Demand for Plant-Based Meat Alternatives and the Role of Habit Formation and Variety Seeking

Zachary T. Neuhofer[1*], Jayson L. Lusk[2]

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[1] Department of Agricultural Economics, Purdue University, West Lafayette, IN, USA
[2] **Oklahoma State University, Stillwater, OK, USA**

*** Corresponding Author. Email: zneuhofe@purdue.edu**

Abstract: Novel plant-based meat alternatives (PBMAs) have the potential to disrupt traditional meat industries, but only if consumers substitute PBMAs for meat over time. This study uses weekly household scanner data from 2018-2020, to estimate demand for PBMAs in the ground meat market. We use a basket-based demand approach by estimating a multivariate logit model to determine cross product relationships between PBMAs, ground turkey, ground chicken, and ground beef, while simultaneously exploring the role of prior consumption habits and demographics on demand. We find demand for PBMAs is higher among younger, higher income, college educated, non-white households. Demand for PBMAs gradually increased over the two year span studied from 2018 to 2020. PBMAs and ground beef are price substitutes, whereas PBMAs are complements with ground turkey and ground chicken. Demand for PBMAs is driven by habit formation rather than variety seeking, as higher past purchases of PBMAs lead to a higher likelihood of current PBMA purchases. At the same time, consumers with higher past ground beef purchases are less likely to choose PBMAs, suggesting growth of this new product is coming from consumers on the margin rather than from heavy beef buyers substituting away from their traditional purchases. Additionally, we find that U.S. households in the aggregate would have to be compensated $1.1 billion per year to forgo ground beef at retail grocery without adversely affecting consumer welfare; still, we value the introduction of PBMAs at $90.27 million per year.

Encouraging substitution to plant-based diets, including novel plant-based meat alternatives (PBMAs) designed to mimic the taste and texture of meat, has been suggested as a way to reduce land-use, water use, and greenhouse gas emissions, while lowering the risk of chronic diseases and mortality rates, and improving animal welfare (Clark et al., 2019; Clark and Tilman, 2017; Eshel et al., 2014; Fehér et al., 2020; Godfray et al., 2018; Heller et al., 2018; Springmann et al., 2016; Zheng et al., 2019). Multiple fast food chains, such as KFC and Burger King, have prominently featured PBMAs on their menu (Burger King, 2021; Valinsky, 2022), and the PBMA market has received substantial attention in media (Reynolds, 2022; Turow-Paul and Egan, 2022). Whether the PBMAs deliver on their promises ultimately depends on consumer acceptance and the extent to which consumers are willing to substitute away from meat towards PBMAs. While there have been several prior analyses of consumer preferences for PBMAs, most have consisted of analyses of stated preference data. We bring revealed preference, longitudinal, household scanner data to bear on the question in a way that allows us to track a given household's purchases over time, which permits a study of the extent to which habit formation or variety seeking helps explain adoption and substitution patterns. Moreover, these data also allow us to estimate the welfare gains that have been generated from the introduction of PBMAs.

Despite initial strong growth and gains in market shares, recent reports and media coverage suggest novel PBMA sales are declining (Ignaszewski, 2023; Little, 2022; Olen, 2022; Reiley, 2022; Reorink, 2022; Reynolds, 2022). A potential explanation for the stagnating growth of the PBMA markets is the higher relative prices of PBMAs, particularly in a time of high food price inflation and waning beef prices (Reiley, 2022). By estimating demand elasticities, we provide evidence of the extent to which relative price changes can help in explaining this phenomenon. It

has also been speculated that the novelty of PBMAs has worn off, with media sources suggesting much of the early growth was a result of variety seeking behavior (Reiley, 2022; Reynolds, 2022). Our analysis provides insights into the role habit formation (or variety seeking) helps explain the early growth of PBMAs.

