Does Dairy and Meat Demand Change over Time? Comparison

Of Aids Demand System from Two Time Periods

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Introduction

Agricultural economics provides theoretical and empirical framework for estimating consumer preferences. The demand analysis in turn, helps 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 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 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 on one generation. Many of the Baby Boom generation, fed their families TV dinners and canned vegetables. In turn the Gen X's 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.

In 2002, per capita fluid milk consumption in the U.S. was 191 pounds[1]. 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. On the

[1]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.

contrary, per capita consumption of butter and cheese[2] 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 2.

Similarly to fluid milk, per capita consumption of beef[3] declined during the study period, from 64.8 pounds in 2002 to 55.5 pounds in 2019. In comparison, per capita consumption of chicken[4] 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.

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.

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.

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

This research 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 test the hypothesis of no taste change. If the hypothesis is rejected, it would suggest that a continuing updates of the demand elasticities with newer data are necessary to more accurately project the future demand for food products. Alternatively, if the no taste change hypothesis is accepted, and no significant differences are observed, most likely we can continue to relay on existing estimates. It also would 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.

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 this research (Bureau of Labor Statistics, 2021a). The data used came from two 5-year time periods, 2002-2006 and 2015-2019[5], 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 coefficients and elasticities obtained. 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, 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 use of household-level data

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

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[6].

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 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

[6] The list of CPI variables used in this research is presented in table 9 in the Appendix.

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:

$$Y_{ih} = f(d_{ih}, ..., d_{sh}). \tag{1}$$

Where Y_{ih} is the hth household binomial value of consumption. If $w_{ih} > 0$ then $Y_{ih} = 1$, and otherwise. This presents a dichotomus 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 10.

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:

$$R_{ih} = \phi(\mathbf{p}_h, \mathbf{d}_h, \mathbf{m}_h)/\Phi(\mathbf{p}_h, \mathbf{d}_h, \mathbf{m}_h) \tag{2}$$

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 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:

$$w_{ih} = \rho_{io} + \sum_{k=1}^{s} \rho_{ik} d_{kh} + \sum_{j=1}^{n} \gamma_{ij} p_{jh} + \beta_i \ln(m_h/Z_h) + \delta_i R_{ih}, \tag{3}$$

where Z is defined as:

$$Z_h = \sum_{i=1}^{n} \ln p_{ih}. \tag{4}$$

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

adding up -

$$\sum_{i=1}^{n} \alpha_i = 0; \qquad \sum_{i=1}^{n} \gamma_i = 0, \quad j = 1, ..., n; \qquad \sum_{i=1}^{n} \beta_i = 0; \tag{5}$$

homogeneity -

$$\sum_{j=1}^{n} \gamma_{ij} = 0, \qquad i = 1, .., n; \tag{6}$$

and symmetry -

$$\gamma_{ij} = \gamma_{ji} \quad \text{for all} \quad i, j(i = j). \tag{7}$$

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).

Results

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 11,232 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, in dollars per week, 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%).

Among dairy products the highest expenditures were for cheese, with \$5.27[7] in 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.

Table 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

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

Table 1: **Dairy expenditures and percent reporting by time period**

Variable	Expenditure Mean	Expenditure SE	Percent reporting
2002-2006			
Butter	$2.99	0.02	13%
Cheese	$5.27	0.03	44%
Ice cream	$4.29	0.02	25%
Milk	$4.17	0.02	65%
Other dairy	$3.50	0.02	30%
2015-2019			
Butter	$4.84	0.04	14%
Cheese	$6.90	0.04	45%
Ice cream	$4.83	0.02	20%
Milk	$4.70	0.03	55%
Other dairy	$5.53	0.04	34%

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 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. Interestingly, several of the relationships where the cross-price elasticities indicate complementarity in 2002-2006, appear to have an opposite relationship in 2015-2019, and vice-versa. 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 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 and 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% increse 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[8] 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)

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

Table 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	1.06***	-0.04	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***	0.78***	-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***	0.24***	-1.26***
	(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	0.33***	-0.904***	-0.969***	-3.84***	-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	-0.22***	-0.206***	-0.329***
	(0.021)	(0.030)	(0.012)	(0.027)	(0.021)	(0.049)

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

for the censored model, yet they were more similar to the uncensored model results in the same study.

Visual examination of the budget shares in Figure 5 and 4, 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.

Tables 12 and 14 show the coefficient estimates from the dairy demand systems, including 7 food products and 12 demographic variables, with a total of 45 and 46 levels[9].

