current Month)	-0.0717	0.0177
Climate (1-month lag)	-0.0675	0.0976
Fat (1-month lag)	0.0309	0.0824
Sustain (1-month lag)	0.0576	0.0174
Vegan (2-month lag)	-0.059	0.0521
Animal Welfare (2-month lag)	0.0578	<.0001
ZIP (2-month lag)	-0.1045	0.0051
Cancer (3-month lag)	0.0739	0.0003
Climate (3-month lag)	-0.1413	0.001
TTF (3-month lag)	0.2125	<.0001
Vegan (3-month lag)	-0.0973	0.0034
Atkins (4-month lag)	0.0142	0.109
Vegan (4-month lag)	0.0543	0.0604
ZIP (4-month lag)	-0.0936	0.0267
Cancer (5-month lag)	0.0803	0.0001
Safety (5-month lag)	-0.0723	0.0014
TTF (5-month lag)	0.151	0.0005
Vegan (5-month lag)	-0.0658	0.0247
Animal Welfare (5-month lag)	0.0405	0.0028
Jan	0.00159	0.9223
Feb	-0.0831	<.0001
Mar	0.0198	0.3024
May	0.0192	0.2481
Jun	0.0369	0.0439
Jul	0.00235	0.8859
Aug	0.0105	0.5447
Oct	0.0361	0.0198
Nov	-0.0303	0.0322

Note: Each information count variable enters the model in natural log format.

FooDS Analysis Appendix

Regression Results (note: one asterisk indicates parameter is statistically different from zero at the 0.05 level or lower; N = 48,358 for each regression)

Variable	Steak demand (1-9)	Relative Steak Demand (-9 to +9)	Ground beef demand (0 to 9)	Relative Ground Beef Demand (-9 to +9)
Intercept	1.088*	-1.125*	0.686*	-1.527*
Income				
<$20K	base	base	base	Base
$20K-$39K	0.05*	0.091*	0.048*	0.089*
$40K-$59K	0.197*	0.333*	0.019	0.155*
$60K-$79K	0.291*	0.44*	-0.072*	0.077
$80K-$99K	0.365*	0.554*	-0.123*	0.065
$100K-$119K	0.394*	0.609*	-0.154*	0.061
$120K-$139K	0.442*	0.521*	-0.184*	-0.105
$140K-$159K	0.5*	0.693*	-0.179*	0.014
≥$160K	0.648*	0.86*	-0.328*	-0.116
Age				
<25	base	base	base	base
25-34	-0.043	0.196*	0.055*	0.294*
35-44	-0.06*	0.16*	0.019	0.238*
45-54	-0.142*	0.154*	0.043	0.338*
55-64	-0.22*	0.074	0.023	0.317*
65-74	-0.226*	0.117*	-0.101*	0.242*
≥75	-0.111*	0.272*	-0.074	0.309*
Household Size				
1	base	base	base	base
2	0.014	0.171*	0.103*	0.26*
3	-0.035	0.109*	0.138*	0.281*
4	-0.045	0.126*	0.224*	0.395*
≥5	-0.163*	-0.09	0.194*	0.267*
Education				
High School Degree or lower	base	base	base	base
Some College	-0.012	0.238*	0.224*	0.475*
BS or BA degree or higher	0	0.141*	0.124*	0.265*
Race				
Asian	base	base	base	base
White	-0.089*	-0.14*	0.38*	0.328*
Black	-0.17*	-0.09	0.064*	0.145*
Other Race	-0.354*	-1.014*	0.05	-0.61*
Non-Hispanic	base	base	base	Base
Hispanic	0.085*	0.082*	-0.095*	-0.098*