Despite the potential for PBMAs to supplant meat consumption, data suggests consumers who buy PBMA alternatives also buy meat (Cuffey et al., 2022; Neuhofer and Lusk, 2022; Zhao et al., 2022). Hypothetical choice experiments (Bryant et al., 2019; Carlsson et al., 2021; Onwezen et al., 2021; Slade, 2018; Tonsor et al., 2022; Van Loo et al., 2020) and household scanner data (Cuffey et al., 2022; Neuhofer and Lusk, 2022) have examined the demographics of PBMA purchasers, finding them to be younger, more educated, higher income, living in urban areas, single, female, employed, and non-white. Despite these analyses, much remains to be learned about household demand for PBMAs and potential substitution effects. We are aware of one prior non-hypothetical demand analysis using retail scanner data aggregated to the national level (Zhao et al., 2022); surprisingly, this study found PBMAs and beef were demand complements, while finding PBMAs to be price substitutes for chicken, turkey, and fish. Other elasticity estimates from hypothetical choice experiments suggest that PBMAs are weak price substitutes for beef (Tonsor et al., 2022). Descriptive studies suggest that a majority of PBMA buying households made purchases of PBMAs on multiple occasions though their meat expenditures did not decline (Cuffey et al., 2022; Neuhofer and Lusk, 2022).

This study contributes to the literature by providing further insight into demand for PBMAs using revealed preference, household scanner data. A limitation of the stated preference hypothetical choice experiments on this topic is that they limit the consumers' options to a predetermined choice in a single moment of time. Additionally, in traditional choice

experiments, all of the products are forced to be demand substitutes, which does not allow for complementary relationships between products. If the result in Zhao et al. (2022) holds, the assumption of demand substitution may be mistaken. The demand relationship between PBMAs and ground meats is critical in understanding the impact of PBMA sales on the livestock industry, with demand shifts toward PBMAs having larger negative impacts on cattle herds and rancher profitability when there is greater substitutability between PBMAs and ground beef (Lusk et al., 2022). Our study builds on prior research by allowing for the effects of household dynamics and prior consumption behaviors on demand – insights that are not captured through analysis of retail scanner data. Determining whether habit formation or variety seeking behaviors prevail is important to provide information into how the market may evolve in the future, and yet static hypothetical choice experiments and retail scanner data cannot provide these insights.

This study has three primary objectives. First, we determine consumer demand for ground meats and PBMAs using a basket based choice model, which permits a flexible representation of substitution or complementary patterns between goods. Prior studies analyzed PBMA demand from descriptive statistics and not an econometric framework (Cuffey et al., 2022; Neuhofer & Lusk, 2022), or product relationships in an AIDS model using retail scanner data and not analyzing household purchases (Zhao et al., 2022). Our second objective is to understand how prior consumption patterns affect demand for meat and PBMAs. If consumers' PBMA demand exhibits variety-seeking behavior, or ground beef demand is characterized by a high degree of habit formation, growth in the market for PBMAs is likely to face headwinds. This deviates from prior studies that analyzed semblances of habit formation, that simply analyzed whether households made a subsequent purchase (Neuhofer & Lusk, 2022) or how their dollar

expenditures changed on PBMAs and other goods after a purchase (Cuffey et al., 2022), but these were not estimated from a structural demand framework controlling for other factors. Finally, we estimate the value of the innovation of PBMAs to U.S. households. Innovation that offers new choice options and creates consumer surplus, and understanding the magnitude of these welfare gains is important in judging the overall success of PBMAs above and beyond a simple analysis of willingness-to-pay or market shares. This deviates from prior studies which have not analyzed consumer welfare extensively (Cuffey et al., 2022; Neuhofer & Lusk, 2022; Zhao et al., 2022) or only did from the hypothetical choice context (Caputo et al., 2022; Carlsson et al., 2021; Tonsor et al., 2022; Van Loo et al., 2020) .

Methods

Data Overview

We use weekly IRI household panel data on ground meat (beef, chicken, turkey) and PBMA purchases from November 2018 to November 2020. Inclusion in the household sample was limited to households who made at least one purchase of a ground meat or a PBMA over the two year span of the purchase data. The final dataset consists of the purchase patterns of 38,847 households in each of the 104 weeks studied. The purchase data is recorded at a Universal Product Code (UPC) level. Each UPC code is attached to a specific product description, which includes a multitude of product characteristics such as brand, processing method, refrigerated vs. frozen, and packaging type. Additionally, demographic information is available for each household, such as income, household size, age, education, and race.

