THREE ESSAYS ON DEMAND FOR MEAT AND DAIRY PRODUCTS

EVIDENCE FROM HOUSEHOLD LEVEL DATA

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by

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The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled

THREE ESSAYS ON DEMAND FOR MEAT AND DAIRY PRODUCTS
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presented by Agnieszka Dobrowolska Perry,
a candidate for the degree of doctor of philosophy,
and hereby certify that, in their opinion, it is worthy of acceptance.

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Professor Patrick Westhoff

Professor Deanna Sharpe

DEDICATION

I dedicate this work...

To my husband, Robert I am still at awe at the love and support you've shown me over the years;

To my parents who never stopped believing this would eventually come together;

To my grandparents who raised me to be strong, independent and hardheaded;

To my family and friends for being there for me and tagging along on this journey.

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ABSTRACT

Dairy and meat demand is not only influenced by prices and income but also by generational cohort (Millennial, Gen X, Baby Boomers, and Traditionalists), race, and other demographic factors. This study examines the demand for meat and dairy product using Consumer Expenditure Survey (CEX) household-level data and the Almost Ideal Demand System (AIDS).

In the first essay, a system for milk, butter, cheese, ice cream, other dairy and meat is estimated using an AIDS model for years 2013-2019. The system is estimated separately for each generation and incorporates demographic variables such as the number of children, employment status, race, or area of residence. The results indicate some material differences in dairy demand between the four generational groups. It also reveals the significant impact of income, race, and employment status on dairy demand. Different generations have much different own-price elasticities for milk, cheese, and ice cream. Among all generations, milk demand is relatively inelastic, while butter and ice cream demand is very elastic. The results of this research indicate that the incorporation of demographic variables and generational cohorts into demand systems has a considerable impact on demand elasticities. Therefore, any future dairy demand forecasts must begin to incorporate demographic information to provide more accurate estimates of future demand.

In the second essay, a Linear Approximate Almost Ideal Demand System (LA-AIDS) for U.S. meat demand is estimated using annual average expenditures on beef, pork, poultry, seafood and food at home, for years 2001-2019. The results are estimated for all consumers, as well as, separately for four generational cohorts. The results sug-

gest that younger cohorts spend more on poultry than older cohorts (Millennials and Gen X vs Baby Boomers and Traditionalists). Contrary to other studies, his study found beef own-price elastictity to be the least elastic among the meat products. The results of this study suggest that the higher consumption of poultry among younger generations compared to beef and pork is a result of change in preference structure.

The third essay determines how own- and cross-price elasticties change depending on the period of data collection. The research uses AIDS model with household level data that includes explanatory variables such as: generational cohort, race, and other demographic factors. This study examines the demand for dairy and meat products in the United States using CEX data from two distinct periods, years 2002-2006 and 2015-2019. The system is estimated separately for each commodity group and incorporates demographic variables such as the number of children, employment status, or race. The results indicate differences in meat and dairy demand between the two periods. It also reveals the significant impact of income, race, and employment status on dairy and meat demand. Demand for beef steak, pork, chicken, and fish was noticeably different between the two periods. Similarly, demand elasticities of all dairy commodities were different between the two periods. Lastly, the results of this research are used to forecast U.S. beef, pork, and poultry consumption by 2030. The consumption projections, based on each period separately, strongly suggest that the period of fit has a noticeable and potentially consequential impact on predicted future outcomes.

1 GENERATIONAL AND DEMOGRAPHIC FACTORS THAT INFLUENCE U.S. DAIRY DEMAND - EVIDENCE FROM AN AIDS ESTIMATION WITH HOUSEHOLD DATA

1.1 Introduction

Policymakers and the food sector need updated analyses of food consumption changes, dietary patterns, and consumer preferences. The gradual decline of per-capita milk consumption has been of concern to researchers, policymakers, and milk producers for several decades (Heien and Wessells, 1988b). The declines in per-capita consumption and the continual rise in herd productivity, have an increasing ripple effect through the whole food system affecting not only milk but also grain prices. Given the increased number of dairy support programs that seem to fall short of their goals, an improved understanding of dairy products' demand is needed for future policy analysis. Previous research (Andreyeva et al., 2010; Blisard et al., 2002; Kuhns and Saksena, 2017; Huang and Lin, 2000; Davis et al., 2011) indicates that food consumption patterns differ between income groups, age groups, genders, ethnic groups, and geographic distributions. This previous research has also shown differences in consumer sensitivity to price changes across different food items and item groups. However, existing research is limited by not considering the impacts of cohort group on the demand and demographic variables from disaggregated data.

Generally, food policy analysis uses the food demand elasticities derived from research studies, whether explicitly or implicitly (Okrent and Alston, 2011). In many research studies, relevant aspects of demand response are derived using elasticities. As a result, the policy analysis's quality is contingent on the quality and relevance of the available elasticity estimates. This research argues that updated dairy product demand elasticities should be of vital interest to policymakers today as consumer behavior continues to evolve. Additionally, the author is looking into the impact of demographics, including generation, on the dairy demand elasticities, which should provide a unique insight into each group's price and income sensitivity with respect to dairy purchases. Changes in dairy demand elasticities could be critical to the success or failure of federal dairy policy and lead to more or less price volatility.

Blisard et al. (2002) measured changes in consumer food spending by examining a variety of demographic characteristics, including income, gender, age, and ethnicity. There were two assumptions explicitly mentioned by the authors that limited the accuracy and informative quality of the study. First, the researchers assumed that preferences change as people age, not considering potential generational differences and constant cohort preferences that stay relatively stable over time in the same generational groups as preferences are often shaped by early life experiences (Lee et al., 2020). Secondly, they assumed that people of the same age will have the same preferences at different points in time. That is, they assume a person who is 25 years old in 1990 would have the same preferences as the person who is 25 years old in 2019. These assumptions are more restrictive than what likely occurs. In contrast, this research draws on a growing body of literature regarding how consumption patterns differ by generation and can change over time and present an updated set of demand elasticities for dairy products.

This study focuses on milk, butter, cheese, ice cream, and other dairy products in the U.S., using the almost ideal demand system (AIDS), first described by Deaton and Muellbauer (1980), with the incorporation of Inverse Mills Ratio (IMR) and demographic effects following Heien and Wessells (1990). To estimate the model, data from the 2013-2019 Consumer Expenditure Survey (CEX), Diary section collected by the Bureau of Labor Statistics (BLS) were used. The results from the estimation suggest that including demographic effects in the estimation, makes a material difference in the elasticity estimates from the dairy demand system. This suggests that food demand research should take into account demographic effects when performing demand analyses and forecasts.

The current analysis has two objectives. First objective is to estimate the demand for dairy products, using household-level data. The use of disaggregated household-level data allows for the measurement of demographic effects, as well as price and expenditure effects. Second, this study reports on estimation using subsets of data, representing each of the four generations, Millennials, Gen X, Baby Boomers, and Traditionalists, over the 7-year period. The objective is to measure cohort effects, in this case, generation effects on dairy purchase behavior. By-generation estimates allow for comparisons of how each cohort responds to changes in prices and expenditures. Such updated elasticities for the whole sample and by generation will aid in a more realistic and accurate forecast of future dairy products demand.

The next section provides data sources for the variables used in the analysis. The method of analysis and the definition of the applied demand system is discussed in the next section, followed by results from the model using full sample and comparison of results by generational cohort. The final section contains the conclusions and suggestions for future research.

1.2 Data

Multiple data sets from the CEX Public Use Micro Data (PUMD) from BLS were combined and used in this research. The CEX data is divided into two parts, the Interview Survey, and the Diary Survey (DS), with different methods and sample populations. This analysis will focus on data provided by the DS. The DS is especially relevant to this research as it collects data on daily expenditures. The DS is a repeated cross-sectional dataset including biweekly detailed purchases of food at home. The DS has two parts, a Household Characteristic Questionnaire, which collects detailed demographic and income information on all members of the household, and a Record of Daily Expenses. The Record of Daily Expenses is a self-reported diary where each respondent records all household expenses for two consecutive weeks, with each week treated as an independent observation. Each week for each household is recorded as a separate observation in the data set. The short survey period, of one week at the time, results in a large number of zero expenditures on a specific product in the data set. However, a zero observation, does not necessarily indicate given household does not consume a certain good, it might rather indicate the product is purchased less frequently, for example once a month. This is most likely true for products such as butter and ice cream, but not for highly perishable staples such as fluid milk. The use of household-level data avoids the problem of aggregation over consumers and provides a large statistically rich sample. The households were divided into four generational cohort groups based on the birth year of the reference person.

One of the main limitations of the CEX PUMD Diary data set is that it does not record the price paid by each household for a given commodity. Therefore, no distinction can be made as to the quality differences of purchases between different demographic groups. As a result, the current research assumes that all households face the same price at the same point in time (each month) for each of the products analyzed. In the absence of price data in the CEX, the price data used is obtained from Agricultural Marketing Service (AMS) for fluid milk and BLS Consumer Price Index (CPI) for the corresponding period. The authors assumption was that the AMS price data was more consistent with the prices faced by the consumers during the study period[1]. The CPI data was chosen following the approach described by Lee et al. (2020). All the data was indexed to January 2013 = 100. Specifically, the following data series from the CPI were used: (1) monthly adjusted national CPI for all food, (2) monthly adjusted national CPI for butter, cheese, ice cream, other dairy, and meat, and (3) AMS milk price monthly series[2]. Next, the CEX PUMD data and the CPI data were merged by date.

1.3 Methods

The demand for dairy products is influenced by a products own price, prices of close substitutes/complements, income (expenditure), and demographic factors. The data

[1]No AMS data was available for the other variables.

[2]The list of CPI variables used in this research is presented in table A2 in the Appendix.

from the CEX DS and CPI used as a proxy for prices are used to estimate an Almost Ideal Demand System (AIDS). The estimated demand system encompasses seven food items with an emphasis on dairy products. The AIDS system is commonly used because of its flexibility and linearity. It is also a complete system, which means it can be restricted to satisfy conditions of adding up, homogeneity and symmetry. The estimation approach employed here follows a two-stage procedure outlined by Heien and Wessells (1990). In this procedure, a probit regression is used to censor the dependent variable as a direct way to deal with zero observations present in the survey data. The most likely reason for the high number of zero observation is the short duration of the survey. Each observation represents a single week. There are many commodities, such as butter or ice cream that are not a weekly purchase for many households.The probit regression is specified as:

$$Y_{ih} = f(d_{ih}, ..., d_{sh}). \tag{1.1}$$

Where Y_{ih} is the hth household binomial value of consumption of ith good. If $w_{ih} > 0$, representing the weekly expense of the hth household on ith good, then $Y_{ih} = 1$, and 0 otherwise. This presents a dichotomous choice problem for each good as a function of demographic variables d of which there are s. The full list of demographic variables is presented in table 1.4.

The result of the probit analysis is used to calculate the IMR, which is then directly used as a predictor in the demand system. The IMR is defined as follows:

$$R_{ih} = \phi(\mathbf{p}_h, \mathbf{d}_h, m_h)/\Phi(\mathbf{p}_h, \mathbf{d}_h, m_h) \tag{1.2}$$

as defined in (Heien and Wessells, 1990) specified for the ith food item for the hth household, where $\mathbf{p}_h$ is the vector of prices and $\mathbf{d}_h$ is the vector of demographic variables, m_h is the total expenditure (here total food at home expenditure) of the hth household, and ϕ and Φ are the density and cumulative probability functions, respectively.

The AIDS model demand relations, in a budget share form, follow the specification given by Deaton and Muellbauer (1980) as outlined by Heien and Wessells (1990). A demographic translation method was applied to incorporate demographic variables into the analysis. The AIDS model is specified as:

$$w_{ih} = \alpha_{io} + \sum_{k=1}^{s} \rho_{ik} d_{kh} + \sum_{j=1}^{n} \gamma_{ij} p_{jh} + \beta_i \ln(m_h/Z_h) + \delta_i R_{ih}, \tag{1.3}$$

where Z is defined as:

$$Z_h = \sum_{i=1}^{n} w_i \ln p_{ih}. \tag{1.4}$$

The following restrictions of economic theory were also applied to the system:

adding up -

$$\sum_{i=1}^{n} \alpha_i = 0; \qquad \sum_{i=1}^{n} \gamma_i = 0, \quad j = 1, ..., n; \qquad \sum_{i=1}^{n} \beta_i = 0; \tag{1.5}$$

homogeneity -

$$\sum_{j=1}^{n} \gamma_{ij} = 0, \qquad i = 1, .., n; \tag{1.6}$$

and symmetry -

$$\gamma_{ij} = \gamma_{ji} \quad \text{for all} \quad i, j(i = j). \tag{1.7}$$

The elasticity calculations are given by:

own- and cross-price elasticities −

$$\varepsilon_{ij}^{M} = \frac{\gamma_{ij} - \beta_i (w_j - \beta_j (lnX/P))}{w_i} - \delta_{ij}$$

$$\text{where} \quad \delta_{ij} = 1 \quad \text{if} \quad i = j$$

$$= 0 \quad \text{otherwise} \tag{1.8}$$

and expenditure elasticities given by:

$$e_i = \frac{\beta_i}{w_i} + 1 \tag{1.9}$$

The equation for the last good, in this case, all other food, was deleted to ensure non-singularity of the error covariance matrix. To warrant the reliability of elasticities, the delta method was used to calculate standard errors of the elsticities, which were used to determine the significance levels. The demand system was estimated using the `sampleSelection` and `systemfit` packages in R (Henningsen and Hamann, 2007; Henningsen and Toomet, 2008).

1.4 Results

1.4.1 Summary statistics

The data were aggregated into the following 7 categories: milk (55%), butter (13%), cheese (44%), ice cream (22%), other dairy (34%), meat (67%) and, other food products (99%). The percentages in parentheses give the proportion of households in the survey sample that reported purchasing given food products during each of the survey weeks (after the outliers were removed). This specification implies that the food items are separable from the other (nonfood) items in the consumer's budget.

Among dairy products, the average consumer expenditures were the largest for cheese \$2.88 and milk \$2.41[3]. Milk and cheese were also the most frequently purchased dairy product. The smallest average weekly expenditures were on butter \$0.58. Butter was also the least frequently purchased dairy product. This can be easily explained by butter being sold in relatively large packages and having a longer shelf life. The largest expenditure and budget share was occupied by the combined meat category, with mean expenditure of \$13.75 and a 14% budget share.

Among generations, there were also, differences in the proportion of households

[3] Means calculated based on all observations, including zeros.

who purchased each dairy product, as well as the average expenditure on each category in each given week recorded in the survey. All generations, spent each week on average, the least on butter, with an average expenditure between \$0.46 and \$0.63 per week. Gen X and Baby Boomers spent the most on milk, \$2.81 and \$2.33, respectively, with Millennials a close third with average weekly milk expenditures at \$2.31. This, seems intuitive, for Gen X and Millennials, as these are the two generations most likely to have children as part of their household. Baby Boomers spent as much on milk as younger generations, even though there were no children present in the vast majority of Baby Boomer households. Traditionally, Baby Boomers grew up drinking milk, which seems to have remained the case over time, highlighting the impact of upbringing and cohort effects on food purchases made later in life.

Children were present in 43% and 66% of Millennial and Gen X households during the study period, respectively; and in 27% of Baby Boomers households. Additionally, among households with children, there were two or more children present in 25% of Millennial and 43% of Gen X households. Children were present in only 12% of the Traditionalist households and the oldest generation spent the least on milk, \$2.06 during the same period. Presence of children provides an explanation of higher milk demand, among Millennial, Gen X and Baby Boomers households, compared to Traditionalists. All generations, spent each week on average, the most on cheese, between \$2.40 and \$3.24, with Traditionalists spending the least and Gen X the most. All generations, third-largest dairy expenditure was other dairy, with Traditionalists spending the least at - \$1.41 and Gen X spending the most at \$2.13. All generations spent similar amounts on ice cream, between \$1.03 and \$1.40. Only 18% of Millennial households reported purchasing ice cream, compared to over 23% of households in all other generations reporting purchasing ice cream in the same time period.

Table 1.1: **Sample statistics for all households - average recorded weekly expenditures per household**

Variable	Mean in $ per week expenditures	SD
Milk	2.41	2.94
Butter	0.58	1.67
Cheese	2.88	4.65
Ice cream	1.31	3.08
Other dairy	1.82	3.41
Meat	13.75	16.23
Food at home	87.82	73.35

[a] Includes all above food categories.

1.4.2 AIDS results, estimation period 2013-2019, censored with full demographics.

Seven years of data from 2013-2019 were used in the estimation. The full sample contained observations from 67,367 households after removing households that did not report any food-at-home purchases. The thresholds determining the outlier cutoff values were set at: milk < 15, butter < 12, cheese < 30, ice cream < 30, other dairy < 30, meat < 75. The observations were removed if the weekly expenditure was larger than values indicated above. The outlier treatment resulted in the removal of 3,639 observations, leaving 63,728 households.

Table 1.2 shows the uncompensated (Marshallian) own- and cross-price elasticities for the 6 different food products for all consumers in the sample[4]. The demand system presented in this research is constrained by total at-home food expenditure, not by income, total expenditure, or total food expenditure (which would include food consumed away from home). Therefore, the omitted equation, represents all other food consumed at home.

[4]All other food variable was omitted.

Table 1.2: **Own- and cross-price elasticities for dairy products 2013-2019 - All generations**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Milk	-0.400***	0.438***	-0.151***	0.240***	0.471***	-0.582***
	(0.007)	(0.006)	(0.005)	(0.004)	(0.009)	(0.002)
Butter	-0.084***	-0.046***	0.763***	-1.246***	0.542***	0.050***
	(0.002)	(0.003)	(0.005)	(0.006)	(0.006)	(0.005)
Cheese	0.250***	-0.395***	-1.359***	-0.401***	-0.150***	0.365***
	(0.005)	(0.005)	(0.023)	(0.005)	(0.005)	(0.017)
Ice cream	0.187***	-1.449***	0.438***	-3.723***	-2.354***	3.442***
	(0.017)	(0.015)	(0.016)	(0.025)	(0.015)	(0.018)
Other dairy	4.075***	-1.033***	0.478***	0.247***	-1.867***	0.245***
	(0.018)	(0.013)	(0.004)	(0.005)	(0.022)	(0.011)
Meat	1.844***	0.098***	0.008	0.092***	-0.122***	-0.672***
	(0.011)	(0.009)	(0.007)	(0.016)	(0.013)	(0.022)

Note. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Standard errors (SE) are shown below the elasticities.

The SE and significance levels were obtained by a delta method approximations.

All own-price elasticity estimates are negative and statistically significant which is consistent with theory and expectations. Based on the presented findings the dairy product most responsive to price changes is ice cream with the elasticity of -3.723. The own price elasticity of other dairy was -1.867, the second most elastic dairy product category, which implies a 1% change in the price of other dairy products will result in a just under 2% decline in demand of other dairy. Milk and cheese, were the least responsive with elasticities of -0.4 and -0.046 respectively.

Based on the uncompensated own-price elasticities, a 1% decrease in the price of ice cream will result in a greater than 3% increase in the amount of ice cream demanded. Milk, butter, and meat own-price elasticities, were all less then 1, implying that a 1% drop in the price of each of these products will result in less than 1% change in the quantity demanded.

Butter own-price elasticity in this study is smaller in absolute values than the elasticities presented in Heien and Wessells (1988b) and Heien and Wessells (1990) (the uncensored model), -0.73, -0.91, respectively. However, it is more inelastic than elasticities in Davis et al. (2011), with the comparison value at -1.78. Own-price milk elasticity in this study is smaller than the ones presented in Heien and Wessells (1988b), Heien and Wessells (1988a), Heien and Wessells (1990), and Davis et al. (2011) and more similar to the one found by Haidacher et al. (1988). Conversely, this study found ice cream demand to be much more elastic compared to other studies (Heien and Wessells, 1990; Davis et al., 2011; Heien and Wessells, 1988b,a). All comparison values are shown in table 1.7.

Table 1.3, shows the expenditure elasticities for the 6 different food products for all consumers in the sample. The coefficients in the system were estimated based on the budget share of each product in the total food at home expenditure. All expenditure elasticities are positive and statistically significant at significance level $p = 0.01$ implying that dairy products are normal goods.

Table 1.3: **Expenditure elasticities for dairy products 2013-2019.**

	Exp. elas.	SE
Milk	0.348***	0.009
Butter	1.127***	0.017
Cheese	1.103***	0.008
Ice cream	0.89***	0.014
Other dairy	1.115***	0.010
Meat	1.219***	0.005

Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Four, out of 6 goods have expenditure elasticities larger than 1, ranging from 1.219 for meat to 1.103 for cheese. Given those elasticities, a 1% increase in the household expenditures for the observed products would increase the demand for butter, cheese, ice cream, other dairy, and meat products. Expenditure elasticities for butter, cheese, and ice cream were similar to those found by Davis et al. (2011)[5] and Heien and Wessells (1990). Butter and cheese expenditure elasticities were also comparable to those found in Heien and Wessells (1988b) and Heien and Wessells (1990). Milk expenditure elasticity was much smaller, at 0.348, compared to other studies (Heien and Wessells, 1990; Davis et al., 2011; Heien and Wessells, 1988b,a), yet much larger compared to the value found by Haidacher et al. (1988) at -0.22[6].

[5]Compared natural cheese in Davis et al. (2011).

[6]Value found by Haidacher et al. (1988) would suggest milk is an inferior good.

The estimated cross-price elasticities reveal several substitution relationships. Ice cream is a substitute (ie. cross-price elasticity is positive) to milk, and other dairy. Meat is a substitute to butter, cheese and ice cream. In addition to the substitution relationships, only one complementary relationship was revealed in this study. Ice cream is a complement (ie. cross-price elasticity is negative) to butter. Heien and Wessells (1990) found cheese to be a complement to milk, butter and meat. Out of those three, this study found cheese to be a substitute only to meat. Similarly to Davis et al. (2011) who found cheese to be a substitute to other diary products, this study found cheese to be a substitute to meat, but no such relationships with the dairy products included in the system was found. One of the major limitations of this study is that it is impossible to determine if all cross-price relationships are actual decisions consumers will make, because of the use of expenditure data instead of actual consumption data. Using expenditure data makes it impossible to determine which foods consumers ate as complements, and which were just purchased at the same time. Additionally, several observed cross-price relationships were larger in magnitude than own-price effects, which is unexpected at best.

Table 1.4: **List of independent variables.**

Variable	Variable definition
Household income quantile	5 levels: **1st quantile**$^{(a)}$, 2nd quantile, 3rd quantile, 4th quantile, 5th quantile
Number of children	4 levels: **No children**, One child, Two Children, Three or more children
Additional adults	3 levels: textbfOne adult, Two adults, Three or more adults
Family type	6 levels: **Married couple/no children**, Married couple/own children, Single parent, Single Consumers, All other husband and wife families, Other families
Housing	3 levels: **Owner/mortgage**, Owner/no mortgage, Renter
Race	4 levels: **White**, Black, Hispanic, Other
Region	5 levels: **Missing**, Midwest, North-East, South, West
Employment	4 levels: **Salaried employee**, Self employed, Retired, Not working/other than retired
Level of urbanization	2 levels: Rural, **Urban**
Number of earners	4 levels: **No earners**, One earner, Two earners, Three or more earners
Season	4 levels: **Spring**, Summer, Fall, Winter

Note. $^{(a)}$ The 1^{st} quantile represents the lowest income group.

The demographic variables in **bold** are the default variables included in the system.

1.4.3 Estimation results 2013-2019, demographic effects

It has been recognized that demand for dairy products is influenced by the population's age structure and other demographic factors. Table A4 in the Appendix shows the coefficient estimates derived from the demand system consisting of 7 different food product categories and 11 demographic variables.

The 11 demographic variables include household income quantile, number of children present in the household, number of adults, family type, dwelling ownership, race, region, type of employment, level of urbanization[7], number of earners, region, and season. The full list of demographic variables and their levels is presented in Table 1.4.

Findings from the demand system estimation show that purchases of milk are posi-

[7] Urban or rural.

tively influenced by the presence of children, with the presence of one child being positive and significant at $p = 0.05$. On the other hand, purchases of butter, cheese and ice cream, seem to be negatively impacted by the presence of children. Among the seasons, fall has a positive statistically significant (at $p = 0.01$) impact on ice cream purchases, with winter having the opposite effect at the same level of significance. Summer and fall seasons also seem to have a negative significant impact on purchases of butter and cheese.

Race defined as Black has a significant negative effect on purchases of all dairy products, and a positive impact on purchases of Meat, all at a $p = 0.01$ significance level. Hispanic respondents reported lower dairy product purchases at $p = 0.01$, and higher purchases of meat at $p = 0.01$. The negative impact of race on dairy purchases was similar to that found by Boehm (1975), specifically for Black households[8]. The annual household income of households where the reference person was Black or Hispanic reported an average income of $52,908 and $56,106 respectively, compared to the rest of the population whose average income was $80,659. Additionally, several research studies showed higher rates of lactose intolerance among Black and Hispanic populations (Lapides and Savaiano, 2018). Lower levels of disposable income to spend on food products including dairy, combined with a higher likelihood of dairy food intolerance are the likely contributor to the observed negative impact of Black and Hispanic race on dairy purchases. Residing in rural areas has a significant positive effect on purchases of milk, butter and cheese, compared to urban dwellers. The opposite seems to be the case for ice cream. The second, third, fourth, and fifth income quantile has a significant negative impact on purchases of milk and meat. This result would suggest that as income increases households spend relatively less on milk and meat. This might suggest a change in preferences among higher income household, switching away from milk and meat towards other food products. All income quantiles compared to the 1^{st} quantile have a positive impact on cheese purchases at significance level of at least

[8]No identified Hispanic households were included in Boehm (1975).

$p = 0.05$.

Of all the estimated demographic variables income, presence and number of children, race, and area of residence seem to have the largest impact on dairy purchases. Given, above findings, the overall influence of demographic variables on the purchase of dairy products is significant and should be considered when estimating the demand for dairy products. Results for demographic effects were very similar across generations, the corresponding coefficients for each generation can found in the Appendix.