Region of Residence				
West	base	base	base	base
Northeast	-0.02	-0.031	-0.051*	-0.061
Midwest	-0.017	0.112*	0.144*	0.273*
South	-0.006	0.035	0.025	0.066*
Gender				
Male	base	base	base	base
Female	-0.356*	-0.683*	-0.118*	-0.445*
Primary Shopper				
No or shared	base	base	base	base
Yes	0.152*	0.338*	0.051*	0.237*
Presence of Children under 12 in household?				
No	base	base	base	base
Yes	0.161*	0.346*	0.011	0.196*
Currently on Food Stamps (or SNAP)?				
No	base	base	base	base
Yes	0.037	0.102*	0.037*	0.102*
Political Ideology				
Conservative scale	0.02*	0.116*	0.06*	0.156*
Don't know Ideology	-0.053	0.002	-0.108*	-0.053
Day of Week of Survey				
Sunday	base	base	base	base
Monday	0.011	-0.134*	-0.073*	-0.218*
Tuesday	-0.009	-0.15*	-0.033	-0.175*
Wednesday	0.017	-0.052	-0.013	-0.083
Thursday	0.036	0.046	-0.058	-0.048
Friday	0.05	0.058	-0.038	-0.029
Saturday	-0.044	-0.102	-0.043	-0.101
Month of Survey				
December	base	base	base	base
January	0.001	-0.002	-0.052	-0.055
February	0.006	0.079	-0.009	0.064
March	0.041	0.029	-0.011	-0.023
April	-0.062	-0.517*	-0.115*	-0.57*
May	0.002	0.121	0.027	0.146*
June	-0.063	-0.087	-0.062	-0.086
July	0.006	0.033	-0.028	-0.002
August	-0.021	0.031	-0.002	0.05
September	0.061	0.135*	-0.054	0.02
October	0.006	0.069	-0.032	0.031
November	-0.032	0.046	-0.029	0.049
Trend Variable				
Trend (1 to 48)	0	-0.003*	0	-0.003*
Food Values (effects coded relative to overall mean)				
Naturalness	0.005	-0.091*	-0.098*	-0.194*

Price	-0.136*	-0.11*	0.094*	0.121*
Taste	-0.002	0.101*	0.081*	0.184*
Safety	-0.057*	0	0.034*	0.091*
Convenience	0.021*	0.097*	0.071*	0.147*
Nutrition	-0.069*	-0.163*	-0.107*	-0.202*
Novelty	0.16*	0.225*	-0.021*	0.044*
Origin	0.057*	0.088*	-0.01	0.021
Fairness	0.006	-0.028	0.004	-0.031
Appearance	0.057*	0.215*	0.054*	0.212*
Environment	-0.002	-0.125*	-0.069*	-0.193*
Animal Welfare	-0.04*	-0.209*	-0.032*	-0.201*
R^2	0.066	0.068	0.063	0.077

Media and Medical Journal Search and Data Analysis Details

Each item below identifies the keywords used and whether Medline or Lexis-Nexis database was utilized. This process follows that of Tonsor, Mintert, and Schroeder (2010) by downloading all articles containing these keywords and building 12 monthly time series variables summarizing the volume of information distributed either through the media or medical sector.

1. Fat, Cholesterol, Heart Disease, Arteriosclerosis (*FCHA*)
    a. Keywords:
        i. Beef Index: "(fat or cholesterol) and (heart disease or arteriosclerosis) and (beef or cattle)"
        ii. Pork Index: "(fat or cholesterol) and (heart disease or arteriosclerosis) and (pork or swine or hogs)"
        iii. Chicken Index: "(fat or cholesterol) and (heart disease or arteriosclerosis) and (chicken or poultry or broiler)"
    b. Use Medline database on medical journal articles

2. Atkins, High Protein, Low Carbohydrate (*Atkins*)
    a. Keywords:
        i. Beef Index: "(Atkins or high protein or low carbohydrate) and (beef or cattle)"
        ii. Pork Index: "(Atkins or high protein or low carbohydrate) and (pork or swine or hogs)"
        iii. Chicken Index: "(Atkins or high protein or low carbohydrate) and (chicken or poultry or broiler)"
    b. Use Lexis-Nexis database on U.S. newspapers.