[9] There is no race variable defined as Hispanic for the 2002-2006 data

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[10], number of earners, region, and season. The full list of demographic variables and their levels is presented in Table 10.

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: **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. In 2002-2006, higher income had a positive impact in ice cream purchases, where the opposite was true for the 20015-2019 period.

[10]Rural vs. urban

Table 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 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, race defined as black coefficients 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.

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 treatment resulted in removal of additional 1,705 observations, leaving 31,410 households. 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 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 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 were for beef steak with $12.04[11] 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. 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

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

Table 5: **Meat expenditures and percent reporting by time period**

Variable	Expenditure Mean	Expenditure SE	Percent reporting
2002-2006			
Beef steak	$12.04	0.11	23%
Chicken	$5.48	0.05	24%
Fish	$9.24	0.06	38%
Ground beef	$6.17	0.02	42%
Other meat	$9.52	0.06	73%
Pork	$8.76	0.07	26%
2015-2019			
Beef steak	$15.50	0.20	19%
Chicken	$7.11	0.08	25%
Fish	$11.36	0.09	35%
Ground beef	$8.28	0.04	31%
Other meat	$12.10	0.11	69%
Pork	$10.10	0.11	21%

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.

Tables 15 and 17 show the coefficient estimates from the meat demand system estimation including 7 food group products. Tables 16 and 18 show the coefficient estimates of the meat demand system including 12 demographic variables, with a total of 45 and 46 levels[12]. The details of the demographic variables are described in section on page 11 and in table 10. Most of the estimation results for meat products coefficients representing demographic effects were not statistically significant. However, 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

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

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 16, similarly to the 2015-2019 estimates, show that higher income quantiles (with the exception of the highest 5th income quantile) 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 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 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	-0.73***	-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***	-0.64***	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***	0.09***
	(0.018)	(0.027)	(0.022)	(0.019)	(0.027)	(0.022)
Other meat	0.45***	-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	-1.53***	0.791***	-0.014	-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***	-2.48***	-0.54***	0.825***
	(0.020)	(0.019)	(0.019)	(0.022)	(0.023)	(0.019)
Beef steak	0.706***	-3.541***	3.797***	2.198***	1.82***	-1.84***
	(0.019)	(0.029)	(0.027)	(0.027)	(0.019)	(0.021)
Pork	-1.518***	-1.318***	-3.513***	0.617***	-1.824***	-1.4***
	(0.021)	(0.020)	(0.030)	(0.019)	(0.020)	(0.022)
Chicken	-1.227***	2.488***	-0.2***	-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)

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

Table 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	1.01***	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-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 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	0.98***	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 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.

Tables 7 and 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).

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 1. The projections also used forecasted CPI, food expenditures, 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).