1.4.4 AIDS results using data 2013-2019, censored with full demographics, divided by generation.

In the next stage of the estimation, the data was divided into four generations depending on the birth year of the reference person, ie. the person in the household who is filling out the survey. Based on birth year the generations have been defined as follows:

- Birth year of 1981 or later - Millennials,
- Birth year from 1965 to 1980 - Gen X,
- Birth year from 1946 to 1964 - Baby Boomers,
- Birth year from before 1945 - Traditionalists.

The data set contains 12,610 Millennial households, 17,353 Gen X, 23,181 Baby Boomers, and 10,584 Traditionalists.

Fifty-three (53%) percent of Millennial households reported purchasing milk, butter - 11%, cheese - 42%, ice cream - 18%, other dairy - 32%, meat - 63%, and all other food - 99%. Gen X households, reported purchases of dairy products more frequently than Millennials, with 59% purchased of Gen X households reporting purchases of milk, butter - 14%, cheese - 48%, ice cream - 23%, other dairy - 37%, meat - 69%, and all other food - 99%. Fifty-five percent (55%) of Baby Boomers households reported purchases of milk, butter - 14%, cheese - 45%, ice cream - 23%, other dairy - 34%, meat - 69%, and all other food - 99%. The percent of Traditionalists indicating purchases of milk, butter, and ice cream was higher than Millennial households, with 54% of Traditionalist households reporting purchases of milk and 24% ice cream. Traditionalists reported purchases of butter in 13% of the households in the survey, cheese - 40%, other dairy - 30%, meat - 63%, and all other food - 99%.

The results of the AIDS estimation for each generational group are presented in Table 1.5 showing the expenditure elasticities by generation and in Table 1.6 showing own- and cross-price elasticities for each product category.

Table 1.5: **Expenditure elasticities for dairy products 2013-2019 - by generation.**

	Millenials	SE	Gen X	SE	Baby Boomers	SE	Traditionalists	SE
Milk	0.411***	0.020	0.339***	0.017	0.283***	0.016	0.404***	0.021
Butter	1.155***	0.041	1.2***	0.030	1.101***	0.027	1.062***	0.040
Cheese	1.113***	0.018	1.063***	0.015	1.104***	0.013	1.166***	0.020
Ice cream	0.896***	0.036	0.881***	0.027	0.877***	0.023	0.902***	0.032
Other dairy	1.144***	0.022	1.11***	0.018	1.119***	0.016	1.082***	0.027
Meat	1.214***	0.010	1.193***	0.008	1.222***	0.007	1.249***	0.012

Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

As shown in Table 1.6 there are some substantial differences in own- and cross-price elasticities observed for each generation. Most own-price elasticities across generations were consistent with theory and statistically significant.

All generations, except Baby Boomers, had negative own-price elasticities for milk purchases, ranging from -0.27 for Millennials, to -0.912 for Traditionalists. Inelastic estimates associated with milk purchases, are intuitive, as milk is considered a staple. Those results are consistent with Huang (1985), yet slightly smaller than those presented by Heien and Wessells (1988b) and Heien and Wessells (1990) and substantially different compared to those in Davis et al. (2011). All comparison values are shown in table 1.7.

Table 1.6: **Own- and cross price elasticities for dairy products 2013-2019 data - by generation.**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Millennials						
Milk	-0.27***	0.499***	-0.226***	0.275***	-0.183***	-0.851***
	(0.017)	(0.014)	(0.012)	(0.011)	(0.021)	(0.005)
Butter	-0.099***	-0.809***	1.455***	1.238***	0.663***	-0.083***
	(0.005)	(0.006)	(0.012)	(0.013)	(0.014)	(0.013)
Cheese	-0.498***	1.346***	-1.429***	-0.726***	0.507***	-1.629***
	(0.013)	(0.012)	(0.053)	(0.012)	(0.012)	(0.039)
Ice cream	-0.729***	-1.953***	1.04***	-2.343***	-3.09***	6.097***
	(0.039)	(0.036)	(0.037)	(0.056)	(0.036)	(0.042)
Other dairy	8.651***	-1.338***	0.572***	0.386***	-2.771***	0.387***
	(0.042)	(0.029)	(0.011)	(0.011)	(0.051)	(0.027)
Meat	2.788***	-0.091***	-0.109***	0.226***	-0.136***	-0.827***
	(0.027)	(0.021)	(0.015)	(0.037)	(0.029)	(0.053)
Gen X						
	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Milk	-0.748***	0.631***	-0.19***	0.559***	0.751***	-0.772***
	(0.012)	(0.011)	(0.009)	(0.008)	(0.016)	(0.004)
Butter	-0.095***	-0.502***	1.475***	-0.979***	0.8***	0.021**
	(0.003)	(0.004)	(0.008)	(0.009)	(0.011)	(0.010)
Cheese	0.121***	-0.225***	-1.239***	-0.569***	-0.082***	3.159***
	(0.010)	(0.009)	(0.042)	(0.009)	(0.009)	(0.030)
Ice cream	1.445***	-2.527***	-0.016	-6.535***	-4.049***	3.09***
	(0.030)	(0.028)	(0.029)	(0.043)	(0.028)	(0.033)
Other dairy	4.216***	-2.461***	1.148***	0.403***	0.095**	0.326***
	(0.033)	(0.022)	(0.008)	(0.008)	(0.040)	(0.020)
Meat	2.431***	0.178***	-0.007	-0.008	-0.248***	-0.559***
	(0.020)	(0.016)	(0.011)	(0.029)	(0.022)	(0.041)
Baby Boomers						
	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Milk	0.103***	0.225***	-0.295***	0.006	0.725***	-0.663***
	(0.011)	(0.010)	(0.008)	(0.007)	(0.014)	(0.004)
Butter	-0.108***	0.538***	0.552***	-3.613***	0.243***	0.296***
	(0.004)	(0.004)	(0.008)	(0.009)	(0.010)	(0.009)
Cheese	1.415***	-2.266***	-0.44***	-0.704***	-0.895***	-0.606***
	(0.009)	(0.009)	(0.037)	(0.008)	(0.009)	(0.027)
Ice cream	-0.324***	-0.43***	0.033	-3.182***	-0.72***	1.965***
	(0.027)	(0.024)	(0.026)	(0.040)	(0.024)	(0.029)
Other dairy	2.223***	0.462***	-0.02	0.193***	-1.35***	0.118***
	(0.029)	(0.021)	(0.007)	(0.008)	(0.034)	(0.018)
Meat	0.926***	0.155***	0.135***	0.003	0.047**	-0.705***
	(0.018)	(0.014)	(0.011)	(0.026)	(0.021)	(0.037)
Traditionalists						
	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Milk	-0.912***	0.565***	0.17***	0.1***	0.173***	0.196***
	(0.015)	(0.014)	(0.014)	(0.011)	(0.021)	(0.006)
Butter	0.043***	0.329***	-1.439***	0.821***	0.759***	-0.465***
	(0.006)	(0.007)	(0.012)	(0.015)	(0.014)	(0.014)
Cheese	-1.732***	2.427***	-4.462***	0.316***	0.926***	0.802***
	(0.014)	(0.015)	(0.055)	(0.014)	(0.015)	(0.044)
Ice cream	0.559***	-0.856***	2.073***	-3.709***	-1.369***	3.673***
	(0.044)	(0.039)	(0.038)	(0.069)	(0.039)	(0.050)
Other dairy	3.262***	-2.556***	0.195***	-0.618***	-4.255***	0.269***
	(0.050)	(0.034)	(0.011)	(0.012)	(0.058)	(0.028)
Meat	1.973***	0.018	-0.098***	0.455***	-0.405***	-0.701***
	(0.029)	(0.020)	(0.018)	(0.038)	(0.034)	(0.054)

Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table 1.7: **Dairy products own- and expenditure elasticities - comparison with other studies.**

	Haidacher et al. (1988)	Heien and Wessells (1988b)	Heien and Wessells (1988a)	Heien and Wessells (1990)[1]	Davis et al. (2011)	This study
Own-price elasticity						
Milk	-0.26	-0.63	-0.81	-0.81 (u) -0.77 (c)	-1.60 to -2.30[2]	-0.400
Butter	-0.17	-0.73	-0.91	-0.91 (u) -0.00 (c)	-1.78	-0.046
Cheese	-0.17	-0.52	-0.57	-0.57 (u) -0.37 (c)	-0.90 to -1.72[3]	-1.359
Ice cream	NA	NA	-2.19	-2.19 (u) -0.05 (c)	-0.75	-3.723
Meat	NA	-0.51	-0.56	-0.56 (u) -0.42 (c)	NA	-0.672
Expenditure elasticity						
Milk	-0.22	0.77	NA	0.78 (u) 0.77 (c)	0.79 to 1.08	0.348
Butter	0.02	1.06	NA	1.10 (u) 0.76 (c)	1.05	1.127
Cheese	0.59	1.01	NA	1.02 (u) 0.89 (c)	0.90 to 1.09	1.103
Ice cream	NA	NA	NA	0.98 (u) 0.61 (c)	1.08	0.890
Meat	NA	1.08	NA	1.06 (u) 1.10 (c)	NA	1.219

Note. [1] In Heien and Wessells (1990) (u) refers to the uncensored and (c) to the censored model. [2] In Davis et al. (2011) range refers to whole milk, 1% milk, 2% milk, and skim milk. [3] In Davis et al. (2011) lower value refers to processed cheese and higher value refers to natural cheese.

Own-price elasticities of butter were relatively inelastic for both Millennials and Gen X, at -0.809 and -0.502 respectively. Own-price ealsticities of butter for Baby Boomers and Traditionalists were positive.

All own-price elasticities associated with ice cream purchases across generations were negative, statistically significant at $p = 0.01$ and larger than two (in absolute values), with -2.343 for Millennials, -6.535 for Gen X, -3.182 for Baby Boomers, and -3.709 for Traditionalists. This implies that a 1% increase in the price of ice cream would result in more than a 2% decline in the quantity of ice cream demanded across all generations. This also, intuitively, makes sense, as ice cream is not a staple food product. Also, across all generations only between 18 and 24% of households reported ice cream purchases in any given week. Consumption seasonality and long shelf life of the product, both contribute to more infrequent purchases of ice cream, which in turn can result in how elastic own-price response is.

Own price elasticities of meat are less than one across all generations, ranging from -0.559 for Gen X to -0.827 for Millennials. Those estimates are much smaller compared to results shown by Heien and Wessells (1988b) and Heien and Wessells (1990), with -1.08 and -1.06, respectively.

Expenditure elasticities by generation, shown in Table 1.5 were consistent with findings for all consumers.

Cross-price elasticities estimated in a demand system, represent relationships of consumers' preferences when purchasing (consuming) one product over another. Cross-price elasticities, shown in Table 1.6 reveal some interesting differences in substitution and complementarity of dairy products across generations. Among Millenials, milk is a complement to cheese. On the contrary, milk is a substitute to all dairy products, but cheese for Traditionalists. For Gen X, milk is a substitute to ice cream and other dairy. Among Baby Boomers, milk is a substitute to other dairy. Butter is a substitute to cheese, for Millennials. Butter is also a complement to ice cream, other dairy, and meat for Baby Boomers. Cheese is a substitute to ice cream and other dairy for Traditionalists. The results are mixed for all other generations. Cheese is a complement to milk for Millenials. For Gen X cheese is a complement to ice cream. For Traditionalists, cheese is a substitute to ice cream and other dairy. Ice cream is a substitute to meat for three out of four generations (excluding Baby Boomers). The patterns of complimentary and substitution relationships are similar between some generations, and different between others. For example, milk being a substitute to other dairy products for all generations but Millennials. Yet, there are some significant differences as well. Ice cream is a complement to cheese for Gen X and a substitute to Traditionalists.

1.5 Conclusions

Economic analysis of disaggregated dairy product demand provides insight into how changes in price, expenditure, and demographic characteristics affect purchases of various dairy products. The results presented research, for all 5 dairy products, and meat, indicate that price, expenditure, and demographic characteristics, all play an important role in determining dairy purchases. The majority of the demographic factors included in this research had marginal, yet statistically significant impact on estimated demand. The inclusion of demographic variables and generation cohorts makes a noticeable difference in the elasticity estimates obtained. Substitution and complimentary relationships between dairy products were also revealed by this study. Since demographic characteristics of a population are not easily changed, further research may be needed to help explain why consumption patterns vary by factors such as race, or region of residence.

Understanding how all consumers in comparison to different demographic groups including generations respond to changes in prices, and which products are considered complements and substitutes can help dairy companies and retailers in tailoring their production, pricing, and marketing strategies to accommodate different consumer groups demands for dairy products. Findings from this study can help dairy companies and retailers in more targeted approaches to pricing, sales, and promotional actions, depending on the product and the age group (generation) targeted. Better incorporation of demographic and generational effects will impact not only business-oriented analysis but also should be used in the assessment of policy and welfare programs.

Future research could further the applicability and robustness of the results of this study by adding more food products into the system. In addition, a comparison of generation effects with age effects, combined with the inclusion of demographic variables, could provide some valuable insights on age and demographic related preference change. The largest drawbacks of this study stem from data limitations, including lack of price and/or quantity data, a large number of zero observations in the survey, many observations that by their size would suggest purchases meant to last longer than the one week period, as well as lack of knowledge if the reference person filling out the survey was also the person making the majority of food purchasing decisions.

The results of this research strongly suggest that incorporation of demographic variables into demand systems has an impact on presented demand elasticities. Therefore any future forecasts of dairy demand should to incorporate demographic information to provide more accurate estimates of future demand.

Appendix A

Table A1: **Dairy expenditures and percent reporting by generation**

Generation	Variable	Expenditure Mean	Expenditure SE	Expenditure percent reporting
All consumers	Milk	$2.41	0.01	55%
	Butter	$0.58	0.01	13%
	Cheese	$2.88	0.02	44%
	Ice cream	$1.31	0.01	22%
	Other dairy	$1.82	0.01	34%
	Meat	$13.75	0.06	67%
Millennials	Milk	$2.31	0.03	53%
	Butter	$0.46	0.01	11%
	Cheese	$2.56	0.04	42%
	Ice cream	$1.03	0.02	18%
	Other dairy	$1.71	0.03	32%
	Meat	$12.44	0.14	63%
Gen X	Milk	$2.81	0.02	59%
	Butter	$0.61	0.01	14%
	Cheese	$3.24	0.04	48%
	Ice cream	$1.35	0.02	23%
	Other dairy	$2.13	0.03	37%
	Meat	$15.50	0.13	69%
Baby Boomers	Milk	$2.33	0.02	55%
	Butter	$0.63	0.01	14%
	Cheese	$2.99	0.03	45%
	Ice cream	$1.40	0.02	23%
	Other dairy	$1.84	0.02	34%
	Meat	$14.35	0.11	69%
Traditionalists	Milk	$2.06	0.02	54%
	Butter	$0.58	0.02	13%
	Cheese	$2.40	0.04	40%
	Ice cream	$1.40	0.03	24%
	Other dairy	$1.41	0.03	30%
	Meat	$11.13	0.14	63%

Table A2: **List of price variables used in estimation**

Series ID	Series Title	Base period
AMS Milk Price Series	Milk price in $ per gallon	
CUSR0000SS10011	Butter in U.S. city average, all urban consumers, seasonally adjusted	1982-84=100
CUSR0000SEFJ02	Cheese and related products in U.S. city average, all urban consumers, seasonally adjusted	1982-84=100
CUSR0000SEFJ03	Ice cream and related products in U.S. city average, all urban consumers, seasonally adjusted	1982-84=100
CUSR0000SEFJ04	Other dairy and related products in U.S. city average, all urban consumers, seasonally adjusted	1982-84=100
CUSR0000SAF11211	Meats in U.S. city average, all urban consumers, seasonally adjusted	1982-84=100
CUSR0000SAF1	Food in U.S. city average, all urban consumers, seasonally adjusted	1982-84=100

Table A3: **Estimated coefficients of the AIDS system**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Intercept	0.07528***	0.00756***	0.0249***	0.01738***	0.01474***	0.11332***
Milk	0.02386***	-0.00363*	0.01728***	-0.00668	0.00941**	0.01571*
Butter	-0.00363*	0.00602**	0.0016	-0.00248	0.00483	0.00141
Cheese	0.01728***	0.0016	-0.01123	0.00595	-0.04574***	0.0143
Ice cream	-0.00668	-0.00248	0.00595	-0.04484*	0.06703***	-0.01725
Other dairy	0.00941**	0.00483	-0.04574***	0.06703***	-0.01682	0.0362***
Meat	0.01571*	-0.00775	0.0143	-0.01725	0.0362***	0.05247**
All other food	-0.05594***	0.00141	0.01783	-0.00173	-0.0549***	-0.10283***
IMR	-0.02701***	8e-04***	0.00326***	-0.00181***	0.00223***	0.03183***
P-index	-0.00099	-0.00052	-6e-05	0.00318**	0.00058	0.01025**

Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table A4: **Estimated demographic marginal effects**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Income 2nd	-0.00334***	-0.00014	0.00183**	0.00043	1e-05	-0.00356*
Income 3rd	-0.00602***	-7e-05	0.00336***	0.00114	0.00106	-0.00855***
Income 4th	-0.00538***	-0.00018	0.00309***	0.00148*	0.00204***	-0.01664***
Income 5th	-0.00609***	-0.00083**	0.00422***	0.0016*	0.00426***	-0.02385***
One child	0.00519***	-0.00019	-0.00261**	-0.00237**	0.00016	0.00334
3 or more children	0.01514***	-0.00118*	-0.00525***	-0.00208	-0.00182	-0.00532
2 children	0.00878***	-0.00037	-0.00248*	-0.00041	1e-04	-0.00512
2 adults	0.00524**	0.00064	9e-04	-0.00106	0.00114	-0.00495
3 or more adults	0.00541*	-0.00028	-0.00255	-0.00152	0.00053	-0.00385
Married couple/own children	0.00485**	-0.00025	0.00223	0.00095	6e-05	-0.00996***
All other husband and wife	0.00734***	9e-05	-2e-05	0.00115	-0.00254*	-0.00556
Single parent	0.00256	0.00012	0.00426**	8e-05	0.00159	-0.01026**
Single consumers	-0.00546**	0.00039	0.00309*	-0.00173	0.00232*	-0.00896*
Other families	0.00085	-0.00022	0.00081	0.00066	-0.00123	-0.00024
Owner/no mortgage	2e-04	0.00038	0.00025	0.00076	-0.00094*	0.00523***
Renter	-0.00187**	-0.00035	0.00056	-0.00074	7e-05	0.00317**
Black	-0.0129***	-0.00117***	-0.01211***	-0.00369***	-0.0065***	0.05383***
Other	-0.0037***	-0.00218***	-0.01576***	-0.00241***	-0.00411***	0.02643***
Hispanic	-2e-04	-0.00243***	-0.00337***	-0.00375***	-0.00281***	0.03585***
North East	-0.00081	0.00093	0.00078	0.00022	0.00556***	0.00553
Midwest	-0.00713***	0.00032	0.00127	-0.00066	0.0028**	-0.00301
South	-0.00665***	-0.00096*	-0.00219	-0.00035	4e-04	0.01235***
West	-0.00557***	6e-05	0.00172	0.00168	0.00328***	-0.00683*
Self employed	0.00051	0.00043	-0.00116	0.00076	0.00111	0.00071
Retired	-0.00269*	0.00047	0.00113	0.00123	6e-05	-0.00094
Not working	0.00184	0	0.00212**	-0.00078	-0.00045	0.00587**
Rural	0.00522***	0.00172***	0.00361***	-0.00094	-0.00265***	0.00387
One earner	-0.00224	-0.00049	0.00276***	-0.0029***	0.00051	0.00126
Two earners	-0.00305	-0.00081	0.00454***	-0.00443***	-0.00055	0.01146***
Three or more earners	-0.00459*	-0.00056	0.00386**	-0.00363**	-0.00166	0.01619***
Summer	-0.00024	-0.00131***	-0.00119*	0.00107*	-0.00039	-0.00479***
Fall	0.00045	-0.00151***	-0.00124*	0.00403***	-6e-05	-0.00361**
Winter	0.00211**	-0.00073**	0.00053	-0.00229***	0.00019	-0.00315*

Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table A5: **Estimated coefficients of the AIDS system - Millennials.**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Intercept	0.09583*	0.00071	0.04975	0.01236	0.03024	0.13811
Milk	0.03124*	-0.00447	0.0212	-0.01034	0.01161	-0.01156
Butter	-0.00447	0.00102	-0.00262	0.00715	0.00774	-0.0155
Cheese	0.0212	-0.00262	-0.01348	-0.02306	-0.06181*	0.03342
Ice cream	-0.01034	0.00715	-0.02306	-0.01899	0.12218***	-0.01909
Other dairy	0.01161	0.00774	-0.06181*	0.12218***	-0.03543	0.05625**
Meat	-0.01156	0.00668	0.03342	-0.01909	0.05625**	0.02959
All other food	-0.03768	-0.0155	0.04634	-0.05785	-0.10054***	-0.0731
IMR	-0.02595***	0.00082***	0.00357***	-0.00147***	0.00288***	0.03075***
P-index	0.00712	0.00071	-0.00168	8e-04	0.00086	-0.00093

Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table A6: **Estimated demographic marginal effects - Millennials.**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Income 2nd	-0.00247	9e-05	-6e-05	0.0022	0.00116	0.00476
Income 3rd	-0.00799***	0.00089	0.00439**	-0.00071	0.00216	0.00558
Income 4th	-0.0078**	0.00129	0.00157	0.00146	0.00418**	-0.00118
Income 5th	-0.0092**	0.00104	0.00257	0.00277	0.00828***	-0.00746
One child	0.01646***	0.00035	-0.00315	-0.00103	-0.00086	0.00279
3 or more children	0.02334***	-0.00102	-0.00604**	-0.00025	-0.00581**	-0.0016
2 children	0.017***	-0.00028	-0.00304	-2e-05	-0.00216	0.00265
2 adults	-0.02068	0.00475	-0.01657	-0.00924	-0.01372	-0.0332
3 or more adults	-0.01701	0.00305	-0.02248	-0.00881	-0.01825	-0.03625
Married couple/own children	8e-05	-0.00143	0.0012	0.00055	0.00132	-0.01004
All other husband and wife	-0.009	-5e-04	0.00095	0.00112	0.00481	0.00525
Sigle parent	-0.0288	0.00335	-0.00995	-0.00616	-0.00996	-0.03285
Single consumers	-0.03285	0.00271	-0.01395	-0.00261	-0.0126	-0.0309
Other families	-0.0047	-0.00068	-0.00036	0.00195	-0.00175	0.00767
Owner/no mortgage	0.00272	-0.00104	-0.00114	0.00182	-0.00261	0.01512**
Renter	-0.00327	-0.00011	0.00032	-6e-05	0.00016	0.00268
Black	-0.01009***	-0.00114	-0.01037***	-0.00326*	-0.00349**	0.05076***
Other	-0.00456	-0.00131*	-0.01695***	0.00165	-0.00422***	0.02113***
Hispanic	-0.00287	-0.00157***	-0.0036**	-0.00287**	-0.00153	0.03073***
North East	0.00206	-0.00036	-0.00051	0.00331	0.00296	0.01515*
Midwest	-0.00673	-0.00066	-0.00132	-0.00115	0.00235	-0.00109
South	-0.00548	-0.00188	-0.00377	0.00123	-0.00071	0.02101**
West	-0.00327	-0.00081	-0.00107	0.00381	0.00304	-0.00064
Self employed	0.00401	-7e-05	-0.00435	0.00064	0.00545**	-0.00032
Retired	-0.01729	0.00056	-0.01151	0.02165**	-0.00466	-0.02112
Not working	0.00137	-0.00022	0.00014	0.00408*	0.00137	-0.00117
Rural	0.00292	0.0023**	0.00552**	-0.00297	-0.00204	-0.00698
One earner	-0.00528	0.00237*	-0.00057	0.00652**	0.00205	-0.0092
Two earners	-0.00497	0.00024	0.00311	0.00887**	-7e-05	-0.00199
Three or more earners	0.00668	2e-04	0.00512	0.00877*	-0.00047	0.00278
Summer	0.00042	-0.00128**	-0.00225	-0.00017	-0.00115	-0.00397
Fall	0.00217	-0.00231***	-0.00186	0.00021	-0.00174	0.00251
Winter	0.00343	-0.00061	-0.00045	-9e-05	-0.00152	-0.00365

Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table A7: **Estimated coefficients of the AIDS system - Gen X.**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Intercept	0.06986***	0.00884***	0.01607***	0.00787	0.01942***	0.13085***
Milk	0.00944	-0.00414	0.02557**	-0.00838	0.02291***	0.02746*
Butter	-0.00414	0.00271	0.00069	-0.0012	0.00802	-0.00092
Cheese	0.02557**	0.00069	-0.00756	0.04603	-0.08042***	-2e-04
Ice cream	-0.00838	-0.0012	0.04603	-0.08077*	0.06146*	-0.03616*
Other dairy	0.02291***	0.00802	-0.08042***	0.06146*	0.02182	0.04866**
Meat	0.02746*	-0.00515	-2e-04	-0.03616*	0.04866**	0.06923*
All other food	-0.07286***	-0.00092	0.01589	0.01902	-0.08245***	-0.10807**
IMR	-0.02772***	0.00108***	0.002***	-0.00174***	0.00218***	0.02841***
P-index	0.00299	-0.00109	0.00284	0.00309	-0.00235	0.01954*

Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table A8: **Estimated demographic marginal effects - Gen X.**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Income 2nd	-0.00525*	0.00019	0.0019	3e-04	-8e-04	-0.00147
Income 3rd	-0.00641**	1e-04	0.00262	0.0031*	0.00178	-0.00877*
Income 4th	-0.00653**	-0.00019	0.00331*	0.00199	0.00374**	-0.01938***
Income 5th	-0.00574*	-0.00117*	0.00387*	0.00256	0.00463***	-0.02461***
One child	0.00589	-0.001	-0.00315	-0.00218	0.00089	0.0041
3 or more children	0.01724***	-0.00153*	-0.00629**	-0.00135	-0.00155	-0.00405
2 children	0.01106***	-0.00087	-0.00339	0.00019	-0.00042	-0.00643
2 adults	0.00726	-0.00025	0.00407	0.00247	-2e-04	-0.00956
3 or more adults	0.00428	0.00101	-0.0023	0.00082	0.00105	-0.00664
Married couple/own children	0.00159	0.00019	0.00299	0.00239	1e-04	-0.01407*
All other husband and wife	-0.00059	-0.0016	0.00337	0.00252	-0.00328	-0.00092
Single parent	-0.00019	-0.00028	0.00737*	0.00609*	-0.00065	-0.01641
Single consumers	-0.00655	-0.00102	0.00495	0.00191	0.00028	-0.02046**
Other families	0.00055	-0.00071	0.00122	0.00178	-0.00284*	-0.00735
Owner/no mortgage	-0.00062	-0.00039	-0.00083	0.00044	0.00015	0.0131***
Renter	-0.00031	-0.00092**	-1e-04	0.00033	-0.00111	0.00576**
Black	-0.01314***	-0.00058	-0.01109***	-0.0021	-0.00565***	0.04777***
Other	-4e-04	-0.00164***	-0.01183***	-0.00288**	-0.00259**	0.01366***
Hispanic	-0.00251	-0.00229***	-0.00298**	-0.00233**	-0.00265***	0.03901***
North East	-0.00477	0.00315***	0.00173	0.00326	0.00696***	-0.00176
Midwest	-0.01011**	0.00193**	0.00317	0.00245	0.00195	-0.01204*
South	-0.01054***	0.00178*	-0.00029	0.00176	0.00095	0.00163
West	-0.00882**	0.00178*	0.00297	0.00352	0.00341	-0.01768**
Self employed	0.00064	0.00092*	-0.00148	0.00195	0.00073	-0.0023
Retired	0.01593*	-0.00029	-0.00541	0.00369	0.00694	0.01015
Not working	0.00083	-7e-05	0.0049***	-0.00017	9e-05	0.00261
Rural	0.00455	3e-04	0.00785***	-0.00189	-0.00479***	0.00392
One earner	0.00455	-0.00193**	0.00737***	-0.00431*	0.00253	0.00019
Two earners	0.00188	-0.00192*	0.00989***	-0.00523*	0.00067	0.01006
Three or more earners	0.0027	-0.00173	0.00976***	-0.00567*	-0.00119	0.01313
Summer	0.00055	-0.00158***	-0.00096	0.00157	-0.00116	-0.00428
Fall	0.00011	-0.00163***	-0.00154	0.00544***	-6e-04	-0.00056
Winter	0.00228	-0.00059	0.00123	-0.00104	-0.00107	-0.0015

Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table A9: **Estimated coefficients of the AIDS system - Baby Boomers.**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Intercept	0.07656***	0.00982***	0.02462***	0.02156***	0.01356***	0.11954***
Milk	0.04222***	-0.00442	0.00794	-0.01203	-0.00029	0.02437*
Butter	-0.00442	0.01032**	0.00951	-0.01518*	0.00372	0.02019*
Cheese	0.00794	0.00951	0.01805	-0.01034	-0.01371	0.00153
Ice cream	-0.01203	-0.01518*	-0.01034	-0.03703	0.03763	0.00753
Other dairy	-0.00029	0.00372	-0.01371	0.03763	-0.00666	0.01804
Meat	0.02437*	-0.02413***	0.00153	0.00753	0.01804	0.04877
All other food	-0.05779***	0.02019*	-0.01299	0.02942	-0.03873	-0.12043***
IMR	-0.02805***	0.00068***	0.00332***	-0.00209***	0.00228***	0.03287***
P-index	0.00119	-0.00258**	0.00161	0.00177	7e-05	-0.00433

Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table A10: **Estimated demographic marginal effects - Baby Boomers.**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Income 2nd	-0.00205	-0.00036	0.00291**	-0.00219*	0.00138	-0.00555
Income 3rd	-0.00418*	0.00013	0.00269*	-0.00079	0.00145	-0.01329***
Income 4th	-0.00362	-0.00028	0.00308**	-0.00036	0.00101	-0.01695***
Income 5th	-0.00554**	-0.00073	0.00473***	-0.00161	0.00351***	-0.02814***
One child	0.00031	-7e-05	-0.00048	-0.00082	-6e-05	0.00041
3 or more children	0.01042**	-0.00146	-0.00337	-0.0012	-0.00208	-0.00264
2 children	0.00416	0	-0.00024	0.00305	0.00074	-0.00778
2 adults	0.00375	0.00106	0.00048	0.00151	0.00098	-0.00293
3 or more adults	-0.00101	0.00048	-0.00164	0.00244	0.00061	0.00045
Married couple/own children	0.00823**	0.00047	0.00101	0.00085	-0.00318*	-0.00434
All other husband and wife	0.01913***	-0.00016	-0.00137	-1e-04	-0.00514**	-0.01329*
Single parent	0.00442	-7e-05	-0.00213	0.00078	-0.0022	-0.02456**
Single consumers	-0.00781*	0.00075	0.00415	-0.00118	0.00189	-0.00348
Other families	0.00403	0.00018	0.00101	0.00104	-0.00072	0.00222
Owner/no mortgage	-0.00012	7e-04*	0.00125	-0.00028	-0.00065	-0.00049
Renter	-5e-04	0.00037	-0.00017	-0.00126	0	0.00262
Black	-0.01491***	-0.00118**	-0.01293***	-0.00438***	-0.00736***	0.05394***
Other	-0.00491**	-0.00258***	-0.01738***	-0.00443***	-0.00395***	0.03456***
Hispanic	0.002	-0.00231***	-0.00337**	-0.00506***	-0.00256**	0.03478***
North East	0.00194	2e-05	-0.00197	-0.00083	0.0062***	0.00469
Midwest	-0.00582*	4e-04	-0.00172	-0.00013	0.00359**	-2e-05
South	-0.00576*	-0.00174*	-0.00477**	0.00023	0.00012	0.01552***
West	-0.00465	-0.00025	5e-04	0.00115	0.00291*	-0.00014
Self employed	0.00032	0.00026	-3e-05	-0.00025	0.00146	0.00575
Retired	-0.00358	-9e-05	0.00178	-0.00331**	0.00181	0.00139
Not working	0.00194	0.00021	0.00305**	-0.00337**	-0.00042	0.00861**
Rural	0.00397*	0.00217***	0.00414***	-0.00049	-0.00111	0.00182
One earner	-0.00291	-2e-05	0.00281*	-0.00381***	9e-05	0.00094
Two earners	-0.00276	-0.00048	0.00376*	-0.00603***	1e-04	0.01244**
Three or more earners	-0.00916**	-0.00035	0.00313	-0.00665***	0.00214	0.01652**
Summer	-7e-04	-0.00155***	-0.00211*	0.00096	-0.00043	-0.00456
Fall	0.00067	-0.00111**	-0.00155	0.00479***	-0.00038	-0.00834***
Winter	0.00258	-8e-04*	0.00061	-0.00314***	0.00085	-0.00464

Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table A11: **Estimated coefficients of the AIDS system - Traditionalists.**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Intercept	0.07291***	0.00947**	0.02154***	0.03304***	0.0159***	0.10948***
Milk	0.00288	0.00161	0.02314*	0.0066	0.00375	0.00417
Butter	0.00161	0.01074	-0.01399	0.01963	-0.01162	-0.01307
Cheese	0.02314*	-0.01399	-0.10428*	0.01697	-0.02572	0.06315*
Ice cream	0.0066	0.01963	0.01697	-0.05753	0.06918	-0.05451
Other dairy	0.00375	-0.01162	-0.02572	0.06918	-0.06125	0.03734
Meat	0.00417	0.0067	0.06315*	-0.05451	0.03734	0.04593
All other food	-0.04215	-0.01307	0.04073	-0.00034	-0.01168	-0.08302
IMR	-0.02515***	5e-04	0.00501***	-0.00208***	0.00155***	0.034***
P-index	-0.00402	-0.00112	-0.0021	-0.00067	-0.00115	0.00908

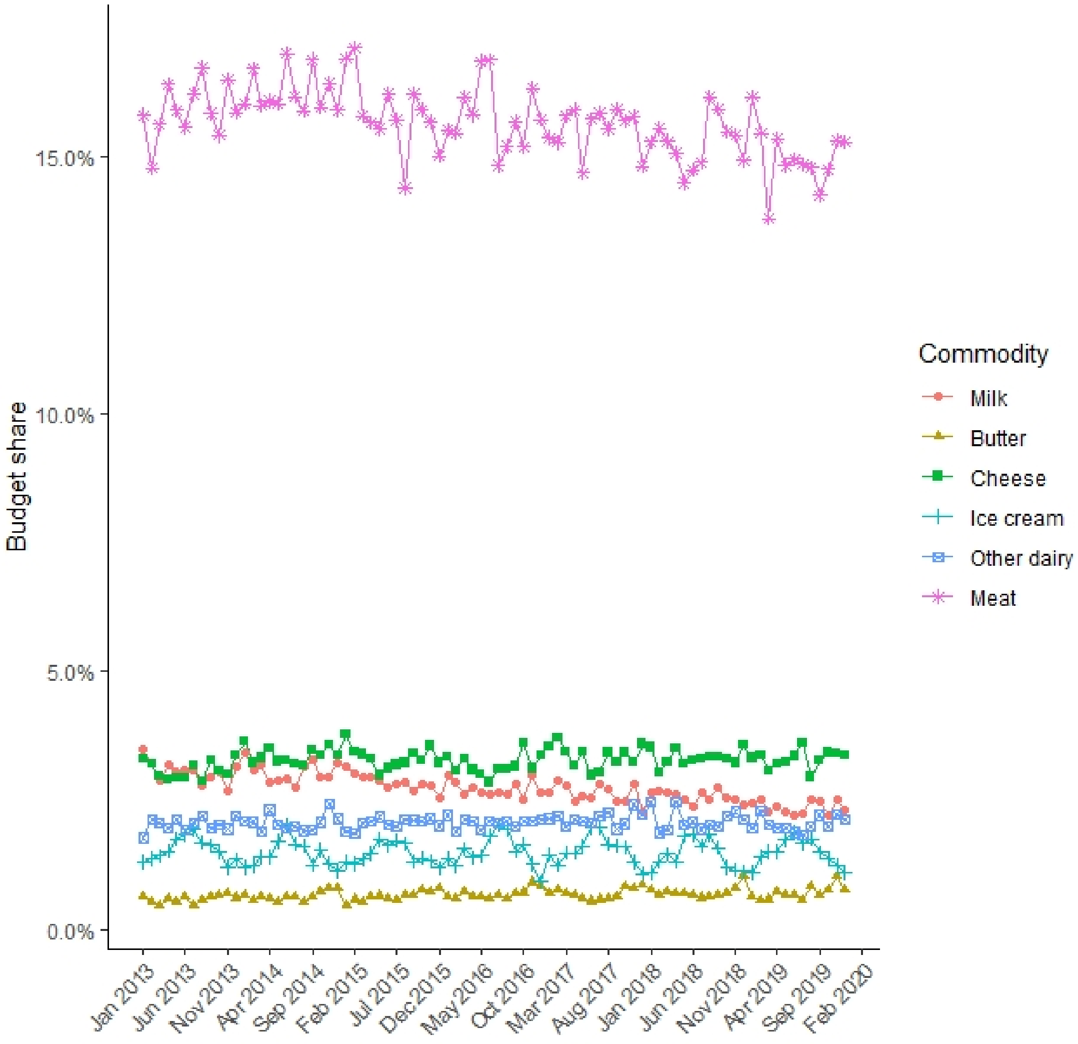
Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table A12: **Estimated demographic marginal effects - Traditionalists.**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Income 2nd	-0.00322	-1e-04	0.00138	0.00163	-0.00201	-0.01014**
Income 3rd	-0.00693**	-0.00105	0.00331*	0.00256	-0.00045	-0.01543***
Income 4th	-0.00458	-0.00097	0.00376*	0.00348	-4e-05	-0.02921***
Income 5th	-0.0039	-0.00268*	0.00841***	0.0048	0.00343	-0.02404***
One child	-0.00277	0.00053	-0.00601	-0.00726*	-4e-04	0.00657
3 or more children	0.00578	0.00314	0.00343	-0.01636	-0.00913	-0.09252**
2 children	-0.00685	-0.00192	-0.00499	-0.00778	-0.00215	0.02251
2 adults	0.00169	0.00265	-0.00119	-0.00603	0.00493	-0.00672
3 or more adults	0.00141	0.00287	0.00687	-0.01337*	0.00456	-0.00535
Married couple/own children	0.01231*	-0.00413	0.00121	0.00522	-0.00079	0.01623
All other husband and wife	0.01229*	0.00202	-0.00623	0.00757	-0.00511	-0.00637
Single parent	0.00635	0.0084	0.00556	0.01414	0.00315	-0.02699
Single consumers	-0.00388	0.0028	0.00043	-0.00606	0.00602	-0.01556
Other families	0.0025	0.00103	0.00056	0.00049	0.00342	-0.00575
Owner/no mortgage	0.00074	-8e-05	-4e-04	-0.00022	-0.00113	0.00958**
Renter	-0.00125	-7e-04	0.00035	-0.00133	-0.00034	0.00294
Black	-0.01431***	-0.00179	-0.01413***	-0.00507**	-0.00893***	0.06065***
Other	-0.00668	-0.00376**	-0.02042***	-0.00365	-0.00901***	0.0489***
Hispanic	0.00784**	-0.00468***	-0.00259	-0.00613**	-0.00568***	0.02735***
North East	-0.00255	0.00119	0.00664**	-0.00485	0.0058**	0.00711
Midwest	-0.00467	-0.00063	0.00765**	-0.00477	0.00315	0.00168
South	-0.00329	-0.00187	0.00181	-0.00516	0.00159	0.01038
West	-0.00417	-0.00013	0.00542*	-0.00178	0.00462*	-0.01408
Self employed	-0.0065	-0.00139	0.00305	-0.00181	-0.00415	-0.00832
Retired	-0.00214	-0.00132	0.00337	0.00156	-0.00373*	0.0052
Not working	0.00548	-0.00124	0.00131	2e-05	-0.00227	0.01248
Rural	0.00908***	0.00185*	-0.00328	0.00078	-0.00387**	0.01285**
One earner	-0.00078	-0.00069	0.00247	-0.00145	-0.00046	0.00581
Two earners	-0.0012	0.00059	0.00356	-0.0047	-0.00077	0.01027
Three or more earners	-0.00153	0.00113	-0.00523	0.00374	0.00353	-0.00741
Summer	-0.00133	-6e-05	0.002	0.00144	0.00143	-0.00695
Fall	-0.00209	-0.00102	0.00073	0.00332*	0.0034**	-0.0056
Winter	-0.00021	-0.00108	0.00025	-0.00435**	0.00245*	-0.00242

Note. $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Figure A1: **Dairy products budget shares in each month 2013-2019 - all consumers.**



Note: All other food variable was omitted in the graph.

REFERENCES

Andreyeva, T., Long, M. W., and Brownell, K. D. (2010). The impact of food prices on consumption: A systematic review of research on the price elasticity of demand for food. *American Journal of Public Health*, 100(2):216–222.

Blisard, N., Lin, B.-H., Cromartie, J., and Ballenger, N. (2002). America's Changing Appetite: Food Consumption and Spending to 2020. *Food Review/ National Food Review*, 25(1):2–9.

Boehm, W. T. (1975). The Household Demand For Major Dairy Products In The Southern Region. Technical Report 2.

Davis, C. G., Yen, S. T., Dong, D., and Blayney, D. P. (2011). Assessing economic and demographic factors that influence United States dairy demand. *Journal of Dairy Science*, 94(7):3715–3723.

Deaton, A. and Muellbauer, J. (1980). An Almost Ideal Demand System. *The American Economic Review*.

Haidacher, R. C., Blaylock, J. R., and Myers, L. H. (1988). Consumer demand for dairy products: a summary analysis. Technical report.

Heien, D. and Wessells, C. R. (1988a). The Nutritional Impact of the Dairy Price Support Program. *Journal of Consumer Affairs*, 22(2):201–219.

Heien, D. and Wessells, C. R. (1990). Demand systems estimation with microdata: A censored regression approach. *Journal of Business and Economic Statistics*, 8(3):365–371.

Heien, D. M. and Wessells, C. R. (1988b). The Demand for Dairy Products: Structure, Prediction, and Decomposition. *American Journal of Agricultural Economics*, 70(2):219–228.

Henningsen, A. and Hamann, J. D. (2007). Systemfit: A package for estimating systems of simultaneous equations in R. *Journal of Statistical Software*, 23(4):1–40.

Henningsen, A. and Toomet, O. (2008). Sample Selection Models in {R}: Package {sampleSelection}. *Journal of Statistical Software*, 27(7).

Huang, K. S. (1985). U.S. Demand for Food: A Complete System of Price and Income Effects. Technical report.

Huang, K. S. and Lin, B.-H. (2000). Demand and Nutrient Household Survey Data. Technical report.

Kuhns, A. and Saksena, M. (2017). Food Purchase Decisions of Millennial Households Compared to Other Generations.

Lapides, R. A. and Savaiano, D. A. (2018). Gender, age, race and lactose intolerance: is there evidence to support a differential symptom response? A scoping review.

Lee, J. Y., Qian, Y., Gustavsen, G. W., Nayga, R. M., and Rickertsen, K. (2020). Effects of consumer cohorts and age on meat expenditures in the United States. *Agricultural Economics (United Kingdom)*, 51(4):505–517.

Okrent, A. M. and Alston, J. M. (2011). Demand for Food in the United States: A Review of Literature, Evaluation of Previous Estimates, and Presentation of New Estimates of Demand. *Giannini Foundation Monograph 48*, (April):125.

2 ASSESSING GENERATIONAL DIFFERENCES THAT INFLUENCE U.S. MEAT DEMAND - EVIDENCE FROM AN LA-AIDS ESTIMATION

2.1 Introduction

In recent years many studies focused on the increased global meat demand by 2050 (see Revell 2015, and Food and Agriculture Organization of the United Nations 2017). As the population ages, the generational composition of the population changes as well. Over time, is is bound to impact food demand. The U.S. population is projected to increase 17.5%[9] by 2050. Yet, as the population composition changes, U.S. will have a higher number of people 65 years of age or older, increasing from 17% in 2020 to 22% in 2050. Yet, the population share of young people is likely to be smaller, with 20% of the population being less than 18 years old in 2050, compared to 22% in 2020. Several studies take into account the impact of age on food demand (Blisard et al., 2002; Lee et al., 2020). However, most studies do not take cohort or generational effects[10] into account when analyzing food demand and how it changes over time. For example, Blisard et al. (2002) measured consumer food spending by examining various demographic characteristics, including age. However, the authors explicitly mentioned two assumptions that limited the accuracy and informative quality of the study. First, the researchers assumed that preferences change as people age, not considering potential generational differences and constant cohort preferences that stay relatively stable over time in the same generational groups. Second, they assumed that people of the same age would have the same preferences at different times. That is they assume a person who is 25 years old in 1990 would have the same preferences as the person who is 25 years old in 2019. This has been proven to be incorrect with respect to meat purchases in the recent research by Lee et al. (2020), which shows impact of birth cohort in meat

[9]Authors own calculations based on 2020 population data and U.S. Census Bureau projections (United States Census Bureau, 2017).

[10]With the exception of recently published Lee et al. (2020). Unfortunately, the research by Lee et al. (2020) most recent data was from 2012.

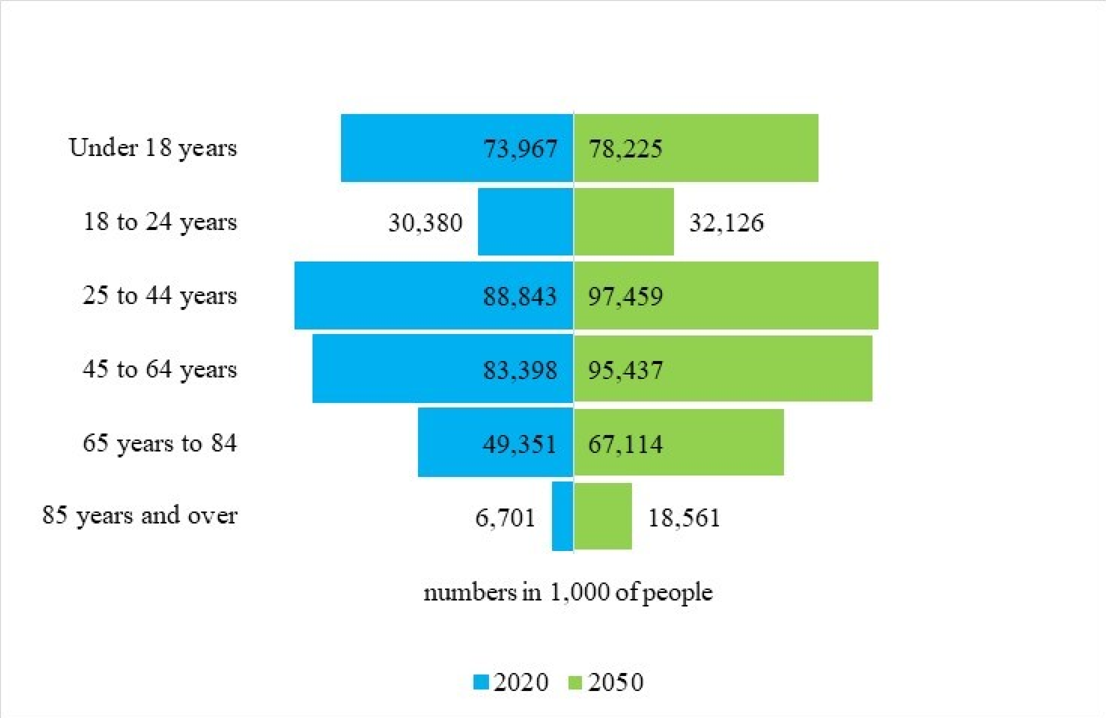
expenditures.

The average age of or each generation during the study period of this research (between years 2001 and 2019) was 26.6 years for Millennials, 36.3 for Gen X, 52.9 for Baby Boomers, and 72.8 for Traditionalists. When looking at the full sample, the Baby Boomer households comprise 37% of all analyzed observations, compared to 11.727.9% , and 23% for Millennials, Gen X, and Traditionalists, respectively. By 2050, the youngest Millennials, born in 1994, will be 56, the youngest Gen X's will be 70, and the youngest Baby Boomers 86, with the youngest Traditionalists being 105. The population age group breakdown comparison between 2020 and 2050 is shown in figure 2.1. However, by 2050 Gen Z[11], Millenials, Gen X, and Baby Boomers will comprise 51% of the total population[12]. Understanding how each of these generations responds to changes in income and prices and, if each generation has different preferences for meat purchases, will help model future meat demand and help understand and predict future generations' behavior.

[11]The next generation after Millennials born between 1995/1997 and 2012, according to a report by Kim Parker and Ruth Igielnik (2020) for Pew Research Center.

[12]Own calculation based on United States Census Bureau (2017) population forecast data.

Figure 2.1: **Age groups U.S. population 2020 and 2050 projections.**



Source: United States Census Bureau (2017).

Household demand for food products, including meat depends on price, income, as well as socioeconomic and demographic variables. Purchasing patterns will also vary by birth cohort (or generation) as each group's food demand is shaped by the events and culture in which they grew up (Lee et al., 2020). According to the United States Department of Agriculture (USDA), changes in production practices, per-capita availability of chicken has doubled since 1970. In that period, the availability of chicken surpassed the availability of both beef and pork (USDA Economic Research Service, 2021). Those changes appear to coincide with increased demand for chicken compared to beef and pork. Several research studies (Marshall, 2000; Kuchler et al., 2005; Chouinard et al., 2007) point to an increased focus of policy on health improvement. This means researchers and policymakers need better and more accurate data and current estimates of meat demand elasticities. Availability of updated meat demand elasticities will likely result in an improved understanding of meat demand which is needed for future policy analysis.

Generally, food policy analysis uses the food demand elasticities from the literature, whether explicitly or implicitly (Okrent and Alston, 2011). In many research studies, relevant aspects of demand response are expressed in terms of elasticities. As a result, the policy analysis's quality is contingent on the quality and relevance of the available elasticity estimates. This research argues that updated meat product demand elasticities should be of vital interest to policymakers in the coming years as consumer behavior continues to evolve. Additionally, the author is looking into the impact of demographics, including generation, on the meat demand elasticities, which should provide a unique insight into each group's price and income sensitivity with respect to meat purchases.

Previous research (Andreyeva et al., 2010; Blisard et al., 2002; Kuhns and Saksena, 2017; Nayga, 1995; Saksena et al., 2018) indicates that food consumption patterns differ between income groups, age groups, genders, ethnic groups, and place of residence. This previous research has also shown differences in consumer sensitivity to price changes across different food items and item groups. However, existing research has several limitations, including not considering that purchasing patterns and preferences can change over time.

These assumptions are more restrictive than what likely occurs. In contrast, this research draws on a growing body of literature regarding how consumption patterns differ by generation and can change over time and presents an updated set of demand elasticities for meat products. This research assumes that variations in purchasing patterns of meat products exist among different birth years cohorts, here defined by generations. The definition of a generation used in this research is "a group of individuals born and living at about the same time" (Webster's, 1996 as cited in Alwin and McCammon 2007).

The purchasing patterns of each generation are likely formed by the events, culture, events and available health and other information available in the times they grew up in (Lee et al., 2020; **?**). These generational cohort effects reflect differences between groups that experienced events at similar stages of life. To observe differences between generational cohorts we assume that the external world impacts people of different ages in different ways, and that the results of these changes are persistent across their lives (Alwin and McCammon, 2007). The generation birth-year cut off values in this research follow the definitions presented in the Bureau of Labor Statistics (BLS) Consumer Expenditure Survey (CEX) generational tables[13] (Bureau of Labor Statistics, 2016). The purchasing patterns of each generation are likely formed by the events, culture and available health and other information available while they were growing up. Those generational cohort effects reflect differences between groups that experienced similar events at a close point in life. To observe differences between generational cohorts, we assume that the external world impacts people of different ages in different ways and that the results of these changes are persistent across their lives (Alwin and McCammon, 2007).

The next section provides data sources for the variables used in the analysis. The method of analysis and the definition of the applied demand system is discussed, followed by results from the model using full sample and comparison of results by generational cohort. Lastly, the final section contains the conclusions and suggestions for future research.