To construct the consumers' choice sets we focus attention on ground meat purchases including ground beef, ground turkey, ground chicken, and PBMAs. While other PBMA products exist, the recently introduced "novel" PBMAs resemble ground meats (Beyond Meat,

2021; Impossible Foods, 2021). Additionally, evidence suggest that demand for meat products, like ground meat is separable from general meat aggregates like "beef" or "chicken" (Eales & Unnevehr, 1988). The IRI household panel dataset does not have a strict code for PBMAs. To identify a PBMA we use key words in product descriptions that reference that the option is a substitute or vegetarian product[3]. Our method of identifying PBMAs differs from Zhao et al., (2022) and Cuffey et al., (2022). Zhao et al., (2022) focuses on the "fresh meat" category of Nielsen retail scanner data which leads to the primary sample being of products from brands such as "Impossible Foods" and "Beyond Meat". Cuffey et al., (2022) includes meat alternatives that are "Dry Goods" and frozen. Our PBMA identification process resembles Neuhofer and Lusk (2022) in that our PBMA sample corresponds to the meat products of interest. We eliminated products that were infrequently purchased – i.e., those with fewer than 50 purchases over the two year period, in part because many of these product types were ambiguous and were unidentifiable as to species of animal product. Ultimately, the dataset used in this analysis consists of information on 500,847 transactions, 490 UPCs, and 38,847 households. Within these transactions and UPCs, major brands and manufacturers of PBMAs, ground beef, ground chicken, and ground turkey were included.

Data Aggregation

UPC data were aggregated to the product level: ground turkey, ground beef, ground chicken, or ground/patty PBMAs. In most weeks, the typical household did not purchase a product, and for these weeks, the household effectively chooses a "no purchase" option. Table 1 shows the purchase frequency for each of the types of ground meat.[4]

[3] Due to our data contract, we are unable to disclose any keywords used from the product descriptions or any brand names of products.

[4] In addition to four aggregate categories, we considered a more disaggregate classification consisting of 17 product types, which differentiated by meat type (i.e., burger or general ground) and the location in the store (i.e.,

Econometric Estimation

It is often the case that multiple items are purchased simultaneously. As such, the conventional single discrete choice modeling framework, such as the multinomial logit (MNL), is likely inappropriate. This is particularly true if some products are demand complements, as the MNL forces all products to be demand substitutes. Following recent literature (Caputo and Lusk, 2022; Richards and Bonnet, 2018), a multivariate logit (MVL) is used to analyze the data. Rather than modeling a single choice out of a set, the MVL considers the bundle or combination of choices made in a given period. The MVL is akin to the MNL but instead of assuming a consumer chooses one of J possible products, it is instead assumed the consumer choses one bundle or basket of products out of 2^J possible bundles. In our case, there are four possible ground products (beef, chicken, turkey, and PBMA) plus "none", implying there are $2^4 = 16$ possible baskets that could be constructed. Table 2 shows the percent of times each basket was chosen.

There are two primary strengths of using a MVL basket-based approach. First, as previously indicated, it is not uncommon for a household to make two or more unique product selections during a shopping trip. A traditional choice model assumes that each choice is unique and independent of other choices, which is not necessarily the case in a grocery store setting. A second strength of the basket-based approach is that it permits a wider array of complements/substitutes relationships.

We opted for the basket-based choice model over a continuous demand system approach, like the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980). The large number of "zeros" poses a problem for AIDS and related models, leading to undefined expenditure

refrigerated or frozen). Purchase frequencies for these 17 items are shown in Appendix Table 1; demand estimates based on this classification are shown in Appendix Table 2.

shares (Tiffin and Arnoult, 2010). Authors sometimes use various econometrics methods to address the selection bias presented by zero purchases (Heien and Wessells, 1990; Yen and Lin, 2006), but the approaches rest on functional form assumptions and first-stage instruments for identification. Another common issue with demand system approaches is that the addition of demand shifters, such as demographics, can lead to estimates that violate invariance as they depend on the units of measurement (Alston et al., 2001). A final concern with continuous demand system approaches that they are conditional demand systems, which assume that consumers follow two-stage budgeting and allocate a given amount of expenditures to "meat." However, PMBAs have the potential to expand the market size and draw in new customers and spending to the category, which leads us to prefer the MVL.