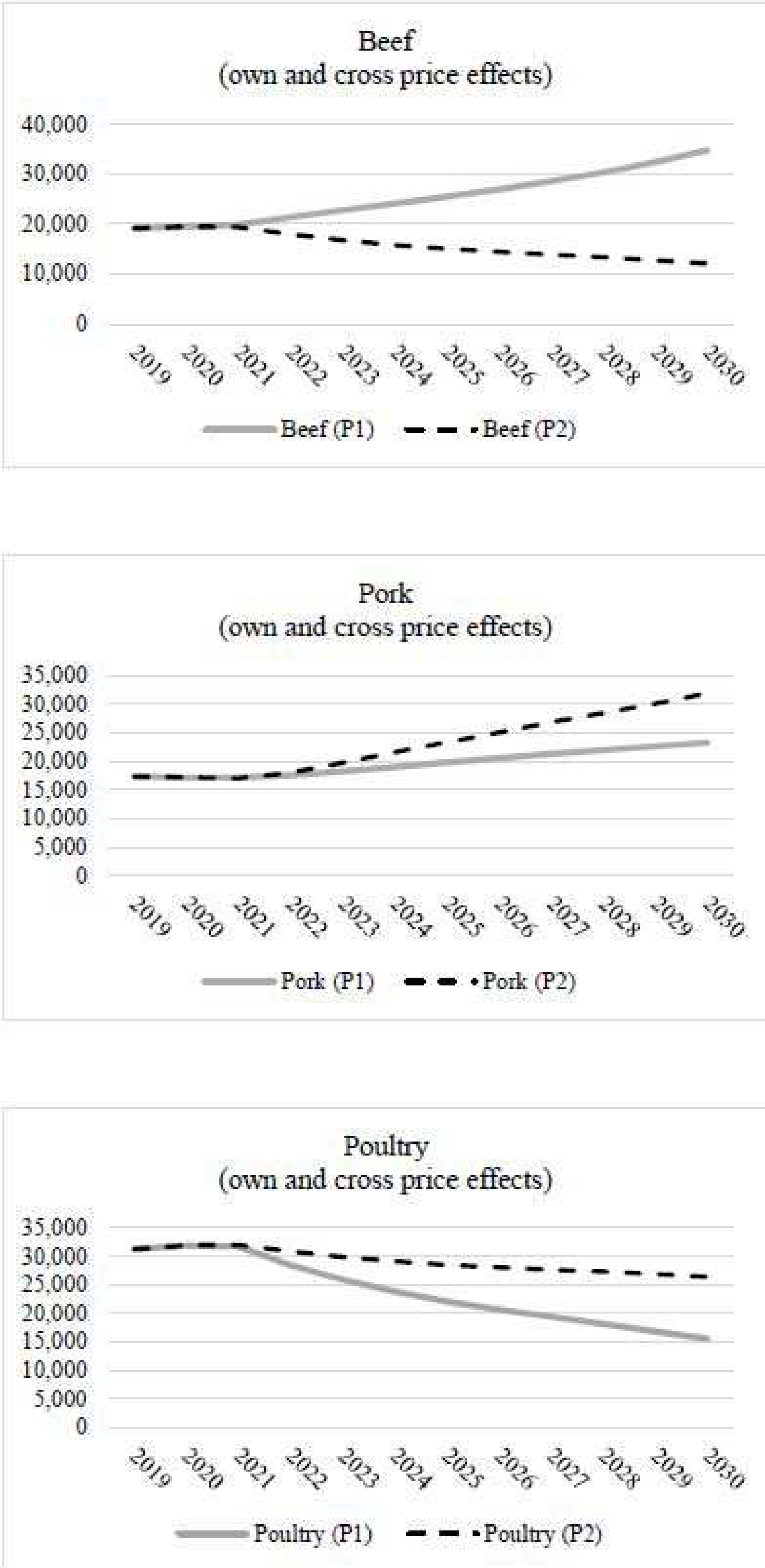
The results based on the estimates of this study show that the period of fit for the elastictity estimates can significantly affect future projections. Showed projections take into account own-, cross-price and expenditure elasticities. The projections do not make any explicit assumptions about the supply 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 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.

Figure 1 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 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 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, estimated 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

Figure 1: **Beef, pork and poultry demand projections – 2021-2030.**



to be 26.3 billion pounds.

These results strongly suggest that the period of fit has a noticeable and potentially significant impact on projections. If such results are used for forecasting and policy work, they have the potential of drastically changing the final outcome.

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 in 2002, by 2019 it increased by 28% to 218 billion pounds (USDA-NASS, 2019). The per capita dairy consumption[13] increased by 11% between 2002 and 2019 (USDA, 2020). Looking at those two trends, it can be inferred that the current dairy supply outpaces dairy demand. This research attempts to give 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 the USDA declined from 186 pounds per capita, to 168 pounds in 2014, and then increased back to 186 pounds in

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

2019. However the composition of the types of meats consumed have changed, with declines in beef and pork and an 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 contrary, chicken became much more price inelastic over time.

The results presented in this research suggest that own- and cross-price elasticities from 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 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.

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

Table 9: **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 10: **List of independent variables**

Variable	Variable definition
Generation[1]	4 levels: Millenials, Gen X, Baby Boomers, Traditionalists
Household income quantile	5 levels: 1st quantile, 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: One 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[2] , 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: (1) 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. (2) There is no variable determining race defined as Hispanic available in the data for years 2002-2006

Table 11: **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 12: **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
Sigle 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 13: **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 14: **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
Sigle 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 15: **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 16: **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 17: **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