2.2 Data

Multiple data sets from the Consumer Expenditure Survey (CEX) Public Use Micro Data (PUMD) were combined and used in this research. The data used encompassed 19 years, from 2001 to 2019, which was the most recent full year of data available at the time. The CEX data is divided into two parts, Interview Survey, and Diary Survey (DS), with different methods and sample populations. This research will focus on

[13]With the exception of merging the two oldest generations in the BLS tables defined as Silent Generation (birth year from 1929-1945) and Greatest Generation (the birth year 1928 or earlier) into a single generation in this research dubbed Traditionalists. The exact definitions used in this research are shown on page 38.

data provided by the DS. The DS has two parts, a Household Characteristic Questionnaire, which collects detailed demographic and income information on all members of the household, and a Record of Daily Expenses. The Record of Daily Expenses is a self-reported diary where each respondent records all household expenses for two consecutive weeks, with each week treated as an independent observation. The DS is especially relevant to this research as it collects data on small daily expenditures such as food, as well as demographic characteristics including respondents age which made parsing the data by generational cohort possible.

After the data sets containing all relevant information were merged, in the next step the household-level data were averaged by year to create an annual data series. The annual data series were created for all consumers as well as for each generation separately. The data has been divided into four generations based on the age of the reference person, ie. the person in the household filling out the survey. Based on birth year the generations have been defined as follows:

- Birth year of 1981 or later - Millennials,
- Birth year from 1965 to 1980 - Gen X,
- Birth year from 1946 to 1964 - Baby Boomers,
- Birth year from before 1945 - Traditionalists.

The average annual expenditures for all consumers and for each generation separately for each of the four meat product categories[14] are presented in Figure 2.2 on page 43.

One of the main limitations of the CEX PUMD Diary data set is that it does not record the price paid by each household for a given commodity. Therefore, no distinction can be made as to the quality differences of purchased commodities between different cohorts. In the absence of price data in the CEX, the price data used was

[14] All other food variable was omitted.

obtained from BLS Consumer Price Index (CPI) for the corresponding period. Specifically, the following data series from the CPI were used: (1) monthly adjusted national CPI for all food, and (2) the monthly adjusted national CPI for beef, pork, poultry, and fish. The CPI data was annualized. Next, the CEX PUMD data and the CPI data were merged by year.

2.3 Methods

Meat demand is influenced by its price, price of close substitutes, and income (expenditure). The data from the CEX DS and CPI are used to estimate an Linear Approximate - Almost Ideal Demand System (LA-AIDS). The estimated system encompasses beef, pork and chicken meat categories and fish and seafood. The estimation approach follows the LA-AIDS outlined by Blanciforti and Green (1983) based on the original specification for the estimation procedure outlined by Deaton and Muellbauer (1980) .

The AIDS model demand relations, in a budget share form, follow the specification given by Deaton and Muellbauer (1980).

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln \left(\frac{X}{P} \right) \tag{2.1}$$

LA-AIDS model uses Stone (geometric) price index P given by:

$$\ln P^* = \sum_k w_k \ln P_k \tag{2.2}$$

The linearized AIDS model in this research follows Blanciforti and Green (1983), which gives the LA-AIDS model. LA-AIDS can be expressed in terms of AIDS parameters assuming P is proportional to $P*$ i.e. $P \cong \zeta P*$. Then the LA-AIDS model can be written as defined by Green and Alston (1990).

$$w_i = (\alpha_i - \beta_i ln\zeta) + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln \left(\frac{X}{P*} \right) \tag{2.3}$$

The conditions of adding up, homogeneity and symmetry were imposed on the system following: adding up -

$$\sum_{i=1}^{n} \alpha_i = 0; \qquad \sum_{i=1}^{n} \gamma_i = 0, \quad j = 1, ..., n; \qquad \sum_{i=1}^{n} \beta_i = 0; \tag{2.4}$$

homogeneity -

$$\sum_{j=1}^{n} \gamma_{ij} = 0, \qquad i = 1, .., n; \tag{2.5}$$

and symmetry -

$$\gamma_{ij} = \gamma_{ji} \quad \text{for all} \quad i, j(i = j). \tag{2.6}$$

Uncompensated (Marshallian) price elasticities are calculated following the specification in Green and Alston (1990):

$$\eta_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \frac{\beta_i}{w_i} \frac{\partial \ln P}{\partial \ln p_j} \tag{2.7}$$

Expenditure elasticities are calculated as follows:

$$\eta_i = 1 + \frac{\beta_i}{w_i} \left(1 - \frac{\partial \ln P}{\partial \ln X} \right) \tag{2.8}$$

The equation for the last good, in this case, all other food, was deleted to ensure non-singularity of the error covariance matrix. The standard errors for the calculated elasticities were approximated using the delta method as described in Klein (1953). The demand system was estimated using `micEconAids` package in R (Henningsen, 2017).

2.4 LA-AIDS estimation for meat products system results

The data were aggregated into 5 categories: beef, pork, chicken, fish and seafood[15], and all other food consumed at home. The average annual expenditure for each of those

[15] Fish and seafood is referred to as meat for the purpose of this research.

categories (except all other food) for all consumers and each generational cohort are presented in Figure 2.2.

In this research we examine potential structural differences in meet demand between the four generations. This research takes the naive approach to structural change as described by (Eales and Unnevehr, 1988). This approach provides an interpretation of the model intercept as the indicator of an exogenous shift in demand, independent of prices and expenditures. Eales and Unnevehr (1988) calls the intercept in the AIDS model equivalent to a time trend in a static model. This interpretation allows for an exogenous growth or decline of budget shares of each of the commodities in the model independent of prices and expenditures (or incomes[16]). The intercept values for each generation and each meat group are presented in Table B2[17] in the Appendix. All intercept values except for Traditionalist model fish and seafood equation are statistically significant at the $p = 0.10$ or less level with most coefficients significant at $p = 0.01$. All the intercept values with exception of fish and seafood among Baby Boomers and Traditionalists were large and positive. However, the beef equation intercept was perceptibly larger in models representing Traditionalists and Baby Boomers compared to Millennials and Gen X. The corresponding coefficients for the pork equation were also higher among Baby Boomers and Traditionalists compared to Millennials and Gen X. The intercept coefficient on the chicken equation was very small in the Millennials model, compared to the other three generations, which would suggest a more pronounced structural change among Gen X, Baby Boomers and Traditionalists in the chicken demand than for Millennials. This observation would be consistent with the Millennial preference for chicken over other meat present in the data throughout the study period, compared to a shift away from pork and towards more chicken purchases among other generations.

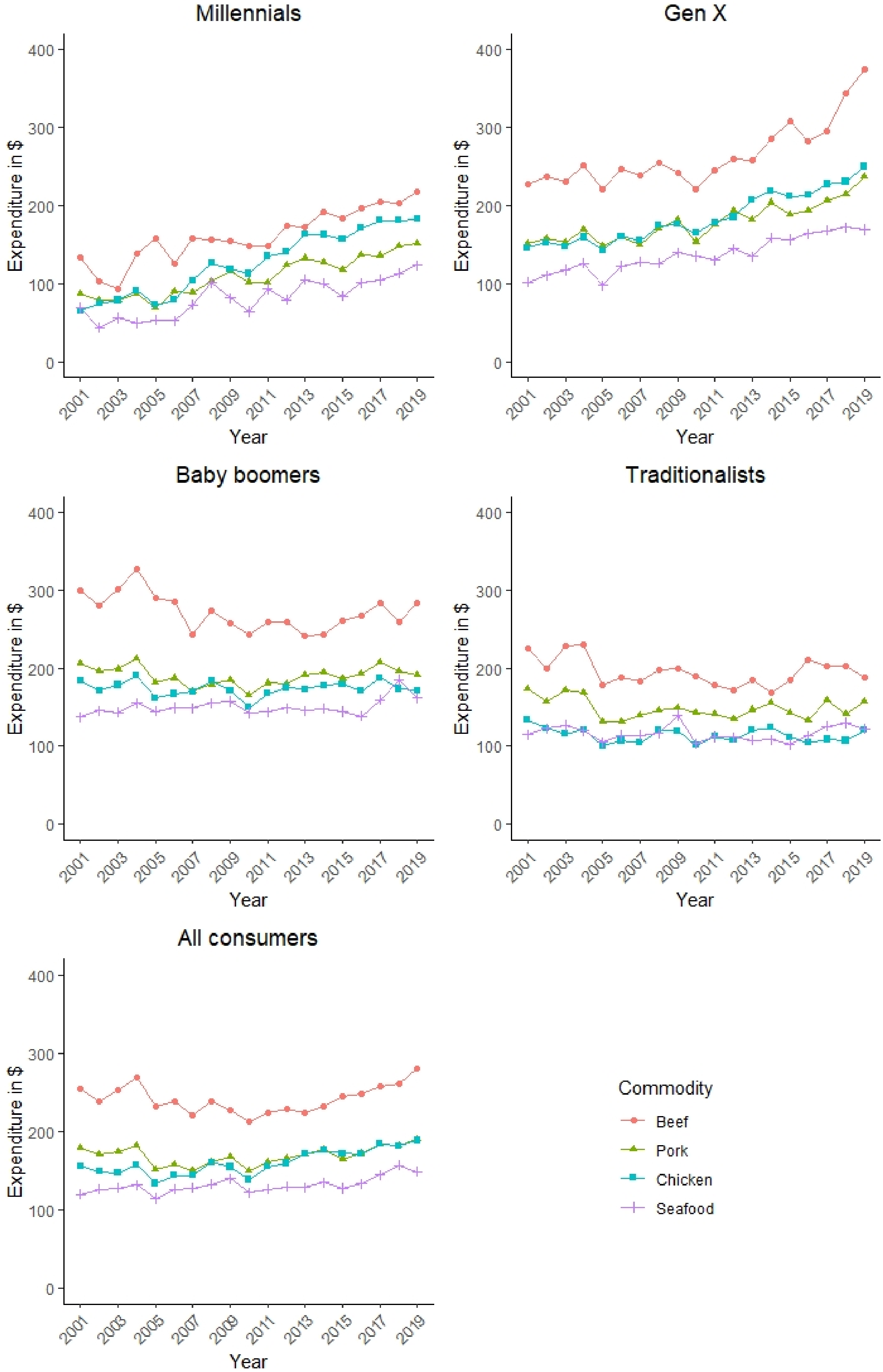
An average annual expenditure for beef was largest of the four meat categories -

[16]Depending on model specification.

[17]Intercept coefficients are denoted by α subscript 1 through 4, representing the four meat categories: beef, pork, chicken, and fish and seafood.

$241, with the lowest average expenditure observed in 2010 - $213, and highest in 2019 - $279. Over the study period beef expenditures increased by 9.8% across all consumers in the sample. Between 2001 and 2012 pork was the second highest meat expenditure, with an average annual expenditure of $164 during that time period. But starting in 2013 chicken expenditures overtook the pork, with the average chicken expenditure of $178 during 2013-2019, compared to $177 for pork in the same period. The fish and seafood expenditures remained relatively stable throughout the study period $131, with an average expenditure in 2001 of $120 and and average expenditure of $149 in 2019, which is slightly below the average annual inflation rate for all food of 1.7% for the corresponding period (Bureau of Labor Statistics, 2021b).

Figure 2.2: **Annual average expenditures on Beef, Pork, Chicken and Seafood - 2001-2019.**



Note: Excludes variable All other food.

Total meat expenditures were stable, without a clearly noticeable upward trend for both Baby Boomers and Traditionalists. Overall, annual expenditures on beef, chicken and meat, declined by 5%, 7% and 8% respectively, and fish expenditures increased by 17% for Baby Boomers. Meat purchases among Traditionalist households also declined with exception of fish which increased by 7% during the study period. Millennials spent, on average, least on beef during the study period $161, with Traditionalists coming in second at $195, Gen X third $264 and Baby Boomers the most, at $271. The beef expenditures among Baby Boomers showed a decline post 2004.

In contrast, both Millennial and Gen X households display a visible growing trend for meat expenditures during the study period. Meat expenditures of the Millennial households increased significantly between 2001 and 2019, with beef up 64%, pork 75%, chicken 181% and fish 79%. Similar trend was observed among Gen X households with increases of 64%, 56%, 71% and 65%, on beef, pork, chicken and fish and seafood, respectively. This trend is understandable as many of the Millennials and Gen X life cycle would indicate larger family sizes with presence of children in the household. The same rationale explains declines in Baby Boomers and Traditionalists meat purchases.

Increase in fish and seafood spending among the oldest generations could be driven by perceived health benefits of fish and seafood consumption over beef or pork meat. This result seems consistent with observations made by Tonsor et al. (2010). Baby Boomers and Traditionalists, spent more on pork than chicken during the study period. On the contrary, the increased purchases of chicken over pork were clearly visible among Millenial and Gen X households. All generations, spent least on fish and seafood, with Millenials spending the least $81 annually, and Baby Boomers spending the most $150. Gen X spent the most on chicken, of all generations $184, with Baby Boomers close behind at $173, Millenials and Traditionalists spent the least on chicken, $126 and $113, respectively.

2.4.1 LA-AIDS results for all consumers - years 2001-2019

Table 2.1 shows uncompensated (Marshallian) own- and cross-price elasticities for the 4 different meat categories for all consumers in the sample. The demand system is constrained by total food-at-home expenditure. Therefore the omitted equation represents all other food consumed at home, if not otherwise specified in the system.

All own-price elasticity estimates for all consumers are negative and statistically significant at $p = 0.01$, which is consistent with theory and expectations. Based on the findings presented below, fish and seafood own-price elasticity was -1.15; hence, the demand for fish and seafood is price elastic in absolute values. All own-price elasticities, except for beef, were larger than 1, which implies that a 1% change in price of pork, chicken, and fish and seafood, will result in a slightly larger than 1% decline in demand for those meat products. Beef was the least price-elastic with own-price elasticity of -0.893.

Beef's own-price elasticity results from this study are comparable to those presented by Gallet (2010) and Marsh et al. (2004). The pork own-price elasticity found in this study was similar to the one in Lee et al. (2020), smaller than Okrent and Alston (2011), and larger than all other studies in the comparison. The own-price elasticity of poultry products found in this study was much higher than in all if the other studies in the comparison. One of the reasons for a higher own-price elasticity, compared to older studies, is an increased availability of easy to prepare substitutes for chicken, therefore consumers are quite sensitive to increases of chicken price. The full comparison of own-price and expenditure elasticities between this and other studies is presented in the Table B3.

Table 2.2, shows the expenditure elasticities for the four meat categories for all consumers in the sample. All expenditure elasticities are positive and statistically significant at $p = 0.01$ implying that meat products are normal goods. Only fish and seafood products have expenditure elasticities greater than 1, at 1.292. Notably, beef was the

Table 2.1: **Own- and cross price elasticity estimates using LA-AIDS model - all consumers.**

	Beef	Pork	Chicken	Seafood
Beef	-0.893***	0.059	0.119**	-0.160**
	(0.060)	(0.030)	(0.029)	(0.082)
Pork	0.045	-1.008***	-0.064	0.000
	(0.039)	(0.041)	(0.038)	(0.071)
Chicken	0.075**	-0.049	-1.109***	0.022
	(0.050)	(0.047)	(0.064)	(0.090)
Seafood	-0.055	0.174**	0.220**	-1.154***
	(0.061)	(0.034)	(0.032)	(0.103)

Note. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

The SE are shown in parenthesis below each estimate value.

Table 2.2: **Expenditure elasticity estimates using LA-AIDS model - all consumers.**

	Estimate	SE
Beef	0.829***	(0.024)
Pork	0.823***	(0.028)
Chicken	0.833***	(0.038)
Seafood	1.292***	(0.031)

Note. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

least expenditure elastic and fish and seafood was the most. Expenditure elasticities for beef, pork and poultry are are higher than those found in Marsh et al. (2004), Olynk et al. (2010), and Lee et al. (2020), and lower than the ones in Mutondo and Henneberry (2007), with exception of pork which was comparable between the two studies.

Additionally, the cross-price elasticities revealed several substitution (ie. cross-price elasticity is positive) and complementary (ie. cross-price elasticity is negative) relationships. Beef is a substitute to pork and chicken, and a complement to fish and seafood. Somewhat unexpectedly, pork and chicken were revealed to be complements. Yet, fish and seafood, is a substitute to both pork and chicken. However, the cross-price relationships presented in this study are difficult to interpret with certainty. Due to the nature of the data used, which represents expenditures not actual consumption. It is impossible to determine if products consumers purchased jointly were indeed consumed together.

2.4.2 AIDS results for years 2001-2019, by generation

In the second stage of the estimation the data was divided into four generations as outlined in section 2.2. The results of the LA-AIDS estimation for each generational group are presented in Table 2.4. Table 2.3 shows the expenditure elasticties by generation.

All own-price elasticities across all four generations were negative and statistically significant at $p = 0.01$, which is consistent with economic theory and expectations. However, as shown in Table 2.4 there are some substantial differences between generations. For all generations, the beef own-price elasticity was inelastic, with most inelastic demand for beef among Millennials, and most elastic among Traditionalists, with -0.703 and -0.888 respectively. Millennials and Baby Boomers own-price elasticity of pork was elastic, with Millennials at -1.442. The elastic pork demand among Millennials would explain the overall low pork demand among Millenials. The opposite was true for Gen X and Traditionalists with own-price elasticity of pork below 1. Demand for chicken was most elastic among Gen X at -1.144 and least elastic among Baby Boomers at -0.934. All generations except Baby Boomers (at -0.933) had own price elasticities for fish and seafood higher than 1, with Traditionalists demand for fish and seafood being most elastic at -1.257.

Table 2.3: **Expenditure elasticity estimates using LA-AIDS model - by generation.**

	Millenials		Gen X		Baby Boomers		Traditionalists	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Beef	0.852***	(0.044)	0.845***	(0.028)	0.817***	(0.028)	0.817***	(0.029)
Pork	0.827***	(0.034)	0.858***	(0.048)	0.812***	(0.028)	0.824***	(0.051)
Chicken	0.919***	(0.101)	0.857***	(0.040)	0.823***	(0.037)	0.831***	(0.064)
Seafood	1.117***	(0.016)	1.12***	(0.017)	1.668***	(0.064)	1.403***	(0.055)

Note. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Cross-price elasticities estimated in a demand system, represent relative relationships of consumer preferences when purchasing (ie. consuming) one product with or over another. Cross-price elasticities, shown in Table 2.4 reveal some interesting differences in substitution and complementarity of different meats across the four generations. For all generations, except Gen X, beef and pork are substitutes. Chicken and beef are substitutes for all generations except Traditionalists. Beef and seafood are complements for all generations but the Traditionalists. Pork and chicken are complements for all generations but Baby Boomers. Chicken and fish and seafood are substitutes for Millenials, Gen X and Baby Boomers. Fish and seafood are also substitutes for pork among Gen X and Millenials. The differences in those relationships between generations suggest different preferences among generations when it comes to meat choice.

Expenditure elasticities for each generation were consistent with findings for all consumers. Expenditure elasticities for beef, pork and chicken were less than 1 for all generations. All expenditure elasticities for fish and seafood, were larger than 1 for all generations.

2.5 Conclusion

Most Americans meals are defined around meat (Haley, 2001). Therefore, understanding how Americans as a whole and each generation specifically respond to changes in meat price is of great significance to policymakers, and market players in the meat industry.

This study evaluated the effect of generational cohort on meat expenditures in the U.S. by using an LA-AIDS model. The data suggest that younger cohorts spend more on poultry compared to older cohorts, relative to their total food budget, 4.8% for Millenials, and 4.4% for Gen X, compared to 4.2% and 3.6% for Baby Boomers and Traditionalists respectively. This might be a sign of younger generations having stronger preference for chicken over other meats, or an income effect, as younger generations have relatively lower incomes, and poultry tend to be more inexpensive than other meats. Millenials, also spend less of their budget on fish and seafood, compared to other generations. Beef and pork are substitutes for all generations but Gen X. Over the life cycle, purchases of meat are expected to first increase and then decline with age, which is evident in comparing trends between Millenials and Gen X vs. Baby Boomers and Traditionalists.

Own-price elasticity of beef is the lowest among meat products, which is opposite to results observed in other studies (Marsh et al., 2004; Mutondo and Henneberry, 2007; Okrent and Alston, 2011; Gallet, 2010, 2012; Lee et al., 2020), while fish end seafood own-price elasticity is the highest. An important finding of this study is that older generations consume less meat across time. This, might be explained by a smaller household size and declining energy needs. Among older generations the largest declines in meat expenditures were observed for beef. Traditionalist households consumed 16.8% less beef between the first and the last year of the study period. Contrary, older generations, consumed more fish and seafood over the study period, with increases of 17.7% and 6.6%, by Baby Boomer and Traditionalist households, respectively.

Higher relative consumption of poultry among the youngest generations, compared to beef and pork, has been a trend observed in other studies. Many economists argue that this change is a result of change in preference structure. Increase in consumption of poultry over beef and pork is a manifestation of preference for meat products possessing more healthful characteristics, such as lower fat and cholesterol levels (Moschini and Meilke, 1989). Additionally to health concerns, some authors argue that an increase in number of women in the work force and increased preference for convenience, caused many households to switch towards easier and faster to prepare poultry dishes over beef and pork (Haley, 2001; Capps et al., 1985).

Lee et al. (2020) suggested that the higher relative consumption of poultry among younger generations were a result of increased availability of poultry which in turn was a result of vertical integration in the poultry industry that took place starting in the second half of 20th century. This could partly explain no impact on the oldest generations compared to the youngest generations.

Understanding how consumers in different generations respond to changes in prices, and which products are considered complements and substitutes can aid the retailers and the meat industry at large tailor pricing and marketing strategies to accommodate different consumers' groups meat demand. Incorporation of generational effects into research has a potential to impact not only business analyses, but also can be used in the assessment of policy and welfare programs.

The largest drawbacks of this study stem from data limitations including lack of price and quantity data in the survey, as well as large number of zero observations at the household level, which is bound to negatively impact the quality of the annualized averaged data. Meyer et al. (2015) highlighted the increased non-response levels in large government ran household surveys including the CEX. Meyer et al. (2015) showed an increase in the non-response rate from approximately 22% in 2001 to about 34% in 2013. The most recent available data from the BLS show a 44% average non-response rate to the CEX DS in 2019 (Bureau of Labor Statistics, 2021b). The household and item non-response rate negatively impact the accuracy of the data and the level of detail available to the researchers. Another major limitation is lack of detailed information of quantities and types of meat consumed away from home, therefore this research is limited only to food at home purchases.

Future research could further test the robustness of the findings presented here by using a different demand system. Furthermore, one could compare age and time period with the generational cohort effects. This research by design made assumption that the generational cohort the household belongs to is defined by the birth year of the person filling out the survey, not necessarily the person making the food purchasing decisions. Replicating this research with a more detailed data set including information about the person in the household who makes the food purchases.

Table 2.4: **Own- and cross price elasticity estimates using LA-AIDS model - by generation.**

	Beef	Pork	Chicken	Seafood
Millennials				
	Beef	Pork	Chicken	Seafood
Beef	-0.703***	0.071	0.275	-0.158***
	(0.190)	(0.077)	(0.114)	(0.154)
Pork	0.067	-1.442***	-0.267	0.159***
	(0.080)	(0.147)	(0.124)	(0.143)
Chicken	0.117	-0.102	-1.05**	0.002
	(0.288)	(0.303)	(0.465)	(0.472)
Seafood	-0.331**	0.646***	0.123	-1.12***
	(0.053)	(0.040)	(0.056)	(0.085)
Gen X				
	Beef	Pork	Chicken	Seafood
Beef	-0.86***	-0.033	0.088	-0.064
	(0.093)	(0.051)	(0.046)	(0.125)
Pork	-0.018	-0.936***	-0.102	0.016
	(0.092)	(0.128)	(0.105)	(0.169)
Chicken	0.054	-0.107	-1.144***	0.035
	(0.080)	(0.100)	(0.120)	(0.146)
Seafood	-0.022	0.219	0.302**	-1.105***
	(0.047)	(0.031)	(0.028)	(0.084)
Baby Boomers				
	Beef	Pork	Chicken	Seafood
Beef	-0.881***	0.124***	0.112**	-0.432***
	(0.062)	(0.026)	(0.024)	(0.067)
Pork	0.096***	-1.003***	-0.001	-0.143**
	(0.034)	(0.039)	(0.039)	(0.047)
Chicken	0.065***	0.001	-0.934***	-0.159***
	(0.044)	(0.054)	(0.071)	(0.064)
Seafood	-0.096	0.067	0	-0.933***
	(0.125)	(0.058)	(0.052)	(0.158)
Traditionalists				
	Beef	Pork	Chicken	Seafood
Beef	-0.888***	0.032	-0.024	-0.133
	(0.066)	(0.038)	(0.034)	(0.072)
Pork	0.022	-0.973***	-0.049	-0.019
	(0.062)	(0.073)	(0.062)	(0.107)
Chicken	-0.008	-0.032	-0.947***	0.006
	(0.083)	(0.093)	(0.122)	(0.129)
Seafood	0.058	0.15	0.189	-1.257***
	(0.083)	(0.061)	(0.048)	(0.132)

Note. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Standard errors (SE) are shown below the elasticities.

The SE and significance levels were obtained by a delta method approximations.