The MVL operates within the random utility framework (Mcfadden, 1974). The random utility derived from the b^{th} basket is assumed to follow $U_{ibt} = V_{ibt} + \varepsilon_{ibt}$ where:

1) $V_{ibt} = \sum_{j=1}^{J} \alpha_{ijt} x_{jt} + 0.5 \sum_{j=1}^{J} \sum_{k \neq j}^{J} \gamma_{jk} x_{ijt} x_{ikt}$

x_{ijt} takes the value of 1 if basket *b* contains the *jth* item in time *t* and zero otherwise. The parameter α_{ijt} represents the base utility of food item *j*. The base utility can be specified as a function of product and household specific variables such as, price, demographic characteristics, quarterly fixed effects, and prior purchases as detailed below.

The parameters denoted by γ_{jk} represent the cross-product relationships between the different products in the basket, which show the effects an additional product purchased has on the utility of the basket. A value of $\gamma_{jk} > 0$ indicates that the products are utility complements, which implies that the utility for product *j* increases when product *k* is also in the basket. When

$\gamma_{jk} < 0$, the utility of product *j* falls when product *k* is in the basket, indicating that products *j* and *k* are substitutes in utility.[5]

Specification of Baseline Utility

Demographic variables were added to the model to control for preference heterogeneity across households. In addition, quarterly time fixed effects were added to account for demand shifts that potentially occurred due to seasonality or other unique demand shocks (e.g., from the spike in grocery spending around COVID19 shutdowns). We specify the initial base utility as:

2) $\alpha_{ijt} = \alpha_{0jt} + \beta p_{ijt} + X_i \delta_j + T_{jt}$

Where the base utility α_{ijt} is a function of an alternative specific constant α_{0jt}, the price of product *j* in time *t* paid by household *i*, p_{ijt}, a vector of household demographics X_i, and a vector of quarterly fixed effects T_{jt}. The parameters are given by β, δ_j, and T_{jt}.

Table 3 defines the individual household characteristics variables used in the model. Among households that have both a male and female head of household, we used the female demographics as the demographic variables of interest for age and education. The female household head characteristics are used because prior research suggests the females are the primary grocery shoppers (Schaeffer, 2019). Some demographic measures apply to a household head while others apply to the entire household. The values of age, education level, and race apply to the household head, while the values of household size, marital status, employment, income, and the presence of children apply to the entire household.

Habit Formation

Economists have long been interested in the effects of the prior consumption on future demand, recognizing that demand is dynamic (Pollak, 1970). Given the panel nature of our data, we can

[5] For more information on assumptions in the MVL model, we follow the procedures in Caputo and Lusk (2022).

explore the extent to which prior purchases influence current decisions (Adamowicz, 1994; Adamowicz and Swait, 2013). Multiple studies have examined habit formation or variety seeking in demand. In many cases demand is reliant on prior purchases, as seen in models that examine household living expenses (Alessie and Kapteyn, 1991; Kapteyn et al., 1997), meat (Holt and Goodwin, 1997), addictive goods like alcohol and tobacco (Pierani and Tiezzi, 2009), tourism (Adamowicz, 1994; Boto-garcía, 2022), and travel (Xu et al., 2017). Additionally, there is a substantial literature on variety seeking behavior (Kahn, 1995; McAlister and Pessemier, 1982; Verplanken, 2018), which has been identified in markets such as food purchases in tourism (Mak et al., 2012), food (Adamowicz and Swait, 2013), and wine (Caracciolo et al., 2022). Our MVL approach can account for both habit forming and variety seeking by allowing the baseline utility of each product to be specified as a function of past purchases of the same product and past purchases of other products. Many previous studies estimate demand in the current period to be a function of a single-period lag of prior purchases (Adamowicz and Swait, 2013; Boto-garcía, 2022). However, given that most of our consumers do not make repeated purchases from one week to the next, we opt to model effects of previous purchases through the total number of prior purchases of products (Adamowicz, 1994; fXu et al., 2017). Examining the cumulative number of prior purchases is a useful way to determine habit formation or variety seeking even when multiple time periods have passed. Additionally, cumulative purchases allow for us to examine the likelihood of subsequent purchases as frequency increases.[6] We specify the baseline utility with prior purchase variables as:

$$3)\quad \alpha_{ijt} = \alpha_{0jt} + \beta p_{ijt} + X_i\delta_j + T_{jt} + \sum_{j=1}^{J} \varphi_j N_{ijt}$$