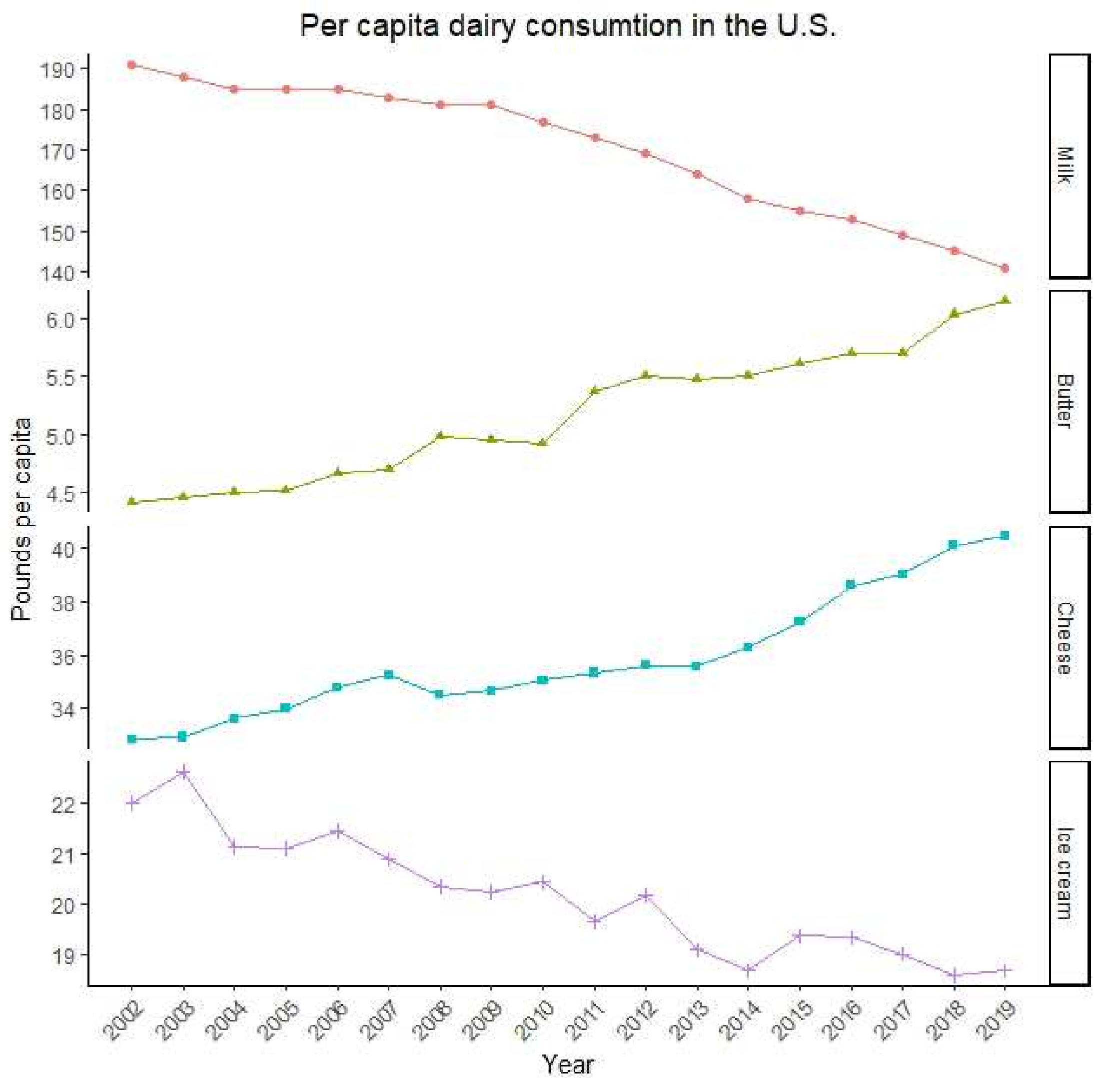
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Table 18: **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