Appendix B

Table B1: **Estimates of LA-AIDS food-demand system**

	Estimate	SE
α_1	0.389***	(0.045)
α_2	0.301***	(0.039)
α_3	0.23***	(0.042)
α_4	0.08	(0.080)
β_1	-0.045***	(0.006)
β_2	-0.036***	(0.006)
β_3	-0.027***	(0.006)
β_4	0.108***	(0.011)
γ_{11}	0.011	(0.013)
γ_{12}	-0.002	(0.007)
γ_{13}	0.009	(0.007)
γ_{14}	-0.017	(0.020)
γ_{21}	-0.002	(0.007)
γ_{22}	-0.013	(0.010)
γ_{23}	-0.019*	(0.009)
γ_{24}	0.033**	(0.016)
γ_{31}	0.009	(0.007)
γ_{32}	-0.019*	(0.009)
γ_{33}	-0.024**	(0.012)
γ_{34}	0.034**	(0.016)
γ_{41}	-0.017	(0.020)
γ_{42}	0.033**	(0.016)
γ_{43}	0.034**	(0.016)
γ_{44}	-0.05	(0.040)

Note. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table B2: **Coefficient estimates - by generation.**

	Millenials		Gen X		Baby Boomers		Traditionalists	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
α_1	0.256***	(0.052)	0.296***	(0.041)	0.514***	(0.066)	0.491***	(0.066)
α_2	0.236***	(0.037)	0.164***	(0.038)	0.4***	(0.052)	0.312***	(0.074)
α_3	0.084*	(0.045)	0.167***	(0.033)	0.284***	(0.049)	0.204***	(0.061)
α_4	0.424***	(0.055)	0.372***	(0.064)	-0.198**	(0.098)	-0.006	(0.113)
β_1	-0.027***	(0.008)	-0.032***	(0.006)	-0.061***	(0.009)	-0.061***	(0.010)
β_2	-0.032***	(0.006)	-0.017***	(0.006)	-0.049***	(0.007)	-0.038***	(0.011)
β_3	-0.006	(0.008)	-0.018***	(0.005)	-0.033***	(0.007)	-0.024**	(0.009)
β_4	0.065***	(0.009)	0.066***	(0.009)	0.144***	(0.014)	0.123***	(0.017)
γ_{11}	0.048	(0.032)	0.019	(0.017)	0.008	(0.015)	0.007	(0.016)
γ_{12}	0.005	(0.014)	-0.009	(0.010)	0.007	(0.007)	-0.012	(0.011)
γ_{13}	0.019	(0.020)	0.006	(0.009)	0.004	(0.007)	-0.015	(0.010)
γ_{14}	-0.072**	(0.027)	-0.016	(0.025)	-0.019	(0.019)	0.021	(0.021)
γ_{21}	0.005	(0.014)	-0.009	(0.010)	0.007	(0.007)	-0.012	(0.011)
γ_{22}	-0.089***	(0.029)	0.005	(0.016)	-0.021	(0.013)	-0.006	(0.020)
γ_{23}	-0.022	(0.024)	-0.016	(0.013)	-0.014	(0.011)	-0.015	(0.016)
γ_{24}	0.106***	(0.026)	0.02	(0.019)	0.028*	(0.015)	0.033	(0.026)
γ_{31}	0.019	(0.020)	0.006	(0.009)	0.004	(0.007)	-0.015	(0.010)
γ_{32}	-0.022	(0.024)	-0.016	(0.013)	-0.014	(0.011)	-0.015	(0.016)
γ_{33}	-0.004	(0.035)	-0.021	(0.015)	0.003	(0.014)	0.003	(0.019)
γ_{34}	0.007	(0.034)	0.031*	(0.018)	0.007	(0.014)	0.028	(0.021)
γ_{41}	-0.072**	(0.027)	-0.016	(0.025)	-0.019	(0.019)	0.021	(0.021)
γ_{42}	0.106***	(0.026)	0.02	(0.019)	0.028*	(0.015)	0.033	(0.026)
γ_{43}	0.007	(0.034)	0.031*	(0.018)	0.007	(0.014)	0.028	(0.021)
γ_{44}	-0.041	(0.048)	-0.034	(0.047)	-0.015	(0.034)	-0.081*	(0.047)

Note. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table B3: **Own-price and expenditure elasticities - comparison with other studies.**

	Marsh et al. (2004)	Mutondo and Henneberry (2007)	Olynk et al. (2010)	Okrent and Alston (2011)	Gallet (2010)	Gallet (2012)	Lee et al. (2020)	This study
Own-price elasticty								
Beef	-0.78	-0.71	-0.42	-0.70	-0.985	-1.084	-1.35	-0.893
Pork	-0.49	-0.46	-0.74	-1.26	-0.913	-0.913	-1.07	-1.008
Poultry	-0.08	-0.30	-0.09	-0.81	-0.778	-0.743	-0.78	-1.109
Seafood	NA	NA	NA	NA	-1.167	-1.249	NA	-1.154
Expenditure elasticity								
Beef	0.59	1.26	0.91	NA	NA	NA	0.78	0.829
Pork	0.28	0.81	0.01	NA	NA	NA	0.68	0.823
Poultry	-0.35	1.04	-0.58	NA	NA	NA	0.69	0.833
Fish and seafood	NA	NA	NA	NA	NA	NA	NA	1.292

REFERENCES

Alwin, D. F. and McCammon, R. J. (2007). Rethinking Generations. *Research in Human Development*, 4(3-4):219–237.

Andreyeva, T., Long, M. W., and Brownell, K. D. (2010). The impact of food prices on consumption: A systematic review of research on the price elasticity of demand for food. *American Journal of Public Health*, 100(2):216–222.

Blanciforti, L. and Green, R. (1983). An Almost Ideal Demand System Incorporating Habits: An Analysis of Expenditures on Food and Aggregate Commodity Groups. *The Review of Economics and Statistics*, 65(3):511.

Blisard, N., Lin, B.-H., Cromartie, J., and Ballenger, N. (2002). America's Changing Appetite: Food Consumption and Spending to 2020. *Food Review/ National Food Review*, 25(1):2–9.

Bureau of Labor Statistics (2016). Consumer Expenditure Surveys (CE) Research Products.

Bureau of Labor Statistics (2021a). CPI Home : U.S. Bureau of Labor Statistics.

Bureau of Labor Statistics (2021b). Household survey response rates : U.S. Bureau of Labor Statistics.

Capps, O., Tedford, J. R., and Havlicek, J. (1985). Household Demand for Convenience and Nonconvenience Foods. *American Journal of Agricultural Economics*, 67(4):862–869.

Chouinard, H. H., Davis, D. E., and Lafrance, J. T. (2007). Homogeneity and Supply View project.

Deaton, A. and Muellbauer, J. (1980). An Almost Ideal Demand System. *The American Economic Review*.

Eales, J. S. and Unnevehr, L. J. (1988). Demand for Beef and Chicken Products: Separability and Structural Change. *American Journal of Agricultural Economics*, 70(3):521–532.

Food and Agriculture Organization of the United Nations (2017). The Future of Food and Agriculture. *Food and Agriculture Organization of the United Nations*, (November):1–52.

Gallet, C. A. (2010). Meat meets meta: A quantitative review of the price elasticity of meat. *American Journal of Agricultural Economics*, 92(1):258–272.

Gallet, C. A. (2012). A Meta-Analysis of the Price Elasticity of Meat: Evidence of Regional Differences. *Business and Economic Research*, 2(2):14–25.

Green, R. and Alston, J. M. (1990). Elasticities in AIDS Models. Technical Report 2.

Haley, M. M. (2001). Changing consumer demand for meat: the US example, 1970-2000. *Changing Structure of Global Food Consumption and Trade*, pages 41–48.

Henningsen, A. (2017). Demand Analysis with the Almost Ideal Demand System (AIDS).

Kim Parker and Ruth Igielnik (2020). What We Know About Gen Z So Far.

Klein, L. R. (1953). *A textbook of econometrics*. Wiley, 1st edition.

Kuchler, F., Tegene, A., and Harris, J. M. (2005). Taxing snack foods: Manipulating diet quality or financing information programs? *Review of Agricultural Economics*, 27(1):4–20.

Kuhns, A. and Saksena, M. (2017). Food Purchase Decisions of Millennial Households Compared to Other Generations.

Lee, J. Y., Qian, Y., Gustavsen, G. W., Nayga, R. M., and Rickertsen, K. (2020). Effects of consumer cohorts and age on meat expenditures in the United States. *Agricultural Economics (United Kingdom)*, 51(4):505–517.

Marsh, T. L., Schroeder, T. C., and Mintert, J. (2004). Impacts of meat product recalls on consumer demand in the USA. *Applied Economics*, 36(9):897–909.

Marshall, T. (2000). Exploring a fiscal food policy: The case of diet and ischaemic heart disease.

Meyer, B. D., Mok, W. K., and Sullivan, J. X. (2015). Household surveys in crisis. *Journal of Economic Perspectives*, 29(4):199–226.

Moschini, G. and Meilke, K. D. (1989). Modeling the Pattern of Structural Change in U.S. Meat Demand. *American Journal of Agricultural Economics*, 71(2):253–261.

Mutondo, J. E. and Henneberry, S. R. (2007). A source-differentiated analysis of U.S. meat demand. *Journal of Agricultural and Resource Economics*, 32(3):515–533.

Nayga, R. M. (1995). Microdata Expenditure Analysis of Disaggregate Meat Products. *Review of Agricultural Economics*, 17(3):275.

Okrent, A. M. and Alston, J. M. (2011). Demand for Food in the United States: A Review of Literature, Evaluation of Previous Estimates, and Presentation of New Estimates of Demand. *Giannini Foundation Monograph 48*, (April):125.

Olynk, N. J., Tonsor, G. T., and Wolf, C. A. (2010). Consumer Willingness to Pay for Livestock Credence Attribute Claim Verification. Technical Report 2.

Revell, B. J. (2015). One Man's Meat … 2050? Ruminations on Future Meat Demand in the Context of Global Warming. *Journal of Agricultural Economics*, 66(3):573–614.

Saksena, M. J., Okrent, A. M., Anekwe, T. D., Cho, C., Dicken, C., Anne, E., Elitzak, H., Guthrie, J., Hamrick, K. S., Hyman, J., Jo, Y., Lin, B.-H., Mancino, L., Mclaughlin, P. W., Rahkovsky, I., Ralston, K., Smith, T. A., Stewart, H., Todd, J., and Tuttle, C. (2018). America's Eating Habits: Food Away From Home. *Economic Information Bulletin No. 196*.

Tonsor, G. T., Mintert, J. R., and Schroeder, T. C. (2010). U.S. Meat Demand: Household Dynamics and Media Information Impacts. Technical Report 1.

United States Census Bureau (2017). 2017 National Population Projections Tables: Main Series.

USDA Economic Research Service (2021). Per capita availability of chicken higher than that of beef.

Webster's (1996). *Webster's New Universal Unabridged Dictionary Fully Revised and Updated*.

3 DOES DAIRY AND MEAT DEMAND CHANGE OVER TIME? COMPARISON OF AIDS DEMAND SYSTEM FROM TWO TIME PERIODS

3.1 Introduction

Agricultural economists use consumer demand theory to estimate how consumers' spending patterns change as a response to price and income changes, advertising, labeling, policy changes and time (Lusk and McCluskey, 2018). Policymakers and the food sector need updated analysis of food consumption changes, dietary patterns, and consumer preferences. Previous research (Andreyeva et al., 2010; Blisard et al., 2002; Kuhns and Saksena, 2017; Lee et al., 2020; Lusk and Tonsor, 2016) indicates that food consumption patterns differ by income level, age, gender, ethnicity, and place of residence. The previous research indicates differences in consumer sensitivity to price changes across different food items and food categories. However, the existing research has several limitations, including not considering that purchasing patterns and preferences can change over time. Food preferences and consumption patterns can change drastically in a span of one generation. Many of the Baby Boom generation, fed their families TV dinners and canned vegetables. In turn Generation X (Gen X) who grew up eating those highly processed and fast food meals often, as parents themselves do not want to serve their children the same highly processed foods (Ellison, 2004; Lusk and McCluskey, 2018). It is yet impossible to say what the impact of the food choices, many choosing "organic," "clean label" etc. made by Gen X, will have on the following generations.

Those changes in diatery habits and preferences between generations are one of the contributors to changing consumption per capita of dairy products such as milk and cheese. In 2002, per-capita fluid milk consumption in the U.S. was 191 pounds[18]. The quantity of milk consumed, continued to decline throughout the study period, by 2006 it was 185 pounds, in 2015 it was 155 pounds, and in 2019 only 141 pounds. In

[18] According to the USDA (2020) data, the fluid milk category includes milk-weight content in: whole, reduced fat, skim and flavored milk, buttermilk, and eggnog.

contrast, per capita consumption of butter and cheese[19] increased throughout the study period. Butter consumption increased from from 4.4 pound to 6.2 pounds, and cheese consumption increased from 32.8 to 40.4 pounds between 2002 and 2019. Ice cream consumption declined slightly in the same period, from 22 to 18.7 pounds. Per-capita dairy consumption throughout the study period is presented in Figure 3.1.

Similar to fluid milk, per-capita consumption of beef[20] declined during the study period, from 64.8 pounds in 2002 to 55.5 pounds in 2019. In comparison, per-capita consumption of chicken[21] increased from 56.6 pounds in 2002 to 66.7 pounds in 2019. Pork consumption displayed a v-shaped trend during the study period. Per-capita pork consumption was 48.5 pounds in 2002, and by 2011 it declined to 42.9 pounds. Starting in 2012, it started to increase, reaching 49.2 pounds in 2019. Per-capita meat consumption throughout the study period is presented in Figure 3.2.

Generally, food policy and market analysis uses food demand elasticities found in academic literature and government reports, whether explicitly or implicitly (Okrent and Alston, 2011). In many research studies, relevant aspects of demand response are expressed in terms of elasticities. As a result, the policy analysis' quality is contingent on the quality and relevance of the available elasticity estimates. This research argues that updated dairy and meat product demand elasticities should be of vital interest to policymakers and the food sector in the coming years as consumer behavior continues to evolve.

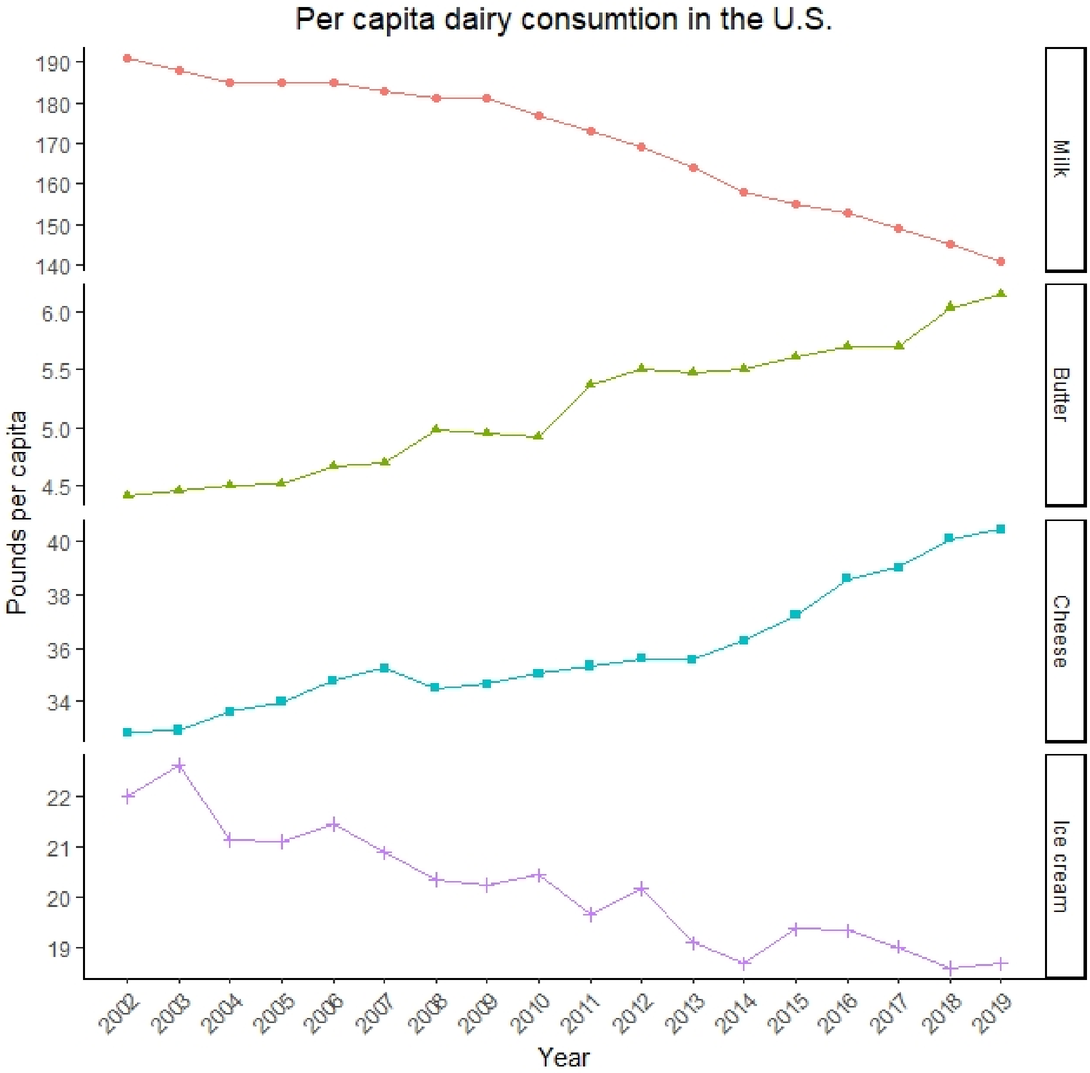
This research study applies the same method of analysis, using the same data set to compare elasticities for meat and dairy products for two separate 5-year time periods: 2002-2006 and 2015-2019. This comparison is attempting to determine if a taste change for different meat and dairy products occurred during the study period. This is accomplished by comparing elasticities computed based on the estimates from the two models representing the two time periods. If this study supports the assumption that

[19]Cheese includes American cheese, Cheese other than American and cottage cheese
[20]Based in per capita disappearance in boneless retail weight (USDA, 2019).
[21]Based on broiler boneless retail weight per capita disappearance (USDA, 2019).

consumer preferences changed, a continuing update of the demand elasticities is necessary to more accurately project the present demand for food products. Alternatively, if the findings fail to support an assumption of preference change, and no differences are observed, existing estimates are sufficient. Such an outcome would also suggest that policies targeting increasing demand for meat or dairy products would most likely be ineffective. The author hopes that such updated elasticities will aid in a more realistic and accurate forecast of future dairy products demand.

The changes in consumption patterns are critical to address as these industries look to the future. Are these consumption patterns related to demand shifts? If so, what is causing the changing demand behavior? Is it related to changing demographics? Or is it changing tastes and preferences? These remain important questions for these industries to answer as they look to the future and determine whether consumption of their products are going to expand or contract.

Figure 3.1: **Dairy consumption per capita in the U.S. - 2002-2019.**



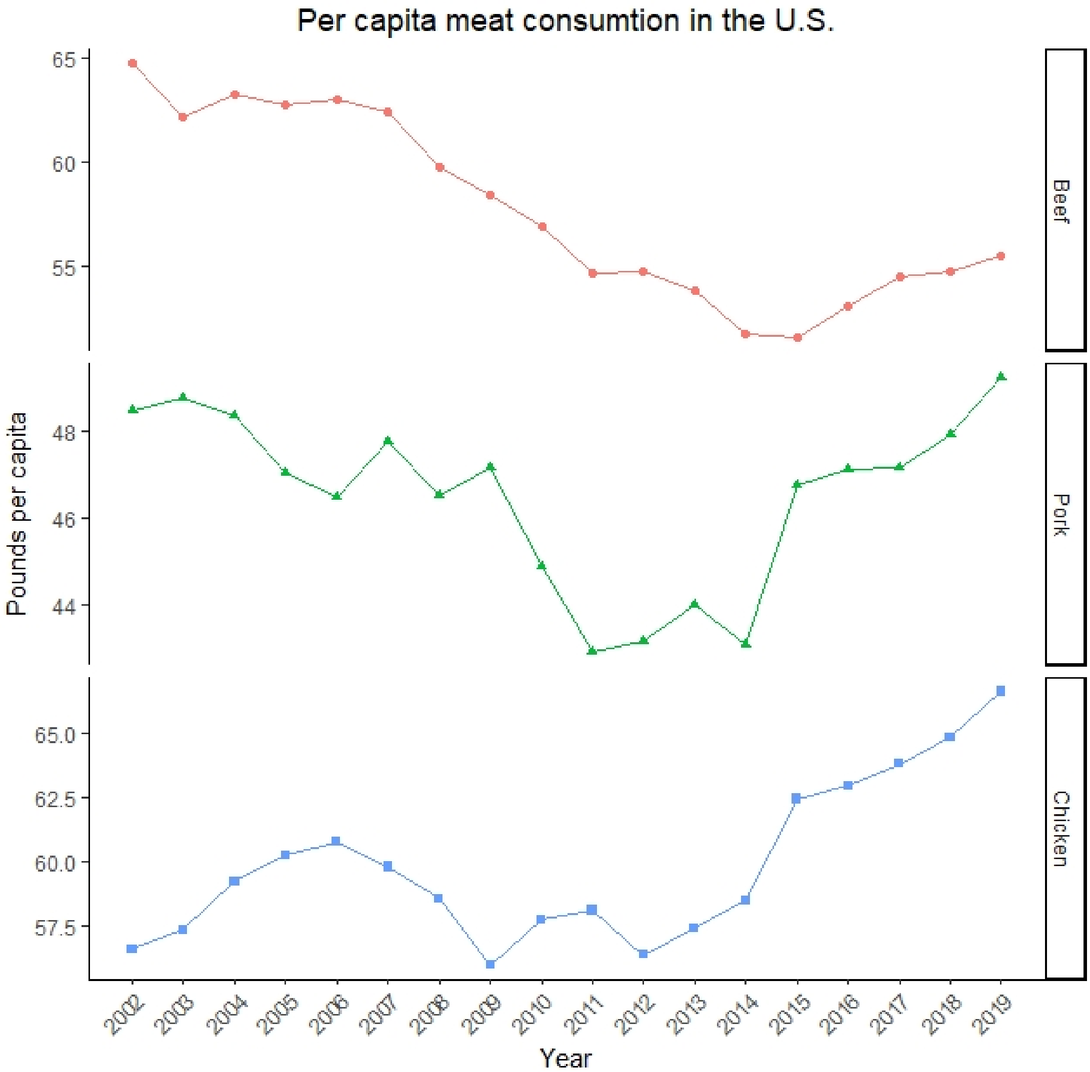
Note: Based on USDA data (USDA, 2020).

3.2 Data

Multiple sets of data from the Consumer Expenditure survey (CEX) Public Use Micro Data (PUMD) from Bureau of Labor Statistics (BLS) were combined and used in the current research (Bureau of Labor Statistics, 2021a). The data used came from two 5-year time periods, 2002-2006 and 2015-2019[22], separated by a 10-year gap. The goal of this separation, was to obtain two distinct data sets, allowing for a comparison, testing if any significant changes occurred in estimated coefficients and computed elasticities.

[22]The most recent year of published data available at the time of conducting this research.

Figure 3.2: **Meat consumption per capita in the U.S. - 2002-2019.**



Note: Based on USDA data (USDA, 2019).

The CEX data is divided into two parts, Interview Survey, and Diary Survey (DS), with different methods and sample populations. This research will focus on data provided by the DS. The DS is especially relevant to this research as it collects data on small, frequent expenditures including food. The DS has two parts, a Household Characteristic Questionnaire and a Record of Daily Expenses. The Household Characteristic Questionnaire collects detailed demographic and income information on all members of the household. The Record of Daily Expenses is a self-reported diary where each respondent records all household expenses for two consecutive weeks, with each week treated as an independent observation. The use of household-level data avoids the problem of aggregation over consumers and provides a large statistically rich sample. The data used represent a system of dairy products including milk, butter, cheese, ice cream, other dairy, and all other food. The meat system includes ground beef, beef steak, pork, chicken, other meat, and all other food.

One of the main limitations of the CEX PUMD DS data set is that it does not record the price paid by each household for a given commodity. Therefore, no distinction can be made as to the quality differences of purchased commodities between different demographic groups. As a result, in this research, it is assumed that all households face the same price at the same point in time (each month) for each of the products analyzed. In the absence of price data in the CEX, the price data used is obtained from BLS Consumer Price Index (CPI) for the corresponding period (Bureau of Labor Statistics, 2021b). Specifically, the following data series from CPI were used for each system. For the dairy product system: (1) monthly adjusted national CPI for all food, (2) monthly adjusted national CPI for milk, butter, cheese, ice cream, other dairy and meat. Similarly for the meat system (1) monthly adjusted national CPI for all food, (2) monthly adjusted national CPI for beef steak, ground beef, pork, chicken, and other meat[23].

[23]The list of CPI variables used in this research is presented in table C1 in the Appendix.

3.3 Methods

The demand for both, meat and dairy products is influenced by its own price, prices of close substitutes, income (expenditure), and demographic effects.The data from the CEX DS and CPI are used to estimate an Almost Ideal Demand System (AIDS). The first estimated demand system encompasses seven food items with an emphasis on dairy products. The second demand system encompasses seven commodities with the focus in on meat. The AIDS system is commonly used because of its flexibility and linearity. It is also a complete system, which means it can be restricted to satisfy conditions of adding up, homogeneity and symmetry. The estimation approach follows a two-stage estimation procedure outlined by Heien and Wessells (1990). In this procedure, a probit regression is used to censor the dependent variable as a direct way to deal with zero observations present in the survey data. The probit regression is specified as:

$$Y_{ih} = f(d_{ih}, ..., d_{sh}). \tag{3.1}$$

Where Y_{ih} is the hth household binomial value of consumption of ith good. If $w_{ih} > 0$, representing the weekly expense of the hth household on ith good, then $Y_{ih} = 1$, and 0 otherwise. This presents a dichotomous choice problem for each good as a function of demographic variables d of which there are s. The full list of demographic variables is presented in the Appendix Table C2.

The result of the probit analysis is used to calculate the Inverse Mills Ratio (IMR), which is then directly used as a predictor in the demand system. The effectiveness in improving the estimates with a censored model was shown by Heien and Wessells (1990), therefore in this study only results from the censored model are shown. The IMR is defined as follows:

$$R_{ih} = \phi(\mathbf{p}_h, \mathbf{d}_h, m_h)/\Phi(\mathbf{p}_h, \mathbf{d}_h, m_h) \tag{3.2}$$

as defined in (Heien and Wessells, 1990) specified for the ith food item for the hth household, where $\mathbf{p}_h$ is the vector of prices and $\mathbf{d}_h$ is the vector of demographic variables, m_h is the total expenditure (here total food at home expenditure) of the hth household, and ϕ and Φ are the density and cumulative probability functions, respectively.