3. Zinc, Iron, Protein (*ZIP*)
    a. Keywords:
        i. Beef Index: "(zinc or iron or protein) and (beef or cattle)"
        ii. Pork Index: "(zinc or iron or protein) and (pork or swine or hogs)"
        iii. Chicken Index: "(zinc or iron or protein) and (chicken or poultry or broiler)"
    b. Use Medline database on medical journal articles

4. Fat (*Fat*)
    a. Given books like *Big Fat Surprise* and other discussions the impact of fat on beef demand *may* have changed to having a fat specific index (not just FCHA) may be useful.
    b. Keywords:
        i. Beef Index: "(fat) and (beef or cattle)"
        ii. Pork Index: "(fat) and (pork or swine or hogs)"
        iii. Chicken Index: "(fat) and (chicken or poultry or broiler)"
    c. Use Medline database on medical journal articles

5. Taste, Tender, Flavor (*TTF*)
    a. Keywords:
        i. Beef Index: "(taste or tasty or tender or juicy or flavor or savor) and (beef or cattle)"

ii. Pork Index: “(taste or tasty or tender or juicy or flavor or savor) and (pork or swine or hogs)”
iii. Chicken Index: “(taste or tasty or tender or juicy or flavor or savor) and (chicken or poultry or broiler)”

b. Use Lexis-Nexis database on U.S. newspapers.

6. Sustainability, Social Responsibility, etc.

a. Use Lexis-Nexis database on U.S. newspapers.

b. *Sustain*
   i. Keywords:
      1. Beef Index: “(sustainable or sustainability or sustain) and (beef or cattle)”
      2. Pork Index: “(sustainable or sustainability or sustain) and (pork or swine or hogs)”
      3. Chicken Index: “(sustainable or sustainability or sustain) and (chicken or poultry or broiler)”

c. *Climate*
   i. Keywords:
      1. Beef Index: “(climate change or greenhouse gas or global warming or water or environment) and (beef or cattle)”
      2. Pork Index: “(climate change or greenhouse gas or global warming or water or environment) and (pork or swine or hogs)”
      3. Chicken Index: “(climate change or greenhouse gas or global warming or water or environment) and (chicken or poultry or broiler)”

d. *Vegan*
   i. Keywords:
      1. Beef Index: “(vegan or vegetarian or meatless) and (beef or cattle)”
      2. Pork Index: “(vegan or vegetarian or meatless) and (pork or swine or hogs)”
      3. Chicken Index: “(vegan or vegetarian or meatless) and (chicken or poultry or broiler)”

7. Food Safety

a. Keywords:
   i. Beef Index: “(safety or recall) and (beef or cattle)”
   ii. Pork Index: “(safety or recall) and (pork or swine or hogs)”
   iii. Chicken Index: “(safety or recall) and (chicken or poultry or broiler)”

b. Use Lexis-Nexis database on U.S. newspapers.

8. Animal Welfare

a. Keywords:
    i. Beef Index: "((animal welfare) or (animal well-being) or (animal friendly) or (animal care) or (animal handling) or (animal transportation)) and (beef or cattle)"
    ii. Pork Index: "((animal welfare) or (animal well-being) or (animal friendly) or (animal care) or (animal handling) or (animal transportation)) and (pork or swine or hogs)"
    iii. Chicken Index: "((animal welfare) or (animal well-being) or (animal friendly) or (animal care) or (animal handling) or (animal transportation)) and (chicken or poultry or broiler)"
b. Use Lexis-Nexis database on U.S. newspapers.

9. Convenience

a. Keywords:
    i. Beef Index: "(preparation or prepare or cook or bake or grill) and (ease or easy or short or quick or fast) and (beef or cattle)"
    ii. Pork Index: "(preparation or prepare or cook or bake or grill) and (ease or easy or short or quick or fast) and (pork or swine or hogs)"
    iii. Chicken Index: "(preparation or prepare or cook or bake or grill) and (ease or easy or short or quick or fast) and (chicken or poultry or broiler)"
b. Use Lexis-Nexis database on U.S. newspapers.

10. *Cancer*

a. Keywords:
    i. Beef Index: "(cancer) and (beef or cattle)"
    ii. Pork Index: "(cancer) and (pork or swine or hogs)"
    iii. Chicken Index: "(cancer) and (chicken or poultry or broiler)"
b. Use Lexis-Nexis database on U.S. newspapers.

A factor analysis was conducted on the 12 resulting indices for each species. On balance the factor analysis failed to provide cleanly separated factors that were intuitive.