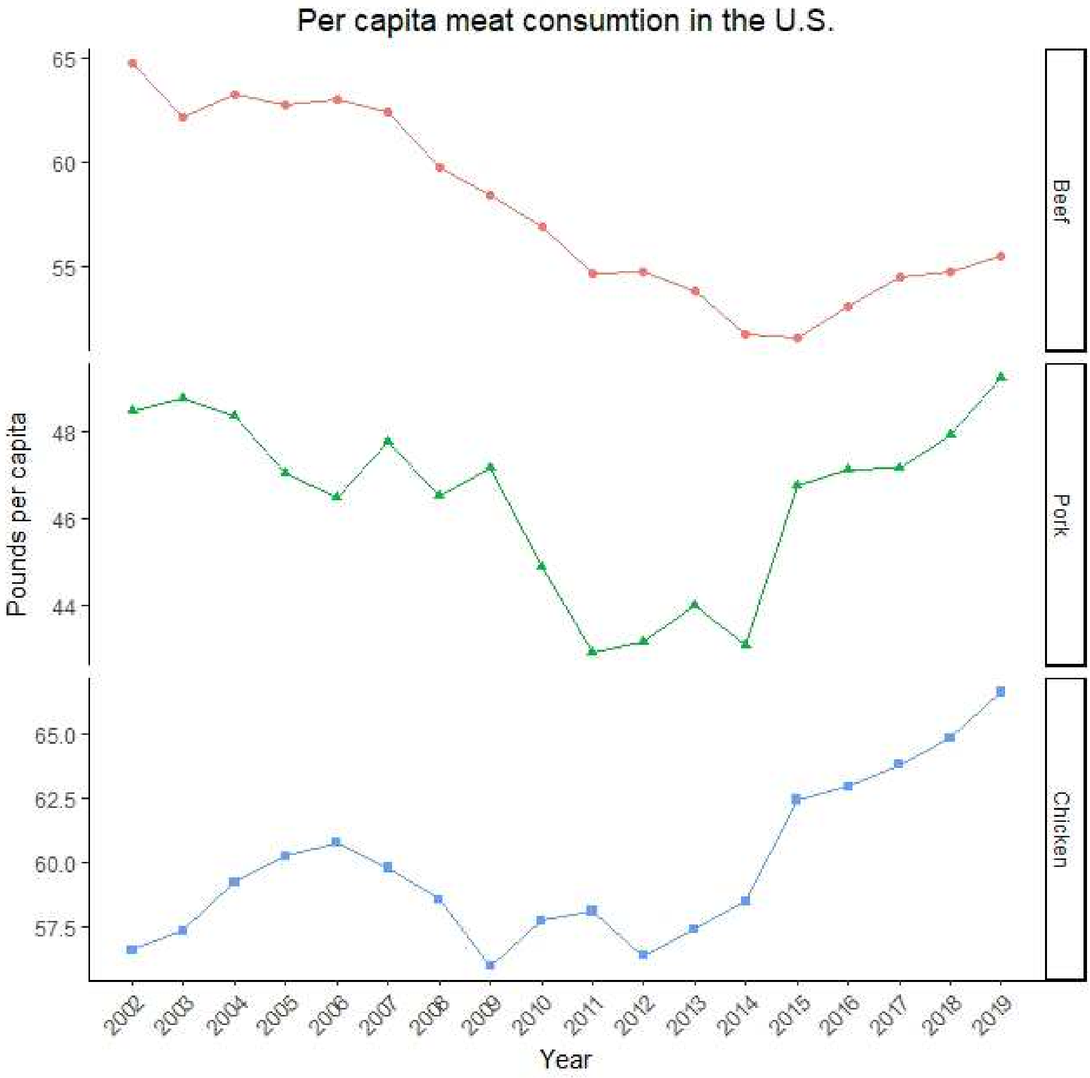
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.10$

Figure 2: **Dairy consumption per capita in the U.S. - 2002-2019.**



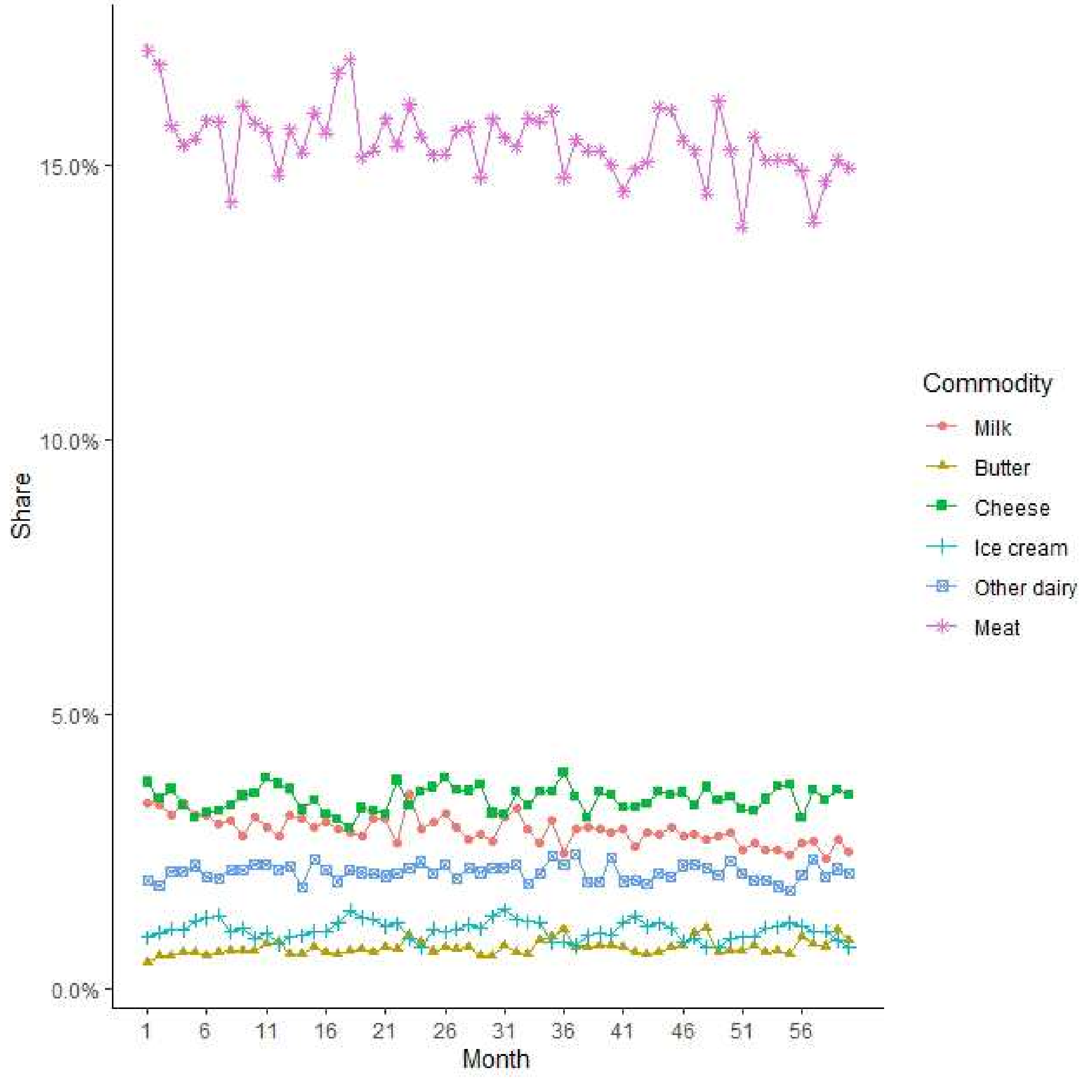
Note: Based on USDA data (USDA, 2020).