The AIDS model demand relations, in a budget share form, follow the specification given by Deaton and Muellbauer (1980) as outlined by Heien and Wessells (1990). A demographic translation method was applied to incorporate demographic variables into the analysis. The AIDS model is specified as:

$$w_{ih} = \alpha_{io} + \sum_{k=1}^{s} \rho_{ik} d_{kh} + \sum_{j=1}^{n} \gamma_{ij} p_{jh} + \beta_i \ln(m_h/Z_h) + \delta_i R_{ih}, \tag{3.3}$$

where Z is defined as:

$$Z_h = \sum_{i=1}^{n} \ln p_{ih}. \tag{3.4}$$

The following restrictions or economic theory were also applied to the system:

adding up -

$$\sum_{i=1}^{n} \alpha_i = 0; \qquad \sum_{i=1}^{n} \gamma_i = 0, \quad j = 1, ..., n; \qquad \sum_{i=1}^{n} \beta_i = 0; \tag{3.5}$$

homogeneity -

$$\sum_{j=1}^{n} \gamma_{ij} = 0, \qquad i = 1, .., n; \tag{3.6}$$

and symmetry -

$$\gamma_{ij} = \gamma_{ji} \quad \text{for all} \quad i, j(i = j). \tag{3.7}$$

The equation for the last good, in case of both meat and dairy systems, all other food, was deleted to ensure non-singularity of the error covariance matrix. The demand system was estimated using the `sampleSelection` and `systemfit` packages in R statistical software (Henningsen and Hamann, 2007; Henningsen and Toomet, 2008).

3.4 Results

3.4.1 AIDS results dairy - years 2002-2006 and 2015-2019

Five years of data were used in the model representing the 2015-2019 period. The total number of households that reported purchases of food at home (FAH) during that time was 47,207. The outlier treatment resulted in removal of 2,867 observations, leaving 44,340. The data were aggregated into the following 7 categories: milk (55%), butter (14%), cheese (45%), ice cream (20%), other dairy (34%), meat (66%) and, other food products (99%). The percentages in parentheses give the proportion of households in the survey sample that reported purchasing given food product. This specification implies that the food items are separable from the other (nonfood) items in the consumer's budget. The outlier thresholds for each commodity were: milk < 1000, butter < 50, cheese < 50, ice cream < 10, other dairy < 50, meat < 75. If the value was larger than the value indicated in the threshold the observation was removed from the data. The same outlier treatment was applied to the 2002-2006 data. For the years 2002-2006 , after removing households that did not purchase any FAH products 62,868 households were left. The outlier treatment resulted in removal of 2,756 observations, leaving 60,112. After the outlier treatment the purchase reporting shares were: milk (65%), butter (13%), cheese (44%), ice cream (25%), other dairy (30%), meat (70%), all other food (99%).

Visual examination of the budget shares in Figure C5 and C4, shows a cyclical pattern in ice cream purchases, with the highest budget share dedicated to ice cream in the summer months, and with the lowest during the winter. Similar cyclicality, but in counter cycle, can be observed for butter purchases. Butter purchases peak during holiday season, between November and December and are the lowest during summer months.

Among dairy products the highest expenditures were for cheese, with $5.27[24] in

[24]Mean expenditures were calculated based on non-zero observations only.

the 2002-2006 and \$6.90 in 2015-2019. Cheese was also the second most frequently reported purchase in both periods, second only to milk. Milk, was the first most frequently purchased dairy product in both periods, with 65% and 55% of households reporting milk purchases in each period, respectively. In 2015-2019, milk was also the smallest average weekly expenditure of \$4.70. The smallest average weekly expenditure in the 2002-2006 was for butter \$2.99, which was much smaller than the corresponding value in 2015-2019 - \$4.84. Overall, all households spent on average more on diary products in 2015-2019 time period, compared with 2002-2006, which can be explained by a steady increase in dairy prices between the two periods. However, the increase in average amount spent on butter and other dairy products, between the two periods, was more pronounced than for other products. This increase could indicate a change in preferences. A slightly different picture is revealed when we look at average weekly expenditures calculated based on all observations (including zeros). In the 2002-2006 period, all households spent most on milk - \$2.68. In 2015-2019, the highest average weekly expenditures were on cheese, \$3.10, which was also the case for averages calculated using only non-zero observations. The smallest average weekly expenditure, based on all observations, in both periods was on butter, \$0.41 and \$0.66, in 2002-2006 and 2015-2019 respectively. The comparison of the means between the two periods of the dairy products is presented in table 3.1.

Table 3.2 shows uncompensated (Marshallian) own- and cross- price elasticties for the 6 food products for the two time periods. The demand system estimated in this research is constrained by total at home food expenditures, as opposed to income, total expenditure, or total food expenditure (which would also include food consumed away from home). All own-price elasticities with exception of ice cream in 2002-2006 were negative and statistically significant at at least $p = 0.05$ significance level. In the 2015-2019 time period all own price elasticities were negative (with exception of cheese), which is consistent with theory and expectations. The 2015-2019 own-price elaticities were statistically significant at at least $p = 0.05$ with exception of milk, which was not

Table 3.1: **Dairy expenditures and percent reporting by time period**

Variable	Expenditure Mean[a]	Expenditure Mean[b]	Percent reporting[c]
	2002-2006		
Milk	$4.17	$2.68	65%
Butter	$2.99	$0.41	13%
Cheese	$5.27	$2.38	44%
Ice cream	$4.29	$1.35	25%
Other dairy	$3.50	$1.06	30%
	2015-2019		
Milk	$4.70	$2.58	55%
Butter	$4.84	$0.66	14%
Cheese	$6.90	$3.10	45%
Ice cream	$4.83	$0.95	20%
Other dairy	$5.53	$1.90	34%

[a] Means calculated based on non-zero observations only.

[b] Means calculated using all observations including zeros.

[c] Percent of households in the sample reporting purchases of each food category in their weekly expenditures.

statistically significant at $p = 0.10$. In the 2002-2006 period the product category most responsive to price changes was other dairy, with the elasticity of -2.079. Elasticity, of other dairy products was much smaller for the 2015-2019, at -1.553. In 2015-2019, the most responsive to price change dairy product was ice cream, with own-price elasticity of -3.84. The second most elastic product, in the 2015-2019 period was butter, with own price elasticity of -2.361, which was much more elastic than the own-price elasticity of butter for the 2002-2006, of -0.947. The own-price elasticity of butter for the 2002-2006 period, implies that a 1% increase in price of butter would result in slightly less than 1% decline in butter demand. On the other hand, the own-price elasticity of butter for the 2015-2019 period implies a 1% increase in price of butter will result in more than 2% decline in butter demand. The most inelastic with respect to own-price in both periods was milk, which seems intuitive, as milk in a staple food product. The own-price elasticity of milk in 2002-2006 was -0.515 and it was even smaller in 2015-2019, -0.055.

The estimated cross-price elasticities for dairy products reveal several substitution/ complementarity relationships. Several of the relationships where the cross-price elasticities indicate complementarity in 2002-2006 appear to have an opposite relationship in 2015-2019. In 2002-2006 milk was a substitute for ice cream and meat (i.e. cross-price elasticity is positive). In 2015-2019 milk was a substitute to other dairy, but did not display any other clearly defined cross relationships. In both periods, butter was a complement (i.e. cross-price elasticity is negative) to cheese and ice cream. In 2015-2019 butter was also a substitute to meat, yet, no such relationship was revealed in 2002-2006. Ice cream and other dairy were complements in both periods, 2002-2006 and 2015-2019. Cheese has been a complement to ice cream and other dairy in 2015-2019, however no substitution or complementary relationship was revealed in 2002-2006. In 2002-2006 meat was a substitute to ice cream and other dairy.

Expenditure elasticities are presented in Tables 3.3 and 3.4. All expenditure elasticities for both periods are positive and statistically significant at $p = 0.01$, implying that dairy products and meat, are normal goods. Four out of 6 products had own price elasticities larger than 1. In both periods, milk and ice cream are the most expenditure inelastic. In 2015-2019, meat and cheese were the most expenditure elastic, with elasticities of 1.185 and 1.139. In 2002-2006, meat and butter were the most expenditure elastic, with elasticities of 1.249 and 1.189, respectively, with cheese coming in as close third at 1.17. Given those elasticities, a 1% increase in the household expenditures on food at home, would increase the demand for butter, cheese, other dairy and meat products by more than 1%. Expenditure elasticities for butter and cheese[25] were similar to those found by Davis et al. (2011). The milk expenditure elasticity was much lower than the elasticities for milk found by Davis et al. (2011), ranging between 0.79 for whole milk and 1.08 for both skim milk and 2%. All but milk expenditure elasticities for both periods were higher than expenditure elasticities shown by Heien and Wessells (1990) for the censored model, yet the expenditure elsticities in the current study were more similar to the uncensored model results in the same study.

Tables C4 and C6 show the coefficient estimates from the dairy demand systems,

[25] As compared to natural cheese in Davis et al. (2011)

Table 3.2: **Own- and cross price elasticties for dairy products 2002-2006 and 2015-2019 data**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
			2002-2006			
Milk	-0.515***	-0.076***	-0.294***	0.196***	-0.438***	0.092***
	(0.016)	(0.012)	(0.009)	(0.008)	(0.017)	(0.004)
Butter	0.012***	-0.947***	-1.063***	-0.043***	-0.188***	0.232***
	(0.004)	(0.002)	(0.003)	(0.005)	(0.012)	(0.005)
Cheese	1.375***	-0.336***	-1.434***	-0.901***	-0.088***	1.664***
	(0.005)	(0.003)	(0.025)	(0.009)	(0.003)	(0.012)
Ice cream	1.060***	-0.040	2.364***	0.027**	-0.088***	0.572***
	(0.012)	(0.017)	(0.014)	(0.012)	(0.017)	(0.009)
Other dairy	0.404***	2.067***	0.780***	-0.399***	-2.079***	0.112***
	(0.009)	(0.014)	(0.008)	(0.004)	(0.019)	(0.010)
Meat	1.364***	-0.202***	-0.002	0.438***	0.240***	-1.260***
	(0.010)	(0.017)	(0.004)	(0.014)	(0.014)	(0.029)
			2015-2019			
Milk	-0.055	0.179***	-0.02	-0.081***	0.509***	-2.284***
	(0.027)	(0.020)	(0.017)	(0.018)	(0.030)	(0.010)
Butter	-0.382***	-2.361***	-1.692***	-0.177***	0.197***	0.466***
	(0.010)	(0.008)	(0.011)	(0.012)	(0.020)	(0.012)
Cheese	2.209***	-2.155***	0.081**	-0.075***	-1.164***	0.855***
	(0.012)	(0.011)	(0.033)	(0.017)	(0.011)	(0.022)
Ice cream	0.330***	-0.904***	-0.969***	-3.840***	-1.487***	4.132***
	(0.022)	(0.022)	(0.027)	(0.028)	(0.022)	(0.022)
Other dairy	6.442***	-2.271***	-0.193***	-0.588***	-1.553***	0.125***
	(0.022)	(0.021)	(0.018)	(0.011)	(0.030)	(0.021)
Meat	0.916***	0.115***	-0.009	-0.220***	-0.206***	-0.329***
	(0.021)	(0.030)	(0.012)	(0.027)	(0.021)	(0.049)

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

including 7 food products and 12 demographic variables, with a total of 45 and 46 levels[26]. The demographic variables include generation, household income quantile, number of children present in the household, number of adults, family type, dwelling ownership, race, type of employment, level of urbanization[27], number of earners, region, and season . The full list of demographic variables and their levels is presented in Table C2.

The 2015-2019 estimation results show that higher income levels, income quantile 2 through 5, are associated with more purchases of butter and cheese. The opposite is true for purchases of ice cream, other dairy and meat. Compared to Baby Boomers, all other generations were negatively associated with purchases of milk and butter. Belonging to a Traditionalist or Millennial generation had a negative impact on cheese and meat purchases, compared to Baby Boomers. Opposite was true for Gen X.

Table 3.3: **Expenditure elasticities for dairy products 2002-2006**

	Exp. elas	SE
Milk	0.423***	0.007
Butter	1.189***	0.015
Cheese	1.17***	0.007
Ice cream	0.994***	0.011
Other dairy	1.109***	0.011
Meat	1.249***	0.004

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

The 2002-2006 estimation results for dairy products show some similar and some opposite demographic effects compared to the 2015-2019 period. In 2002-2006 period Millennials, Traditionalists and Gen X compared to Baby Boomers had a positive impact on Milk and Butter (with the exception in Traditionalists). The opposite was the case for the 2015-2019 period, all generations had a negative impact on milk and butter purchases. Belonging to a higher income group (ie. 2nd through 5th income quantile) compared the the lowest income group, had positive impact on ice cream purchases in the 2002-2006 period. Yet, the opposite was true for the 2015-2019 period, where

[26]There is no race variable defined as Hispanic for the 2002-2006 data
[27]Rural vs. urban

higher income groups spent less on ice cream than the lowest group.

Table 3.4: **Expenditure elasticities for dairy products 2015-2019.**

	Exp. elas	SE
Milk	0.475***	0.010
Butter	1.128***	0.018
Cheese	1.139***	0.009
Ice cream	0.794***	0.017
Other dairy	1.134***	0.011
Meat	1.185***	0.005

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

In both time periods, higher income levels had a negative impact on meat purchases, with several of the coefficients at a significance level of $p = 0.01$. Employment status, compared to salaried employees, had a positive impact on meat purchases in 2002-2006, where the opposite was true in the 2015-2019 period. Only one of the employment coefficients associated with meat purchases - self employed - was statistically significant at $p = 0.05$ level in 2002-2006. All the employment coefficients were statistically significant in the 2015-2019 period at $p = 0.01$ level. Region of residence (compared to the suppressed region variable) had negative impact on all dairy purchases except for, butter and meat, in the 2002-2006 period. With all the meat coefficients being significant at $p = 0.05$ and Midwest and South regions coefficients being significant at $p = 0.10$. The results for the 2015-2019, varied more, with meat purchases being negatively impacted by region of residence, with Midwest and South coefficient statistically significant at $p = 0.10$. Race defined as Black, relative to race defined as White in the survey data, had a positive impact on purchases off milk, butter, cheese, and meat and negative on purchases if ice cream and other dairy in 2002-2006, with positive coefficient associated with meat purchases being significant at $p = 0.01$. The same impact was observed for race defined as other (compared to white), with the positive coefficient associated with cheese purchases, significant at $p = 0.05$ level. In 2015-2019 period, coefficients associated with race defined as Black were negative for milk, cheese and ice cream, and negative impact on purchases of all other products in the system. Race defined as

Hispanic, had positive impact on butter and other dairy purchases, and positive on all the other products. Race defined as other had negative impact in milk, butter, cheese, and ice cream purchases and, positive on meat and other dairy. Yet, none of the race coefficients in the 2015-2019 dairy system were statistically significant.

3.4.2 AIDS results meat - years 2002-2006 and 2015-2019

The sample of all observation from years 2015-2019 after removal of households that did not report purchasing any food at home had 47,207 observations. Subsequently, households that did not report purchases of any meat or fish products were removed, leaving 32,485 observations. The outlier threshold for each product category was applied as follows: ground beef < 20 and fish < 50. The data were aggregated into following 7 categories, with the percentages indicating the proportion of households in the survey that reported purchasing given item: ground beef (31%), beef steak (19%), pork (21%), chicken (25%), other meat (69%), fish (35%) and all other food (100%). The outlier treatment resulted in removal of additional 1,075 observations, leaving 31,410 households.

The same procedure as outlined above was applied to the data from years 2002-2006 and the same cutoff values in the outlier treatment were applied. The initial number of households who reported purchases of food at home was, 62,868. After removing all households who did not report purchases of any meat or fish products, 45,416 households were left. The outlier treatment resulted in removal of another 688 observations, leaving a total of 44,728, The percentages indicating the proportion of households in the survey that reported purchasing a given item: ground beef (42%), beef steak (23%), pork (26%), chicken (24%), other meat (73%), fish (38%) and all other food (100%).

Among meat products the highest expenditure share was for beef steak with $12.04[28] in 2002-2006 and $15.50 in 2015-2019. In 2002-2006, 23% households reported purchases of beef steak. By 2015-2016, only 19% of households reported beef purchases.

[28]Mean expenditures were calculated based on non-zero observations only.

Other meat purchases were the most frequently reported meat category purchases, 73% in 2002-2006 and 69% in 2015-2019. In both periods, chicken was the smallest average weekly expenditure, of \$5.48 and \$7.11, in 2002-2006 and 2015-2019 period, respectively. The second most frequently reported meat purchase in 2002-2006 was ground beef, with 42% of households reporting the purchase. In 2015-2019, fish was the second most frequently reported meat product category, with 35% of households reporting purchases of fish.

Similar to the case of dairy expenditures, the ranking of meat expenditures differs when one considers all observations, and not just the non-zero observations.. The largest average weekly expenditure in both periods was on other meat, which include lunch meats, bacon and sausages among other. In 2002-2006 other meat expenditure was \$6.91, and in 2015-2019 it was \$8.34. The smallest average weekly expenditure was on chicken \$1.32 and \$1.77, in 2002-2006 and 2015-2019 respectively.

The mean expenditures calculated with or without zeros reveal two insights. The averages, without zeros, show how much on average a household spent when they made a purchase of a certain type. Yet, it does not tell us if that is equivalent to weekly consumption for the household. It may be that the purchase represents a bi-weekly or just occasional purchase. On the other hand, the weekly expenditures calculated using all observations, including zeros potentially reveal how much an average household consumed of the purchased product. The same logic can be applied to both, meat and dairy products.

Tables C7 and C9 show the coefficient estimates from the meat demand system estimation including 7 food group products. Tables C8 and C10 show the coefficient estimates of the meat demand system including 12 demographic variables, with a total of 45 and 46 categories[29]. The details of the demographic variables are described in section 3.4.1 on page 72 and in table C2. Most of the estimation results for meat products coefficients representing demographic effects were not statistically significant. However,

[29] There is no race defined as Hispanic in 2002-2006 data.

Table 3.5: **Meat average expenditures and percent reporting by time period**

Variable	Expenditure Mean[a]	Expenditure Mean[b]	Percent reporting[c]
2002-2006			
Ground beef	$6.17	$2.58	42%
Beef steak	$12.04	$2.74	23%
Pork	$8.76	$2.30	26%
Chicken	$5.48	$1.32	24%
Other meat	$9.52	$6.91	73%
Fish	$9.24	$2.52	38%
2015-2019			
Ground beef	$8.28	$2.59	31%
Beef steak	$15.50	$2.98	19%
Pork	$10.10	$2.15	21%
Chicken	$7.11	$1.77	25%
Other meat	$12.10	$8.34	69%
Fish	$11.36	$3.98	35%

[a] Means calculated based on non-zero observations only.

[b] Means calculated using all observations including zeros.

[c] Percent of households in the sample reporting purchases of each food category in their weekly expenditures.

even though the lack of statistical significance would suggest most of the observed coefficients are not statistically significantly different from zero, the author believes some interesting insights can be gleaned from the results, as suggested by McCloskey (1999).

The 2015-2019 estimates show that higher income, 2nd through 5th income quantile, compared to the first income quantile, are associated with more purchases of ground beef, beef steak, and pork. The opposite was true for purchases or chicken, other meat and fish. Presence of children had positive effect on purchases of beef steak, and chicken and an opposite effect on purchases of ground beef, pork, other meat and fish. Race other than white was positively associated with purchases of ground beef and other meat, and opposite for pork and fish. The results for beef steak and chicken were mixed among different races. Residing in rural areas compared to urban residents was positively associated with expenditures on chicken and fish and negatively associated with purchases of all other meats. Residence in region other than undefined was negatively associated with purchases of other meat and fish, and positively associated with purchases of pork and chicken.

The 2002-2006 results, shown in table C8, similarly to the 2015-2019 estimates, show that higher income quantiles (with the exception of the highest 5th income qunatile) are positively associated with purchases of ground beef, beef steak, and other meat, and negatively associated with purchases of pork, chicken and fish. Presence of children in the household, is positively associated with purchases of ground beef, pork and fish, and negatively associated with purchased of other meat, with results for beef steak and chicken being mixed. In 2002-2006, compared to Baby Boomers, Gen X were negatively associated with purchases of ground beef, pork, and chicken and fish, and positively associated with purchases of beef steak and other meat. Belonging to the Traditionalists and Millennials generations had a positive impact on ground beef, beef steak and other meat purchases, compared to Baby Boomers.

The own- and cross-price elasticities for meat products for both periods are presented in Table 3.6. All own-price elasticities in both periods were negative and statistically significant at $p = 0.01$ (with exception of fish in 2015-2019 period), which is consistent with theory and expectations. In 2002-2006 fish was the most price elastic, with own-price elasticity of -4.201. The second most elastic meat product was chicken with own price elasticity of -3.248. In 2015-2019, beef steak and pork were the most price elastic, with own price elasticities of -3.541 and -3.513, respectively.

Table 3.7: **Expenditure elasticities for meat products 2002-2006 data**

	Exp. elas	SE
Ground beef	0.964***	0.012
Beef steak	1.025***	0.017
Pork	0.993***	0.015
Chicken	0.975***	0.018
Other meat	0.989***	0.007
Fish	1.010***	0.013

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

In 2002-2006, beef steak and other meat were the most inelastic, with elasticities of -0.64 and -0.675, respectively. In 2015-2019, chicken and ground beef were the most price inelastic, with respective elasticities of -0.677 and -0.754. Ground beef own-

Table 3.6: **Own- and cross-price elasticities for meat products 2002-2006 and 2015-2019**

	Ground beef	Beef steak	Pork	Chicken	Other meat	Fish
2002-2006						
Ground beef	-0.730***	-1.145***	-0.508***	-2.311***	-1.707***	-0.246***
	(0.011)	(0.010)	(0.008)	(0.016)	(0.013)	(0.010)
Beef steak	-0.204***	-0.640***	1.885***	1.053***	-1.565***	0.921***
	(0.010)	(0.011)	(0.017)	(0.013)	(0.010)	(0.011)
Pork	0.804***	0.241***	-1.166***	-1.091***	0.435***	2.395***
	(0.011)	(0.008)	(0.026)	(0.008)	(0.008)	(0.018)
Chicken	1.524***	-0.682***	-0.021	-3.248***	-0.216***	0.090***
	(0.018)	(0.027)	(0.022)	(0.019)	(0.027)	(0.022)
Other meat	0.450***	-1.385***	-1.001***	0.685***	-0.675***	-0.021
	(0.022)	(0.020)	(0.016)	(0.016)	(0.057)	(0.033)
Fish	-0.009	-1.530***	0.791***	-0.0140	-0.579***	-4.201***
	(0.033)	(0.013)	(0.013)	(0.022)	(0.020)	(0.038)
2015-2019						
Ground beef	-0.754***	1.285***	0.381***	-2.480***	-0.540***	0.825***
	(0.020)	(0.019)	(0.019)	(0.022)	(0.023)	(0.019)
Beef steak	0.706***	-3.541***	3.797***	2.198***	1.820***	-1.840***
	(0.019)	(0.029)	(0.027)	(0.027)	(0.019)	(0.021)
Pork	-1.518***	-1.318***	-3.513***	0.617***	-1.824***	-1.400***
	(0.021)	(0.020)	(0.030)	(0.019)	(0.020)	(0.022)
Chicken	-1.227***	2.488***	-0.200***	-0.677***	0.655***	1.353***
	(0.022)	(0.027)	(0.028)	(0.035)	(0.027)	(0.026)
Other meat	5.872***	-0.532***	-0.925***	1.211***	-1.708***	-0.624***
	(0.026)	(0.030)	(0.022)	(0.027)	(0.047)	(0.037)
Fish	-0.293***	-0.428***	1.488***	-0.112**	-0.261***	-0.037
	(0.037)	(0.023)	(0.027)	(0.028)	(0.030)	(0.052)

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

price elasticity in both periods are comparable to results for beef presented by Marsh et al. (2004), Mutondo and Henneberry (2007) and Okrent and Alston (2011). Pork own-price elasticity in 2002-2006 was similar to the ones in Okrent and Alston (2011) and Lee et al. (2020), and higher than other studies (Marsh et al., 2004; Mutondo and Henneberry, 2007; Olynk et al., 2010). Chicken own-price elasticity in both periods was much higher than most studies (Marsh et al., 2004; Mutondo and Henneberry, 2007; Olynk et al., 2010). The own-price elasticity of chicken in 2015-2019 was similar to the one presented in Gallet (2010), Gallet (2012) and Lee et al. (2020). The own-price elasticity of chicken in 2002-2006 of -3.248 was much higher than found in any other studies.

Table 3.8: **Expenditure elasticities for meat products 2015-2019**

	Exp. elas	SE
Ground beef	0.972***	0.017
Beef steak	0.987***	0.022
Pork	0.997***	0.022
Chicken	0.976***	0.020
Other meat	0.980***	0.010
Fish	1.009***	0.016

***$p < 0.01$; **$p < 0.05$; *$p < 0.10$

The cross-price elasticities estimated in the demand system represent the relative relationships of consumer preferences when purchasing (i.e., consuming) one good with or over another. Cross-price elasticities, shown in Table 3.6 show variation in substitution and complementary of different meats across the two periods. For example, ground beef and beef steak were complements in 2002-2006 period, and appear to have an opposite relationship 2015-2019. In 2002-2006, beef steak and pork, and fish and pork were substitutes. In the same period, ground beef and fish, beef steak and other meat, pork and chicken, and other meat and fish were complements. The relationships revealed in 2015-2019 were different from the ones observed in the earlier period. In 2015-2019, ground beef and chicken, beef steak and fish, pork and other meat, and other meat and fish were complements. In the same period, beef steak and chicken and other meat, and chicken other meat were substitutes. This shift would suggest some significant changes in the way these meats are consumed in each period.

There are several reasons why interpreting own- and cross- price relationships presented in the current study is challenging. First, the data used does not represent actual consumption but expenditures. Therefore, it is impossible to determine if products that were purchased in the same week were indeed consumed together. Secondly, the lack of individual price data in the data set, lead to use of proxy prices, under the assumption that all consumers faced the same prices at the same time. Third, abundant zero observations in the surrey, also limit the reliability and robustness of the results of the estimation.

Tables 3.7 and 3.8 contain the expenditure elasticities for the two time periods. All expenditure elasticities in both periods were positive and statistically significant at $p = 0.01$ significance level, implying all the meat products are normal goods. Most of the expenditure elasticities were less than one, with the exception of beef steak and fish in 2002-2006 and fish in 2015-2019. Expenditure elasticities found for beef, pork and poultry were much higher than the ones found by Marsh et al. (2004) and Lee et al. (2020). However, expenditure elasticities for poultry were slightly lower than the one in Mutondo and Henneberry (2007). Ground beef own price elasticity found in this study in either period was in line with the beef expenditure elasticity found in Olynk et al. (2010).