[6] In addition, we considered a specification in which demand was specified as a function of prior purchases only in the prior three weeks. The results of this model are shown in Appendix Table 5. Model fit statistics, such as AIC, indicate the model with the cumulative number of purchases over all previous weeks in the sample provide a better it to the data.

where N_{ijt} is the cumulative number of times product *j* was purchased by household *i* prior to period *t* divided by the number of weeks, 104. Dividing by 104 results in a variable bound between zero and one, which aided in model convergence.[7] Habit forming behavior occurs when $\varphi_j > 0$, implying more past purchases of *j* increases the current utility of *j* (Adamowicz, 1994). A value of $\varphi_j < 0$, indicates variety seeking behavior as more past purchases of product *j* reduce the utility of *j* at present (Adamowicz, 1994). For other products *k*, a value of $\varphi_{ikt} > 0$ indicates that more prior purchases of product *k* increase the likelihood and utility of selecting product *j*, and a value of $\varphi_j < 0$ indicates that more prior purchases of product *k* decrease the likelihood and utility of selecting product *j*.

Prices and Endogeneity

As with all analyses of household scanner datasets, price series must be constructed before demand estimation can proceed. For chosen items that are not random weight, unit prices are calculated: expenditure is divided by the total weight (in lbs.). Many meat products, however, are sold random weight, meaning expenditure but not weight is known. For random weight products, we assigned per-pound prices by averaging the prices of non-random weight items of the same type (beef, chicken, turkey, or PBMA) in the same week the purchase was made. Similarly, for products that were not selected in a basket, we impute prices by calculating the average weekly per-pound price of all items purchases that week of the same type. In the calculation of prices, there were some extreme outliers, likely indicating mistakes in data recording (e.g., prices greater than $50/lb.). We trimmed the price distribution by replacing outliers in the 1% tails of the distribution with the mean observed per pound price of all other

[7] We also considered a specification that ignored the cross-product effects (e.g., past purchases of beef were only permitted to affect beef demand). This model is shown in Appendix Table 4. A Likelihood Ratio Test rejects his model (Chi-Square value of 4,433, degrees of freedom of 12, and p-value of 0.00) in favor of the model presented in the main text with the prior cross-product effects.

items of the same type purchased in the same week. While these procedures have the potential to introduce measurement error, they also have the advantage of reducing concerns about endogeneity issues associated with strategic pricing or unobserved qualities affecting prices.

To help ensure our price effects are causal demand responses, we adopt the control function approach of Petrin and Train (2010). Demographic factors are included in the first stage control function under the premise that these can capture some of the quality variation across household (Brooks and Lusk, (2010) and Cox and Wohlgenant, (1986)). As described above, random weight items and prices of products that were not selected have no price variation within a given time period as these observations use the mean price as the imputed value, and as such we include a dummy indicating whether the product selected has a unique per pound price that is not the imputed mean price for the week. In addition to the demographic regressors for quality control in the control function, we include some wholesale meat prices as instruments to control for potential supply side shocks.. We used primal chuck boxed beef price for ground beef, frozen wholesale hen prices for ground turkey, wholesale chicken breast prices for ground chicken, and soybean meal for PBMAs; all data are originally reported by USDA and were obtained from the Livestock Marketing Information Center (LMIC). These wholesale prices were chosen because typically ground meats are formed from the trimmings of other meat cuts. In the case of soybean meal, it is a common input in animal feed and soy is a common input in PBMAs. In the first-stage regression, each of the wholesale prices were lagged two weeks to account for differences in timing of cost incurred by retailers and ultimate retail prices charged to consumers. Additionally, we included the time period fixed effects[8].

[8] Prices may vary based on the geographic location of the purchases; however, our household panel data does not include any geographic variables on the purchases so no geographic instruments were used.