Figure 3: **Meat consumption per capita in the U.S. - 2002-2019.**



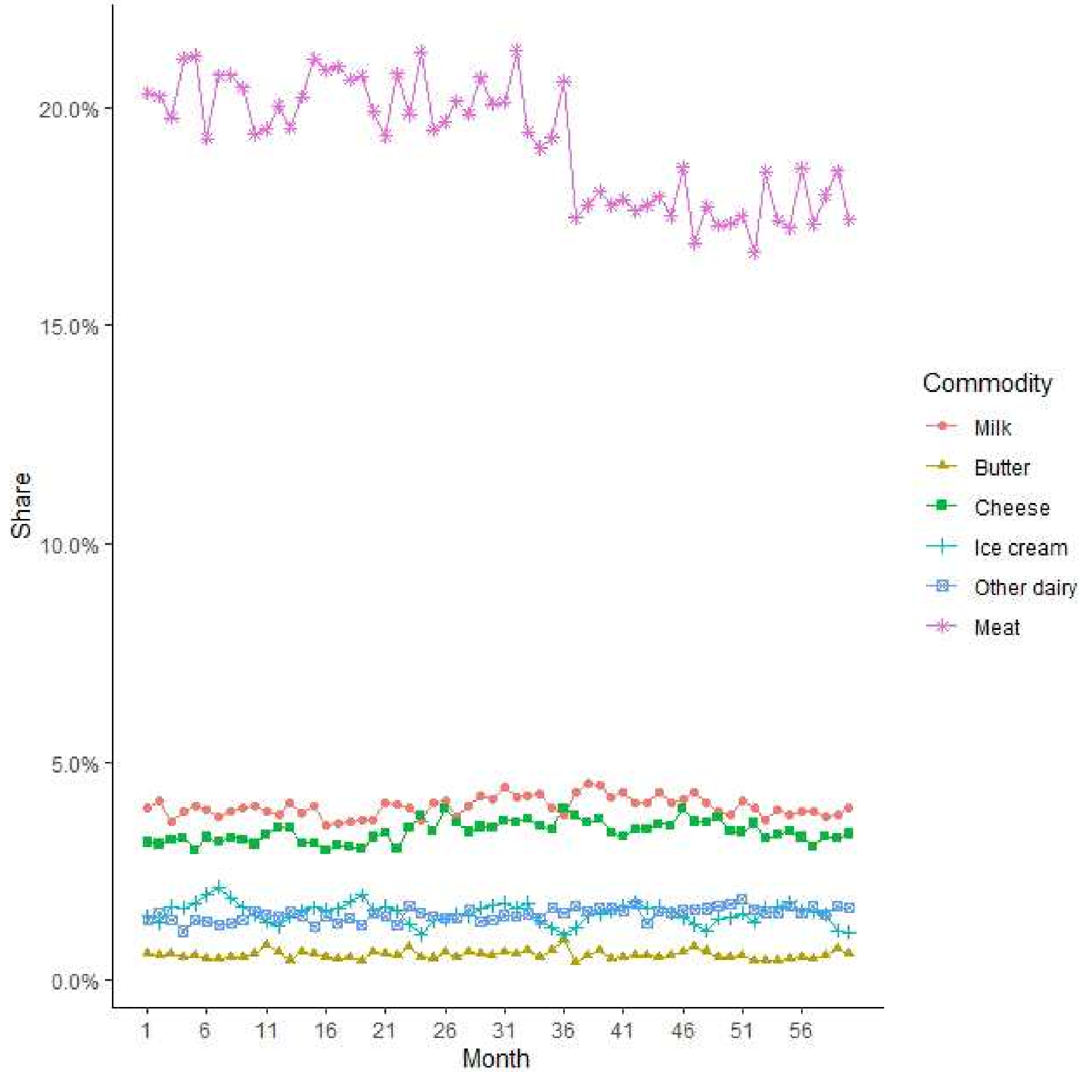
Note: Based on USDA data (USDA, 2019).