3.5 Meat demand projections – 2021-2030

In the final step, the elasticity estimates for the 2002-2006 and 2015-2019 meat system were used to project a U.S. beef, pork and poultry consumption out to 2030. Projections for each commodity were compiled using estimated elasticities from each period. The comparisons are shown in the Figure 3.3. The projections shown below used forecasted CPI, food expenditure estimates, and U.S. population change values from the 2020 and 2021 Food and Agricultural Policy Research Institute (FAPRI) outlooks (FAPRI-MU, 2021; FAPRI-MU, 2020).

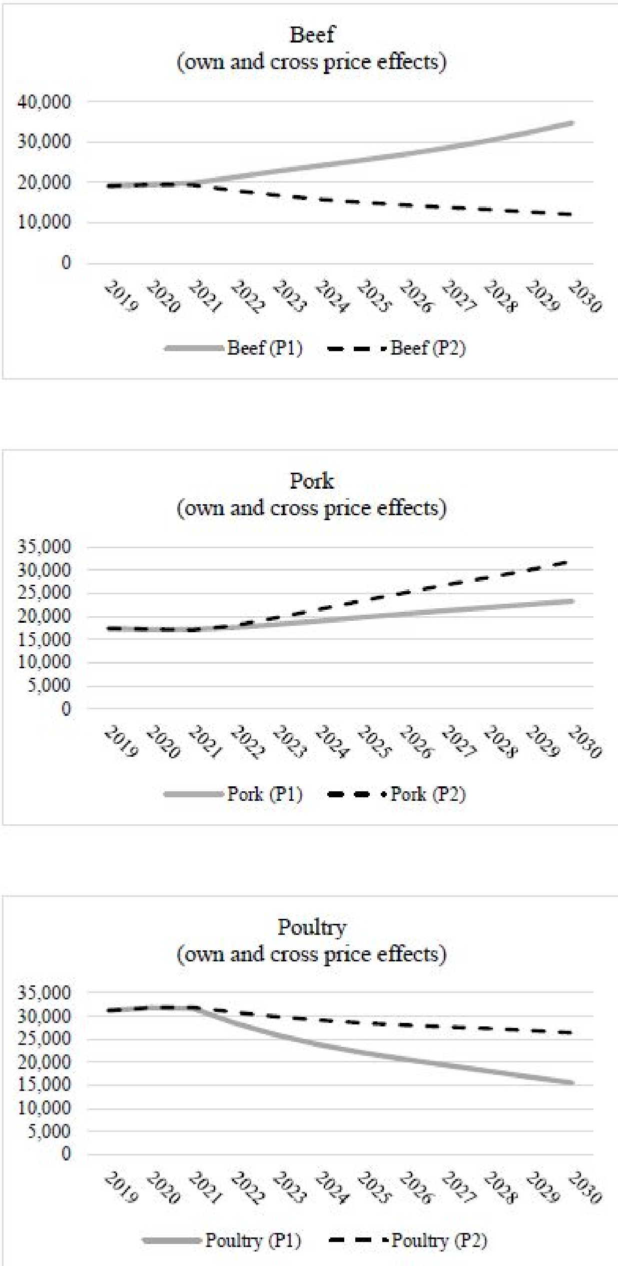
However, making assumptions about prices and food expenditures, takien directly from the 2021 FAPRI outlook does not allow for any dynamic adjustment of prices. Imposing FAPRI prices and expenditures into the estimated system provides an estimate of the expected consumption level. That consumption level is a direct result from plugging in the values from the FAPRI baseline. Of course, if the full system of FAPRI projections, was re run with these demand system parameters, the supply side would adjust, and different prices would occur. However, this projection provides only the first -level effects on consumption from directly using FAPRI's prices and food expenditures. In addition, this forecast is done using estimates representing food at home consumption only estimated in the current study. Those food at home elasticities are imposed on all food consumption, including both: food at home and away from home.

The results based on the estimates of this study show that the period of fit for the elastictity estimates can significantly affect future projections. The shown projections take into account own-, cross-price and expenditure elasticities. The projections do not make any explicit assumptions about the supply side, apart from using the FAPRI projected CPI commodity prices. The implicit assumption is that supply will be able to meet future demand. Under each alternative, the supply side is assumed to adjust to the estimated domestic demand level. The main focus of this forecast is that an accurate measure of demand elasticities is critical in determining long-run consumption and therefore industry size[30].

Figure 3.3 shows a clear difference in consumption levels of beef, pork, and poultry depending on the period of fit results used. The most pronounced divergence can be observed in beef demand. The projected 2030 U.S. beef consumption based on the 2002-2006 period (indicated as P1) shows a continuous growth is in beef consumption. By 2030, the U.S. total beef consumption is projected to be 34.7 billion pounds. When the elasticities from the 2015-2019 time period are used, the trend is reversed, and beef

[30] With the caveat of measuring only U.S. domestic demand.

Figure 3.3: **Beef, pork and poultry demand projections – 2021-2030.**



consumption continues to decline. The forecasted U.S. beef consumption in 2030 based on the second estimation period (marked as P2) is 12.0 billion pounds.

In the case of pork, projections based on either period show an overall increase in pork consumption. Use of the 2002-2006 period estimated results in a projected 23.3 billion pounds of pork consumed by 2030. When the 2015-2019 period is used, the U.S. pork consumption in 2030 reaches a much higher level of 32.0 billion pounds.

For poultry, estimates from both periods result in a projected decline in poultry consumption by 2030. When the 2002-2006 elasticity estimated are used, the total U.S. poultry consumption in 2030 is projected to be 15.5 billion pounds. When the 2015-2019 estimates are used, the resulting total consumption in the U.S. in 2030 is projected to be 26.3 billion pounds.

These results strongly suggest that the period of fit has a noticeable and potentially significant impact on projections. However, it is more than likely that using fixed future price projections, are most likely not the prices that would be observed during the projection period.

It is difficult to tell with any level of certainty that the use of elasticities for projections based on the most recent data is the best predictor of the future level of consumption. These differences highlight the importance of the choice of elastictities for forecasting and policy work. In practice, no single estimation approach should be used as the sole base for as definitive projection. If such results are used for forecasting and policy work, they have the potential of drastically changing the final outcome.

3.6 Conclusions

Food, agriculture and related industries in the U.S. contribute $1.1 trillion to the gross domestic product in 2019, which constitutes about 5.2% (USDA Economic Research Service, 2020b). Additionally, agriculture, food and related industries create over 22.2 million jobs (10.9% of U.S. employment), based on 2019 data, with food and beverage manufacturing and processing creating about 2 million jobs, equivalent to 1% of U.S.

employment (USDA Economic Research Service, 2020a).

The U.S. dairy production was 170 billion pounds, by 2019 it increased by 28% to 218 billion pounds (USDA-NASS, 2019). The per-capita dairy consumption[31] increased by 11% between 2002 and 2019 (USDA, 2020). Looking at those two trends, it can be inferred that the current U.S. dairy supply outpaces domestic dairy demand. This is mitigated by rapidly growing export demand for U.S. dairy products. This research attempts to give in insight into factors behind dairy demand and potential drivers of the existing changes. Understanding those drivers can help policymakers and the dairy industry at large to better target the policy, production decisions and marketing strategies. This research revealed several changes in the dairy demand elasticities between the two research periods. For example, the butter became more price elastic between 2002-2006 and 2015-2019, yet, cheese became significantly more price inelastic during the same period.

From the beginning of the study period, 2002, meat production in the U.S. increased by 23% from 85 billion pounds, to 105 billion pounds in 2019 (USDA, 2019). In the same time period, overall meat consumption, according to the USDA, declined from 186 pounds per capita, to 168 pounds in 2014, and then increased back to 186 pounds in 2019. However the composition of the types of meats consumes have changed, with declines in beef and pork and increase in poultry consumption. Examining the findings of this research reveals that in response to changes in preferences, the composition of meat budget also changed over time. Additionally, the own-price elasticities also changed between the two research periods. For example, own-price elasticity of beef steak and pork became more elastic between 2002-2006 and 2015-2019. On the other hand, chicken became much more price inelastic over time.

The results presented in this research suggest that own- and cross-price elasticities form most dairy and meat products change over time. Given those findings, it seems that using updated and based on most current data elasticity estimates can change the

[31] In milk-fat milk-equivalent basis as defined in USDA (2020).

expectations, effectiveness of policy solutions and marketing strategies, and improve the accuracy and informative quality of future demand forecasts.

The largest drawbacks of this study stem from data limitations including lack of price and quantity data in the survey, as well as as well as large number of zero observations at the household level. The most recent available data from the BLS show a 44% average non-response rate to the CEX DS in 2019 (Bureau of Labor Statistics, 2021a). The household and item non-response rate negatively impact the accuracy of the data and the level of detail available to the researchers. Another major limitation is lack of detailed information of quantities and types of meat consumed away from home, therefore this research is limited only to food at home purchases.

Unfortunately, no one estimation technique has the ability to provide all the answers. The AIDS estimation system is robust yet very restrictive which can yield variable results. Future research could further test the robustness of the findings presented here by using a different demand system. Furthermore, one could expand the system with more commodities, to increase the informative quality of the estimation, especially for the meat and dairy industries. Future research would also involve replicating this research with a more detailed data set including information about the person in the household who makes the food purchases.

Appendix C

Table C1: **CPI variables for the dairy and meat models**

Series ID	Series Title
CUSR0000SAF1	Food in U.S. city average, all urban consumers, seasonally adjusted
	Dairy variables
CUSR0000SEFJ01	Milk in U.S. city average, all urban consumers, seasonally adjusted
CUSR0000SS10011	Butter in U.S. city average, all urban consumers, seasonally adjusted
CUSR0000SEFJ02	Cheese and related products in U.S. city average, all urban consumers, seasonally adjusted
CUSR0000SEFJ03	Ice cream and related products in U.S. city average, all urban consumers, seasonally adjusted
CUSR0000SEFJ04	Other dairy and related products in U.S. city average, all urban consumers, seasonally adjusted
CUSR0000SAF11211	Meats in U.S. city average, all urban consumers, seasonally adjusted
	Meat variables
CUSR0000SEFC01	Uncooked ground beef in U.S. city average, all urban consumers, seasonally adjusted
CUSR0000SEFC03	Uncooked beef steaks in U.S. city average, all urban consumers, seasonally adjusted
CUSR0000SEFD	Pork in U.S. city average, all urban consumers, seasonally adjusted
CUSR0000SEFE	Other meats in U.S. city average, all urban consumers, seasonally adjusted
CUSR0000SEFF	Poultry in U.S. city average, all urban consumers, seasonally adjusted
CUSR0000SEFG	Fish and seafood in U.S. city average, all urban consumers, seasonally adjusted

Table C2: **List of independent variables**

Variable	Variable definition
Household income quantile	5 levels: **1st quantile**[(a)], 2nd quantile, 3rd quantile, 4th quantile, 5th quantile
Generation[(b)]	4 levels: Millennials, Gen X, **Baby Boomers**, Traditionalists
Number of children	4 levels: **No children**, One child, Two Children, Three or more children
Additional adults	3 levels: textbfOne adult, Two adults, Three or more adults
Family type	6 levels: **Married couple/no children**, Married couple/own children, Single parent, Single Consumers, All other husband and wife families, Other families
Housing	3 levels: **Owner/mortgage**, Owner/no mortgage, Renter
Race	4 levels: **White**, Black, Hispanic[(c)], Other
Region	5 levels: **Missing**, Midwest, North-East, South, West
Employment	4 levels: **Salaried employee**, Self employed, Retired, Not working/other than retired
Level of urbanization	2 levels: Rural, **Urban**
Number of earners	4 levels: **No earners**, One earner, Two earners, Three or more earners
Season	4 levels: **Spring**, Summer, Fall, Winter

Note. [(a)] The 1^{st} quantile represents the lowest income group.

[(b)] Based on birth year the generations have been defined as follows: birth year of 1981 or later - Millenials, birth year from 1965 to 1980 - Gen X, birth year from 1946 to 1964 - Baby Boomers, birth year from before 1945 - Traditionalists.

[(c)] There is no variable determining race defined as Hispanic available in the data for years 2002-2006

The demographic variables in **bold** are the default variables included in the system.

Table C3: **Estimated coefficients of the AIDS system - dairy - 2002-2006**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Intercept	0.09755***	0.07931	0.10137***	-0.01717	0.00954	0.00081
Milk	0.03335**	1e-04	-0.0048	-0.01901**	0.01105	-0.03249*
Butter	1e-04	0.00106	0.00522	-0.00263	-0.0043	-0.00014
Cheese	-0.0048	0.00522	-0.00565	0.03055***	-0.00453	0.07451***
Ice cream	-0.01901**	-0.00263	0.03055***	0.02128*	0.00313	0.03483***
Other dairy	0.01105	-0.0043	-0.00453	0.00313	-0.0139	0.01898*
Meat	-0.03249*	-0.00014	0.07451***	0.03483***	0.01898*	-0.04019
All other food	0.01181	0.00069	-0.0953***	-0.06816***	-0.01042	-0.0555*
IMR	-0.03381***	0.00099***	0.00528***	-0.00143***	0.00152***	0.04296***
P-index	-0.01981	-0.04778	-0.06383*	0.04058	0.00533	0.22111***

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table C4: **Estimated demographic marginal effects - dairy - 2002-2006**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Gen X	1e-04	0.0035	-0.00057	-0.00171	-1e-04	-0.01437**
Millenials	0.00192	0.00782	0.00446	-0.00148	-0.00148	-0.05602***
Traditionalists	0.00011	-0.00075	1e-05	0.00038	0.00083	0.00509*
Income 2nd	0.00198	0.00255	0.0012	-0.00343	-3e-04	-0.00295
Income 3rd	0.00204	0.00261	-0.00114	-0.00154	-0.00015	-0.00697***
Income 4th	0.00287*	0.00132	-0.00177	-0.00098	0.00014	-0.01138***
Income 5th	0.00235	0.00012	-0.00536*	-0.00048	1e-05	-0.01441***
One child	-0.00658	-0.00348	-0.00236	0.00208	0.00115	0.0082
3 or more children	-0.00588	-0.00734	-0.00795*	0.00737	0.00133	0.01732*
2 children	-0.00557	-0.00631	-0.00541*	0.00497	0.00166	0.01854**
2 adults	-0.00662	-0.00484	-0.00584*	0.00347	0.00065	0.01473**
3 or more adults	-0.00635	-0.00813	-0.00853*	0.00828	0.00204	0.03272**
Married couple/own children	0.00281	0.00053	0.00084	-2e-05	-0.00062	0.00383
All other husband and wife	0.00214	0.00331	0.00079	-0.00308*	-0.00224*	0.00861
Single parent	-0.00111	0.0011	-0.00202	-0.00085	-0.0011	-0.00912
Single consumers	-0.00337	0.00567	0.00684	-0.00606	-0.00024	-0.03671**
Other families	-0.00156	-6e-04	0.00285*	-0.00138	-0.00058	-0.00633*
Owner/no mortgage	-0.0012	0.0024	-1e-04	-0.00125	-0.00034	-0.00328
Renter	0.00143	0.00154	0.00315*	-0.00214	6e-05	-0.00405*
Black	0.00429	0.00212	0.01113	-0.00138	-0.00133	0.01321***
Other	0.00265	0.00719	0.0238**	-0.00602	-0.00208	0.00364
North East	-0.01002	0.00118	-0.00647	-0.01844	-0.00391	0.06106***
Midwest	-0.01118	0.00471*	-0.0071	-0.02026	-0.0045	0.05367***
South	-0.00721	0.00764*	-0.00397	-0.02058	-0.00406	0.05696***
West	-0.00884	0.0066*	-0.00539	-0.01978	-0.00326	0.05476***
Self employed	0.00304	-0.00188	0.00093	-0.00019	0.00119*	0.00669**
Retired	0.00045	-0.00171	-0.00323	0.00141	0	0.00611
Not working	0.00137	-0.00205	-0.00167	-0.00206	-0.00057	0.00191
Rural	0.0013	-0.00126	0.00285	-0.00437	0.00047	-0.009**
One earner	0.00079	-0.0027	-0.00305	0.00064	0.00085	0.00717*
Two earners	0.00318	-0.00203	-0.00622**	9e-05	0.001	0.00778*
Three or more earners	-3e-04	-0.00254	-0.008*	-0.00011	0.00031	0.01544**
Summer	-0.00289**	8e-05	-7e-05	0.005	-0.00016	9e-04
Fall	0.00033	-0.00219	0.00127*	-0.00322	0.00021	-0.00094
Winter	-0.00103	-0.00096	4e-05	-0.00632	0.00046	0.00075

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table C5: **Estimated coefficients of the AIDS system dairy 2015-2019**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Intercept	0.02012	-0.00552	0.01026	-0.04023	0.03033	0.28869***
Milk	0.03806	-0.01571	0.0065	-0.00101	-0.00377	0.01705
Butter	-0.01571	-0.00937	0.01524	-0.01483	-0.01163	-0.00107
Cheese	0.0065	0.01524	0.03541	0.01079	-0.02937	-0.03081
Ice cream	-0.00101	-0.01483	0.01079	-0.03618	0.08193***	-0.02935
Other dairy	-0.00377	-0.01163	-0.02937	0.08193***	-0.0109	0.0186
Meat	0.01705	-0.00107	-0.03081	-0.02935	0.0186	0.10096**
All other food	-0.04112*	0.03736***	-0.00776	-0.01136	-0.04486**	-0.07539**
IMR	-0.02137***	0.00088***	0.00452***	-0.00262***	0.00265***	0.02655***
P-index	0.05411	-0.00243	0.01469	0.06501	-0.01287	-0.19098

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table C6: **Estimated demographic marginal effects dairy 2015-2019**

	Milk	Butter	Cheese	Ice cream	Other dairy	Meat
Gen X	-0.00028	-5e-04	0.00035	-0.00365	-0.00128*	0.0065
Millenials	-0.00327	-0.00015	-0.00017	-0.00802	-9e-05	0.01887
Traditionalists	-0.00158	-0.00012	-0.00089	0.00359*	0.00122	0.00923
Income 2nd	-3e-05	-0.00083	0.00171	0.00202	-9e-05	-0.00504
Income 3rd	0.00062	-0.001	0.00267	0.00116	-0.00058	-0.0083
Income 4th	0.00048	-9e-04	0.00225	0.00313	-0.00157	-0.01347
Income 5th	-0.00189	-0.00126	0.00451	0.00242	-0.0036	-0.01914*
One child	0.00443	0	-0.00201	0.00245	-0.00255	-0.00847
3 or more children	0.01228	-0.00028	-0.00321	0.00502	-0.00243	-0.0158
2 children	0.00919	-1e-04	-0.00156	0.00519	-0.00232	-0.01534
2 adults	0.00493	0.00135	-7e-04	0.00623	0.00111	-0.00821
3 or more adults	0.01056	0.00168	-0.00442*	0.014	0.00221	-0.01771
Married couple/own children	0.00505	-0.00019	0.00186	0.00283	0.00114	-0.00127
All other husband and wife	0.00262	0.00015	0.00323	-0.00567	0.00141	0.00496
Single parent	0.00276	-1e-05	0.00262	0.00633	0.00614***	-0.00426
Single consumers	-0.00665	0.00069	-0.00264	-0.00536	0.00338	0.02193
Other families	-0.00177	0.00044	0.00088	3e-05	0.00065	0.00588
Owner/no mortgage	0.00059	-0.00041	-0.00058	0.00106	0.00105	-0.00291
Renter	-5e-04	-0.00046	-7e-04	-0.00114	0.00044	0.00405
Black	-0.01074	0.00016	-0.00749	-0.00875	0.00171	0.00075
Other	-0.00648	-0.00017	-0.00613	-0.00876	0.00098	0.00495
Hispanic	-0.00086	0.00039	-0.00189	-0.01026	0.00177	-0.00833
North East	-0.00052	-0.00017	0.00181	0.00213	-0.00018	-0.01617
Midwest	-0.00177	5e-05	0.00198	-0.00255*	0.00081	-0.00909*
South	-0.00456	3e-04	0.00133	-0.00085	0.00087	-0.01308*
West	-0.00293	0.00043	0.00162	-0.00228*	2e-04	-0.0065
Self employed	0.00104	-0.00083	2e-04	-0.00039	0.00165	-0.00828***
Retired	0.00044	-0.00044	0.00145	0.00277*	-0.00075	-0.01612***
Not working	0.00305*	-0.00039	0.00267	4e-04	0.00149	-0.01157***
Rural	0.00375	-1e-05	-0.00095	-0.00523	-0.00047	0.00175
One earner	6e-05	-8e-05	0.00011	-0.00038	0.00063	-0.00653*
Two earners	-0.00203	-0.00067	0.00138	-0.00064	0.00102	-0.01314**
Three or more earners	-0.00437	-0.00078	0.00361	-0.00119	0.00125	-0.00938
Summer	0.00034	0.00027	-0.00018	0.00606	0.00038	0.00228
Fall	0.00174	0.00104	0.00143	-0.0022	0.00105	0.00123
Winter	0.00394**	0.00056	0.00266**	-0.00831	0.00092	-0.00229

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table C7: **Estimated coefficients of the meat AIDS system - 2002-2006**

	Ground beef	Beef steak	Pork	Chicken	Other meat	Fish
Intercept	-0.01392	0.13985	-0.02952	-0.07909	0.08065*	-0.16623
Ground beef	0.00948	-0.00723	-0.04035***	-0.01792**	-0.0815***	-0.06017***
Beef steak	-0.00723	0.01066	0.02375**	0.00712	0.0557***	0.03113**
Pork	-0.04035***	0.02375**	-0.00429	0.0393**	-0.0176	-0.00055
Chicken	-0.01792**	0.00712	0.0393**	-0.0369*	0.00735	-0.02276
Other meat	-0.0815***	0.0557***	-0.0176	0.00735	0.0264	-0.00079
Fish	-0.06017***	0.03113**	-0.00055	-0.02276	-0.00079	-0.12591***
All other food	0.19769***	-0.12114***	-0.00025	0.02381	0.01045	0.17904***
IMR	-0.00126***	0.00074	-0.00018	-0.00041	-0.00087	4e-04
P-index	0.02202	-0.09323	0.05411	0.06751	-0.01356	0.18964**

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table C8: **Estimated demographic marginal effects - meat system 2002-2006**

	Ground beef	Beef steak	Pork	Chicken	Other meat	Fish
Gen X	-0.00103	0.00507	-0.00321	-0.00146	0.00059	-0.00467
Millenials	0.00073	0.00857	-0.01181	-0.00979	0.00123	-0.01506
Traditionalists	1e-05	0.00571	0.00073	6e-04	6e-05	0.01037**
Income 2nd	0.00032	0.0051	-0.00061	-0.00136	0.00054	-0.01457**
Income 3rd	9e-04	0.00282	-0.00368	-0.00503	0.00039	-0.01014**
Income 4th	4e-05	0.00204	-0.00503	-0.00669	0.00048	-0.00583*
Income 5th	-0.00223	0.00212	-0.00865	-0.00993	-1e-05	0.00367
One child	0.00091	-6e-05	0.00411	0.00055	-0.00085	0.00269
3 or more children	0.00574	-0.00168	0.00653	0.00947	-0.00353	0.01258**
2 children	0.00385	0.00079	0.00484	0.00327	-0.00272	0.00156
2 adults	0.00028	-0.00106	0.00658	-0.00096	-0.00555	0.01433**
3 or more adults	0.00057	-0.01034	0.01704	0.01173	-0.00146	0.0241**
Married couple/own children	0.00012	0.00116	-0.00284	0.00529	0.00117	-0.00139
All other husband and wife	-0.00069	-0.00147	-0.00315	0.0054	-0.004	-0.00548
Single parent	-0.00045	0.00775	-0.0018	-0.00333	-0.00541	-0.00118
Single consumers	-0.00412	0.01575	-0.00605	-0.01204	-0.00478	-0.00381
Other families	-0.00011	-0.00224	-0.00122	0.00291	-0.00088	-1e-04
Owner/no mortgage	-0.00032	0.00484	-0.00128	-0.00085	0.00181	-0.00936**
Renter	0.0015	-0.00066	-0.00119	0.00171	0.00096	-0.00201
Black	-0.00022	0.00855	0.00875	0.00659	-0.0024	0.01861**
Other	-0.0035	0.00149	0.00678	0.00885	0.00143	0.05102**
North East	0.01963*	0.00831	-0.01492	0.01036	0.01943	0.03138
Midwest	0.02237**	0.01849	-0.01271	0.00456	0.01931	0.00098
South	0.02192**	0.00998	-0.01432	0.01141	0.01847	0.01048
West	0.01948	0.00537	-0.0144	0.01221	0.01942	0.02318
Self employed	0.0019	-0.00216	9e-05	-0.00248**	0.00042	0.01282*
Retired	-0.00077	0.0031	-0.00047	-9e-04	-0.00085	-6e-05
Not working	0.00132	0.00383	0.00254	0.00232	-0.00175	-0.00481
Rural	0.00079	0.00219	0.00401	-0.00038	0.00144	-0.02309**
One earner	-0.00134	-0.00206	0.0023	0.00262	-0.00354	0.00514**
Two earners	-0.00154	-0.00056	0.00185	0.00318	-0.00442	0.00039
Three or more earners	0.00023	-0.00483	0.00304	0.00657	-0.00503	0.00825**
Summer	-0.00128	0.00108	-9e-05	-0.00022	0.00056	-0.00607*
Fall	-0.00152	0.00383	-0.00043	0.00022	0.00543***	-0.00767**
Winter	-0.0027*	0.00218	0.00077	0.00043	0.00255	-0.00012

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table C9: **Estimated coefficients of the AIDS system - meat 2015-2019**

	Ground beef	Beef steak	Pork	Chicken	Other meat	Fish
Intercept	0.1143	-0.10366	0.09021	0.00488	0.22765***	0.13323
Ground beef	0.007	0.02013	0.03665*	0.01087	-0.07082***	-0.01543
Beef steak	0.02013	-0.06204**	-0.03707*	-0.03219	0.09268***	0.05365**
Pork	0.03665*	-0.03707*	-0.05061*	-0.02471	0.0501*	-0.00403
Chicken	0.01087	-0.03219	-0.02471	0.00569	0.10355***	-0.00941
Other meat	-0.07082***	0.09268***	0.0501*	0.10355***	-0.05428	-0.02249
Fish	-0.01543	0.05365**	-0.00403	-0.00941	-0.02249	0.03472
All other food	0.0116	-0.03515	0.02967	-0.0538	-0.09873**	-0.037
IMR	-8e-04	-0.00031	-7e-05	-0.00042	-0.0015**	0.00031
P-index	-0.07933	0.05852	-0.06896	0.01068	-0.13461	-0.08097