Figure 4: **Dairy products budget shares in each month 2015-2019.**



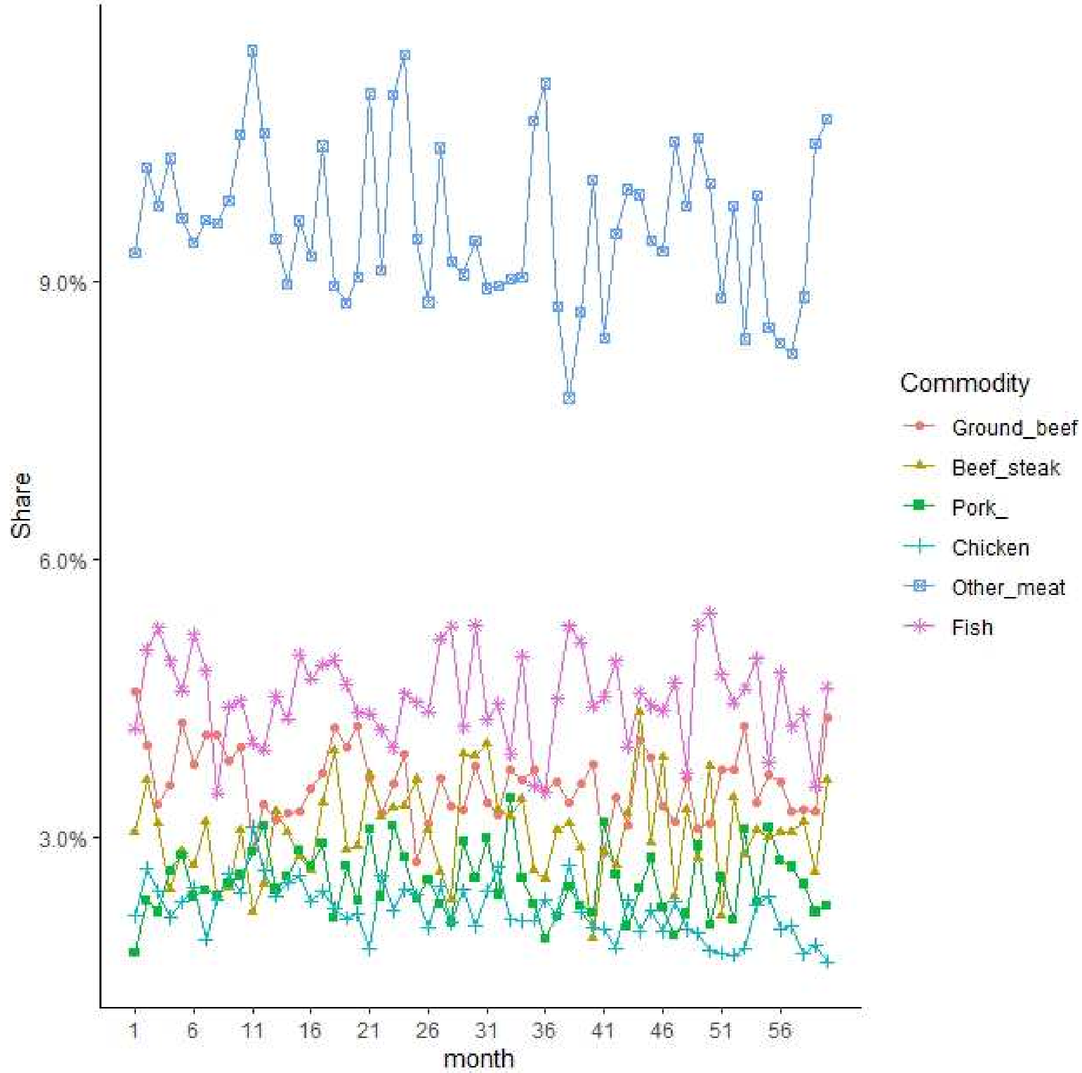
Note: All other food variable was omitted in the graph.

Figure 5: **Dairy products budget shares in each month 2002 - 2006.**



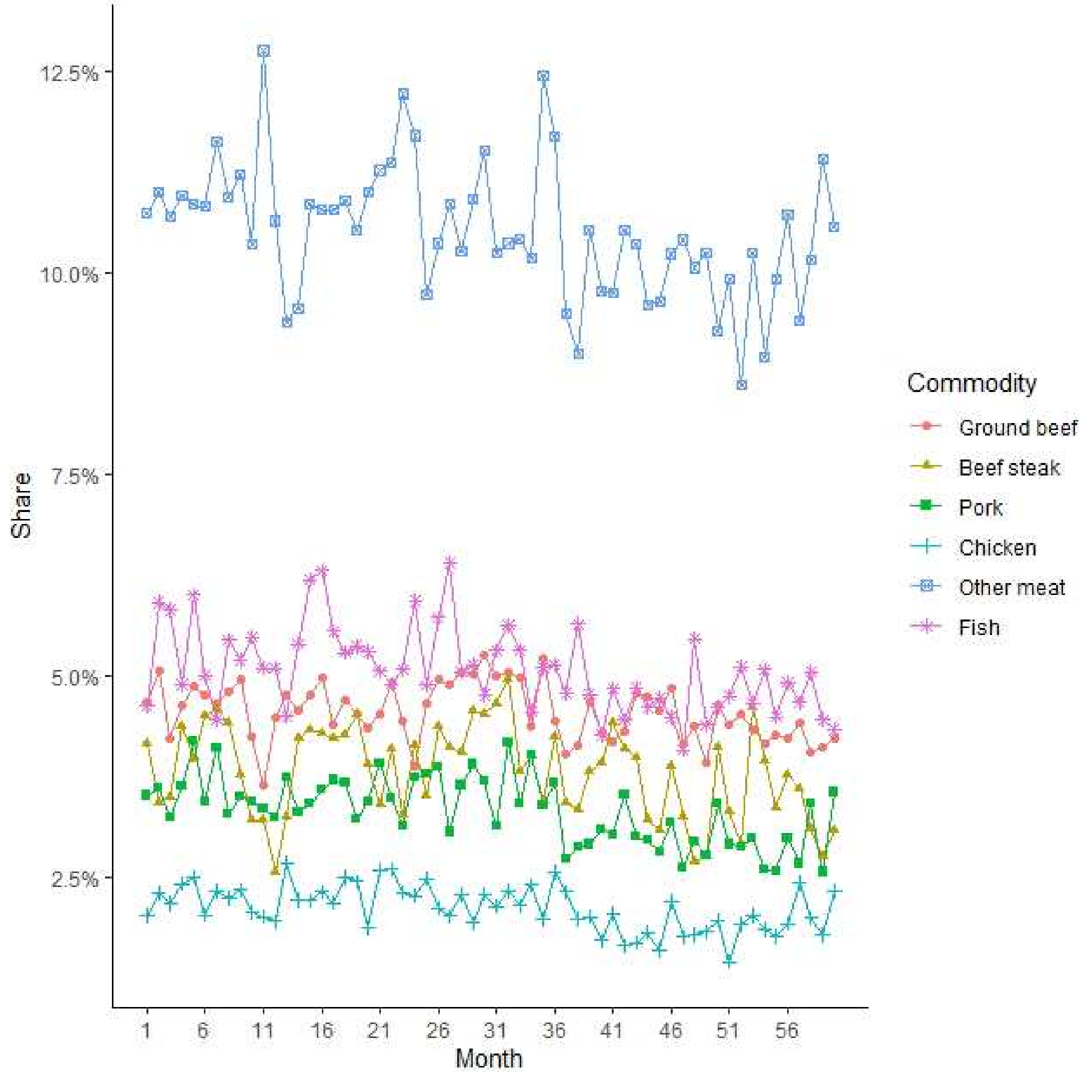
Note: All other food variable was omitted in the graph.

Figure 6: **Meat products budget shares in each month 2015-2019.**



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

Figure 7: **Meat products budget shares in each month 2002-2006.**



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

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