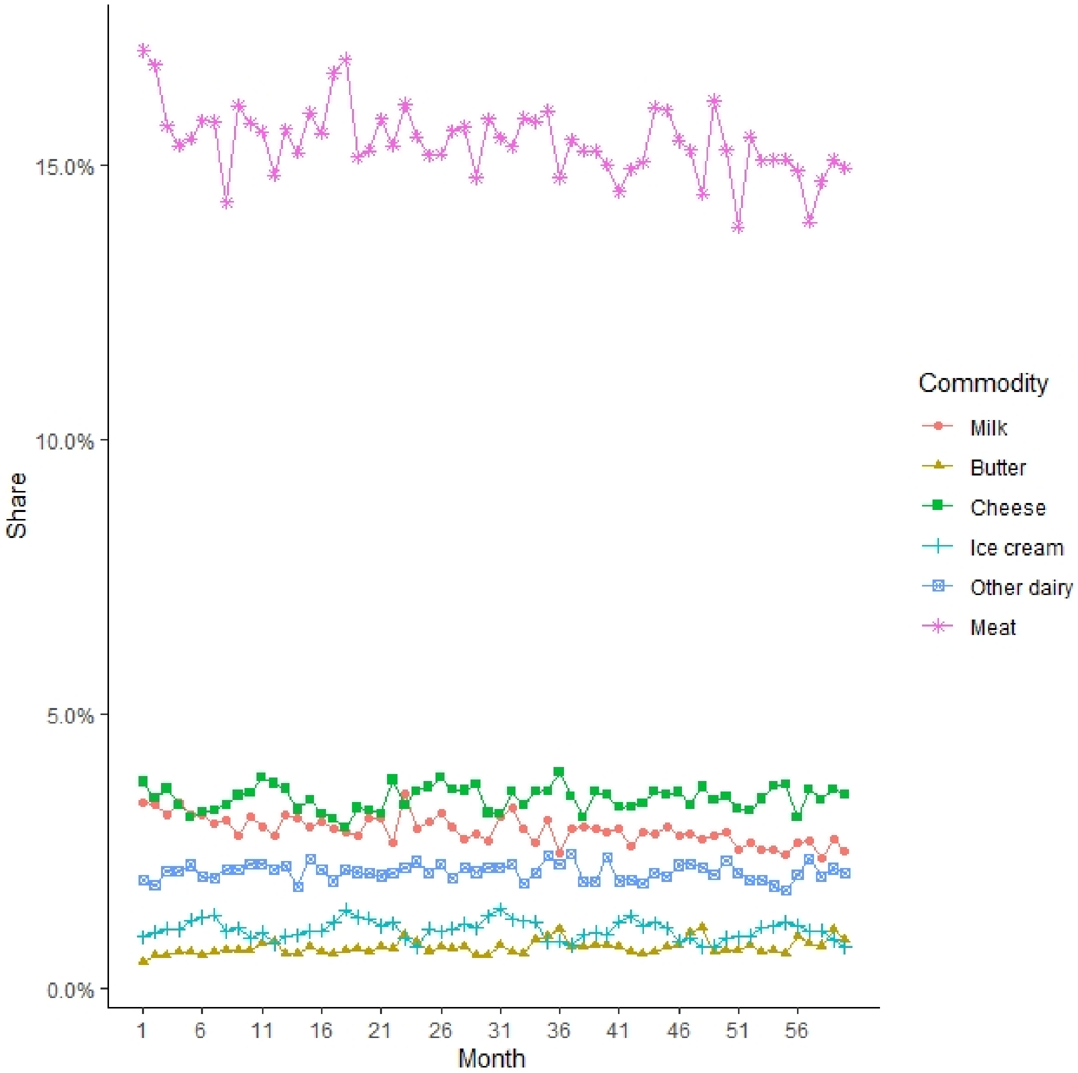
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table C10: **Estimated demographic marginal effects - meat - 2015-2019**

	Ground beef	Beef steak	Pork	Chicken	Other meat	Fish
Gen X	0.00046	0.00122	0.00422	-0.00088	-0.00074	0.00321
Millenials	0.00245	-0.00032	0.01145	0.00208	0.00406	0.00686
Traditionalists	0.00186	-0.00224	0.00291	-0.00082	0.00322	0.00194
Income 2nd	0.00416	0.00277	0.00239	-0.00131	-0.00032	-0.00244
Income 3rd	0.00394	0.00372	0.00186	-0.00168	-0.00159	-0.00305
Income 4th	0.00484	0.00387	0.00235	-0.00158	-0.00439	-0.00675
Income 5th	0.00782	0.00838	0.00238	-0.00096	-0.00351	-0.01064
One child	-0.00522	0.00609	-0.00084	0.00183	-0.00182	-0.00178
3 or more children	-0.00972	0.00612	-0.00596	0.00112	-0.01076	-0.00499
2 children	-0.01034	0.0078	-0.00383	0.00156	-0.0092	-0.00181
2 adults	0.00018	0.00366	-0.00694	0.00307	-0.00519	0.00032
3 or more adults	-0.00328	0.00602	-0.01635	0.00634	-0.00957	-0.01018
Married couple/own children	-0.00161	-0.00531	-0.00029	-0.00159	-0.00143	0.00289
All other husband and wife	-0.00622	-0.00258	0.00386	-0.00124	-0.00494	0.00998
Single parent	-0.00291	-0.00552	-0.00343	-0.00139	0.00291	0.00232
Single consumers	0.01243	-0.00379	0.00382	-9e-05	0.00894	0.00747
Other families	-0.00066	-6e-05	-0.00125	-0.00214	0.00198	0.00585
Owner/no mortgage	0.00146	-0.00192	0.00047	-0.00038	0.00135	0.00052
Renter	-0.00033	-0.0023	0.00146	0.00054	0.00645	-0.00132
Black	0.00646	-0.00503	-0.00346	0.00246	0.00456	-0.0071
Other	0.01439	-4e-05	-0.00986	-0.00157	0.02228	-0.01638
Hispanic	0.0048	0.00631	-0.00573	0.00385	0.00786	-0.00619
North East	0.00537	0.00336	-0.00025	0.00362	-0.00333	-0.01502
Midwest	0.00127	-0.00271	0.00192	0.00234	-0.00532	-0.00732
South	0	0.00033	0.00105	0.00357	-0.0027	-0.00749
West	0.00934	0.00178	0.00703	0.00328	-0.00101	-0.0072
Self employed	-0.00322	0.00259	-0.00191	0.00058	0.00173	-0.0025
Retired	0.00263	0.00217	-0.00333	-0.00348	-0.0015	-0.00698
Not working	0.00284	0.002	-0.0042	-0.00158	-8e-04	0.00041
Rural	-0.0038	-0.00549	-0.00548	0.00139	-0.00109	0.00418
One earner	0.00426	-0.00077	-0.00125	-0.00106	-0.00055	0.00022
Two earners	0.00363	-0.00062	-0.001	-0.00246	0.00311	-0.00031
Three or more earners	0.00371	-7e-04	-0.00339	-0.00325	0.00019	0.00153
Summer	0.00086	0.00631	0.00203	0.00043	0.00212	8e-04
Fall	6e-04	0.00165	0.00096	0.00026	0.00374**	0.00152
Winter	-0.00085	0.00471	0.00062	0.00155	0.00398**	0.00039

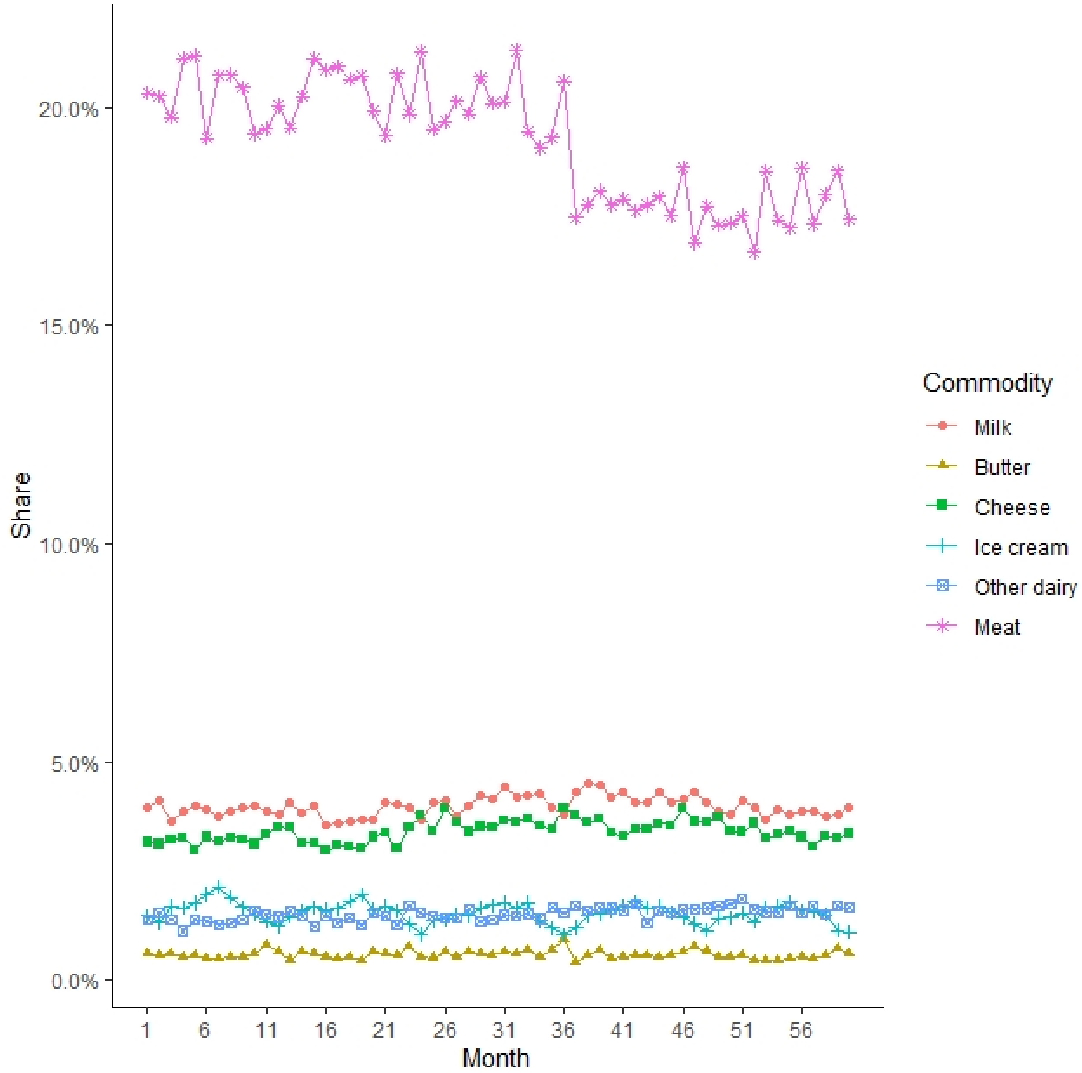
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Figure C4: **Dairy products budget shares in each month 2015-2019.**



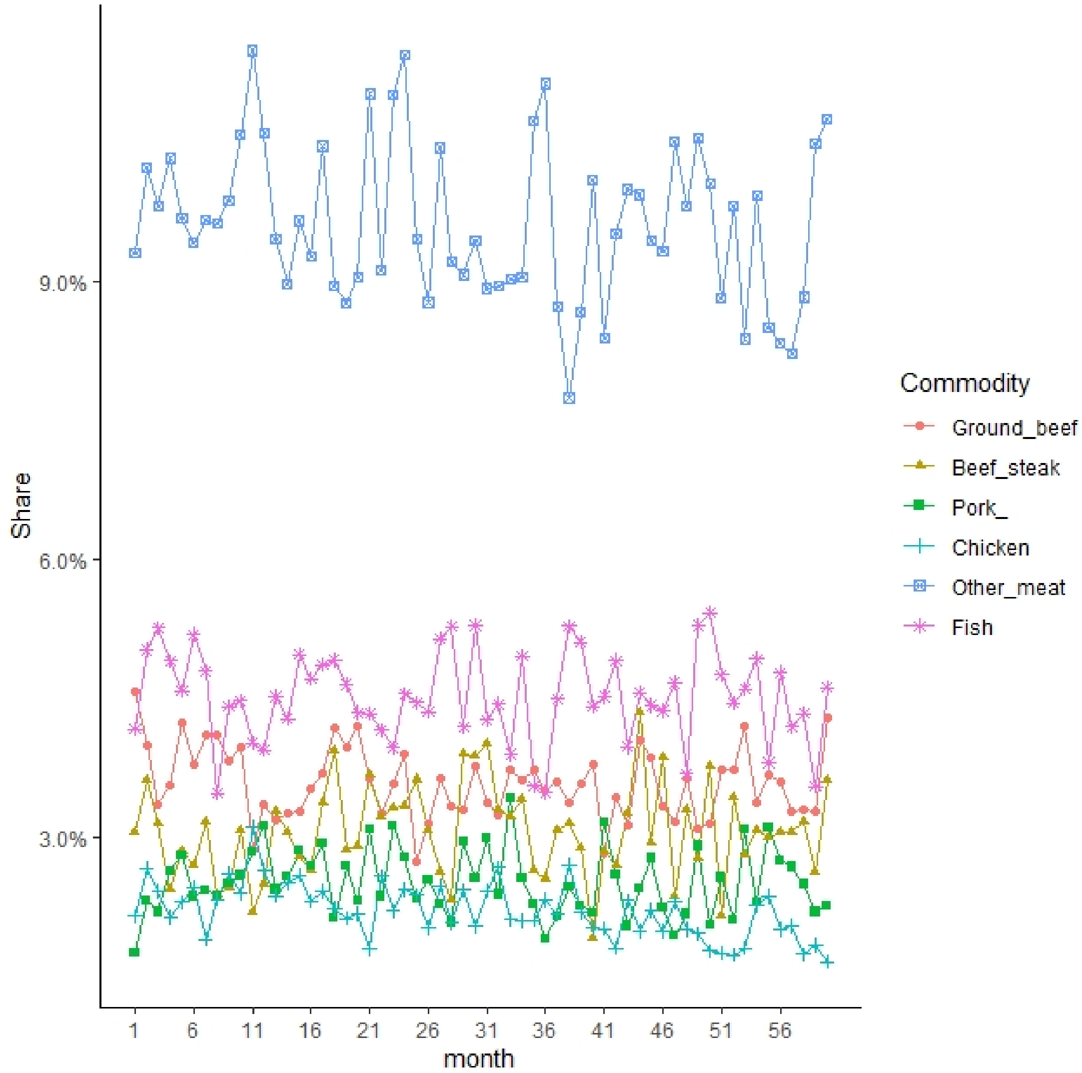
Note: All other food variable was omitted in the graph.

Figure C5: **Dairy products budget shares in each month 2002 - 2006.**



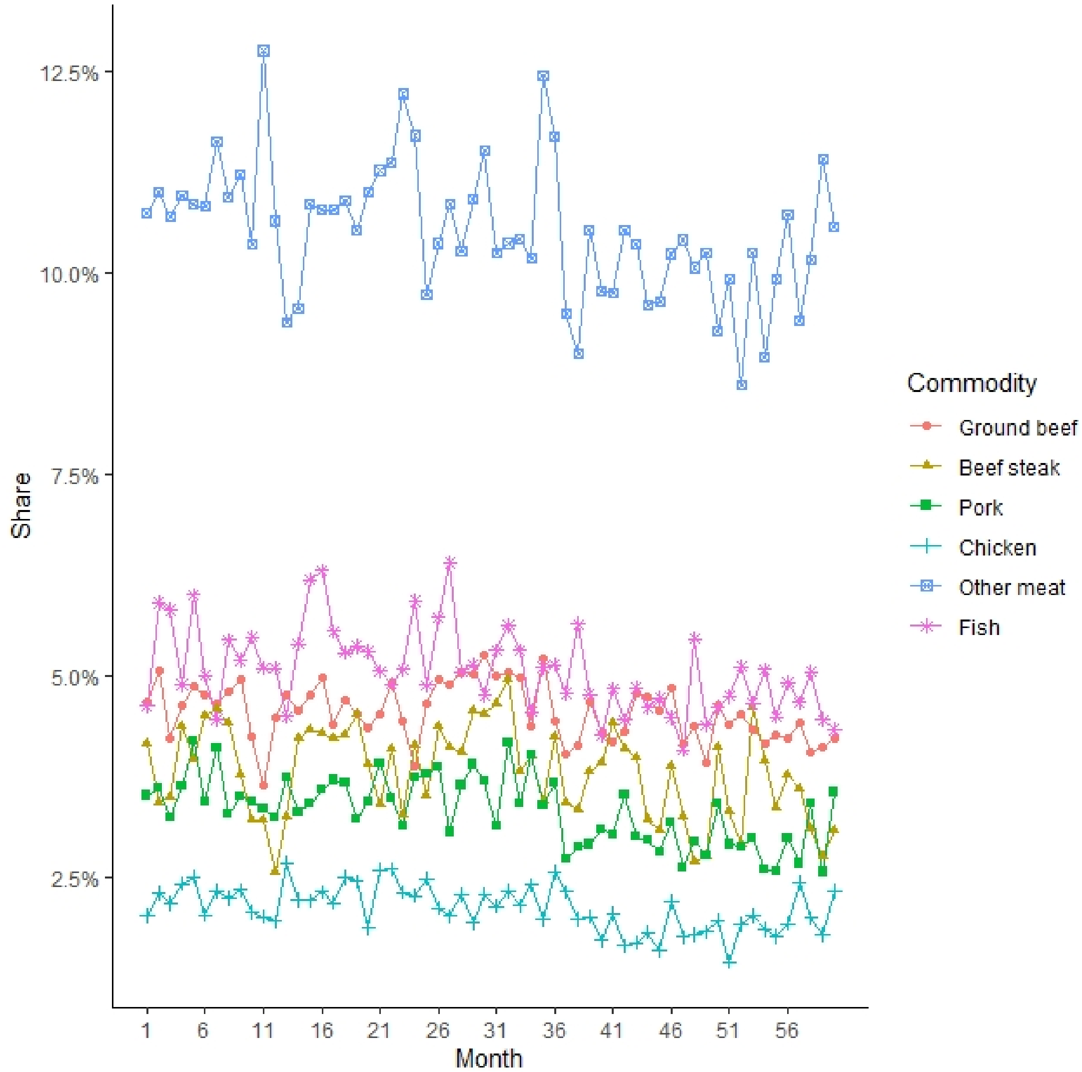
Note: All other food variable was omitted in the graph.

Figure C6: **Meat products budget shares in each month 2015-2019.**



Note: All other food variable was omitted in the graph.

Figure C7: **Meat products budget shares in each month 2002-2006.**



Note: All other food variable was omitted in the graph.

REFERENCES

Andreyeva, T., Long, M. W., and Brownell, K. D. (2010). The impact of food prices on consumption: A systematic review of research on the price elasticity of demand for food. *American Journal of Public Health*, 100(2):216–222.

Blisard, N., Lin, B.-H., Cromartie, J., and Ballenger, N. (2002). America's Changing Appetite: Food Consumption and Spending to 2020. *Food Review/ National Food Review*, 25(1):2–9.

Bureau of Labor Statistics (2021a). Consumer Expenditure Surveys (CE) Public Use Microdata Home.

Bureau of Labor Statistics (2021b). CPI Home : U.S. Bureau of Labor Statistics.

Davis, C. G., Yen, S. T., Dong, D., and Blayney, D. P. (2011). Assessing economic and demographic factors that influence United States dairy demand. *Journal of Dairy Science*, 94(7):3715–3723.

Deaton, A. and Muellbauer, J. (1980). An Almost Ideal Demand System. *The American Economic Review*.

Ellison, S. (2004). As Shoppers Grow Finicky, Big Food Has Big Problems.

FAPRI-MU (2020). U.S. Agricultural Market Outlook 2020.

FAPRI-MU (2021). U.S. Agricultural Market Outlook 2021. Technical report.

Gallet, C. A. (2010). Meat meets meta: A quantitative review of the price elasticity of meat. *American Journal of Agricultural Economics*, 92(1):258–272.

Gallet, C. A. (2012). A Meta-Analysis of the Price Elasticity of Meat: Evidence of Regional Differences. *Business and Economic Research*, 2(2):14–25.

Heien, D. and Wessells, C. R. (1990). Demand systems estimation with microdata: A censored regression approach. *Journal of Business and Economic Statistics*, 8(3):365–371.

Henningsen, A. and Hamann, J. D. (2007). Systemfit: A package for estimating systems of simultaneous equations in R. *Journal of Statistical Software*, 23(4):1–40.

Henningsen, A. and Toomet, O. (2008). Sample Selection Models in {R}: Package {sampleSelection}. *Journal of Statistical Software*, 27(7).

Kuhns, A. and Saksena, M. (2017). Food Purchase Decisions of Millennial Households Compared to Other Generations.

Lee, J. Y., Qian, Y., Gustavsen, G. W., Nayga, R. M., and Rickertsen, K. (2020). Effects of consumer cohorts and age on meat expenditures in the United States. *Agricultural Economics (United Kingdom)*, 51(4):505–517.

Lusk, J. L. and McCluskey, J. (2018). Understanding the impacts of food consumer choice and food policy outcomes. *Applied Economic Perspectives and Policy*, 40(1):5–21.

Lusk, J. L. and Tonsor, G. T. (2016). How meat demand elasticities vary with price, income, and product category. *Applied Economic Perspectives and Policy*, 38(4):673–711.

Marsh, T. L., Schroeder, T. C., and Mintert, J. (2004). Impacts of meat product recalls on consumer demand in the USA. *Applied Economics*, 36(9):897–909.

McCloskey, D. N. (1999). Cassandra's Open Letter to Her Economist Colleagues.

Mutondo, J. E. and Henneberry, S. R. (2007). A source-differentiated analysis of U.S. meat demand. *Journal of Agricultural and Resource Economics*, 32(3):515–533.

Okrent, A. M. and Alston, J. M. (2011). Demand for Food in the United States: A Review of Literature, Evaluation of Previous Estimates, and Presentation of New Estimates of Demand. *Giannini Foundation Monograph 48*, (April):125.

Olynk, N. J., Tonsor, G. T., and Wolf, C. A. (2010). Consumer Willingness to Pay for Livestock Credence Attribute Claim Verification. Technical Report 2.

USDA (2019). USDA ERS - Meat Domestic Data.

USDA (2020). USDA ERS - Dairy Data.

USDA Economic Research Service (2020a). Agriculture and its related industries provide 10.9 percent of U.S. employment.

USDA Economic Research Service (2020b). What is agriculture's share of the overall U.S. economy?

USDA-NASS (2019). USDA/NASS QuickStats Ad-hoc Query Tool.

CONCLUSION

These three essays provide an insight into the relationship between demographic characteristics of a household, the influence of a generational cohort, and the estimation period on estimated demand for meat and dairy demand in the U.S.

The first essay looks more closely at U.S. dairy demand between 2013-2019, with a focus on demographic characteristics of households that impact dairy demand as well as on generational cohorts. The AIDS system is estimated using disaggregated household level data. The results strongly suggest that both, demographics and generational cohort impact U.S. domestic dairy demand.

The second essay focuses on U.S. meat demand and the impact of generational cohort on demand elasticity estimates. The results of the LA-AIDS estimation show differences in own-price and cross-price effects across generations. The second essay uses annual expenditure averages, instead of household level disaggregated data for the estimation.

The third essay highlights the importance of period of fit used in the demand estimation for meat and dairy. This essay uses the same AIDS estimation method, applied to disaggregated household level data, in two separate 5-year periods: 2002 to 2006 and 2015 to 2019.

One issue that became apparent for the first and third essays was that the AIDS estimation techniques, which used disaggregated household level monthly data, did not fit the expectations and prior research. One of the reasons for such an outcome is a lack of individual household price data in the BLS CEX Survey. As a result, an assumption was made that all households face the same price derived from the AMS and BLS CPI data. Using the same price data across all households, is problematic and does not reflect the true prices faced by each consumer. More research is needed to fully understand the impact of such an assumption on estimation results and ways to mitigate the potential negative impacts.

The results of this research were somewhat surprising in terms of own- and cross-price relationships. With the lack of price data and large number of households reporting zero expenditures on products of interest during each of the survey weeks, this potentially suggests that a choice of different method of analysis would yield more predictable results. AIDS demand system is known and widely used due to its flexibility and compatibility with demand theory. However, the years of research using the AIDS system have also shown it to be fragile and restrictive, often yielding unexpected results.

This research, due to data limitations, looks only at the demand for foods consumed at home. As this research focuses only on at home food consumption, it does not show the full picture, especially for products that are often consumed in restaurants and other food service venues.

Unfortunately, no one estimation technique has the ability to provide all the answers. Future research could further test the robustness of the findings presented in the current research by using a different demand system estimation method. Furthermore, one could expand the system with more commodities, to increase the informative quality of the estimation, especially for the meat and dairy industries. Future research would also involve replicating this research with a more detailed data set including information about the person in the household who makes the food purchases.

VITA

Agnieszka Dobrowolska Perry was born and raised in Poland and moved to the United States in July 2013 to pursue her PhD degree. Agnieszka holds a Bachelor's degree in Agronomy and Agriculture and Master's degree in Agribusiness and Marketing from Warsaw University of Life Science in Poland. Prior to attending the University of Missouri, Agnieszka, worked for the European Commission in Brussels, Belgium and for Farm Accountancy Data Network in Poland. Along the way, Agnieszka worked in the ag industry, employed in research and business roles in the agricultural lending and finance sector. Agnieszka completed her Doctoral Degree in Agricultural and Applied Economics in the spring of 2021. Currently, Agnieszka uses her background in economics and the U.S. and international agricultural markets and research to assist producers across number of sectors to obtain the financing they need to grow their business in a global marketplace.