Following the framework of Petrin and Train (2010), the residuals from the first-stage regression equation are included in the base utility terms in the second stage estimation of equation 3). A significant coefficient on the residuals in the second stage regression indicates the presence of endogeneity (Petrin and Train, 2010). We can specify the first stage regressions as[9]:

4) $p_{ijt} = \zeta_{ij} W_{t-2} + \tilde{T}_{jt} + X_i \widetilde{\delta_j} + I_{ijt}\lambda + I_{ijt} X_i \varrho + \tilde{\varepsilon}_{ijt}$

Where we regress the endogenous price value for household *i* for product *j* in time period *t* (p_{ijt}) on the vector of wholesale prices of primal chuck boxed beef, frozen hens, chicken breasts, and soybean meal two time periods prior to time period *t* (W_{t-2}); a vector of quarterly fixed effects ($\tilde{T}_{jt}$), a vector of household demographics (X_i), an indicator variable to denote that the price was a unique non-imputed price (I_{ijt}), and an interaction between the demographic controls and the non-imputed price indicator to account for variations in product quality (Brooks & Lusk, 2010; Cox & Wohlgenant, 1986). The residual value that is input into the second stage regression is denoted as $\tilde{\varepsilon}_{ijt}$, which leads to our final base utility estimation as:

5) $\alpha_{ijt} = \alpha_{0jt} + \beta p_{ijt} + \tilde{\varepsilon}_{ijt} + X_i \delta_j + T_{jt} + \sum_{j=1}^{J} \varphi_j N_{ijt}$

Willingness-to-Pay Estimates

Relative willingness-to-pay (WTP) between products is given by:

6) $WTP = \frac{V_{imt} - V_{int}}{-\beta}$.

This calculation shows the price difference between two baskets (one with bundle of goods *m* and another with a bundle of goods *n*) that makes the average consumer indifferent between the two baskets.

[9] Results from the first stage regressions are found in Appendix Table 7

Additionally, we estimate the additive WTP for an additional product in the basket (AWTP). This calculation is:

7) $AWTP = \frac{\gamma_{jk}}{-\beta}$.

This calculation indicates the additional monetary value (or discount) of having both products *j* and *k* in the same basket above that is implied by the summation of the linear effects.

Welfare Effects of Product Introduction or Removal

To determine the welfare effects of adding or removing a meat option from a consumer's choice set, compensating variation (CV) is calculated as:

8) $CV = \frac{1}{-\beta}[\ln \sum_{b=1}^{16} e^{V_{ibt}} - \ln \sum_{b=1}^{8} e^{V_{ibt}}]$

where the log sum of utility for all baskets without a particular product (consisting of only $2^3 = 8$ possible baskets) is subtracted from the sum of utility for all possible baskets from the full suite of 4 products (consisting of only $2^4 = 16$ possible baskets) (Carlsson, 2012).

Results

Table 1 shows the percentage of times a product was chosen and the average prices of each item. Ground beef had the highest market share at 8.08% of all choices; ground beef was in70.45% of baskets conditional on a product being selected. The product with the second-largest market share is ground turkey, which was also the most affordable option on average. PBMAs were the third most selected product and were in 0.88% of baskets overall or in 7.71% of baskets conditional on a product being selected. The average price of PBMAs was $6.57/lb., higher than the average ground beef price of $3.82/lb. The least popular product was ground chicken, which was selected in 0.43% of baskets overall and in 3.77% of baskets in which a product was selected.

Table 2 shows all the potential baskets and how often each was selected. The most commonly selected basket was "none" – selected 88.53% of the time. The next most popular basket was ground beef alone, which accounted for 7.69% of baskets, followed ground turkey alone (2.20%), and PBMA alone (0.77%). The two most common baskets that contained multiple products were ground beef and ground turkey (0.27%) and the basket that contained ground beef and a PBMA (0.06%). The most common three-product basket consisted of ground turkey, ground beef, and ground chicken (0.01%).

Estimates of equation (3) are shown in Table 4[10].[11] All the cross-product utility effects are positive, suggesting that all products are utility complements. For example, when ground beef is purchased alongside PBMAs, utility increases 0.258. Because these are estimates from a logit model, it indicates that the odds of purchasing beef are exp(0.258) = 1.29 if a PBMA is also in the basket; that is, adding ground beef to the basket is associated with a (1.29 – 1)*100 = 29% increase in PBMA also being placed in the basket. It is interesting to note that without including habit/variety effects (see model in Appendix Table 3), ground beef and PBMAs are estimated as utility substitutes (Appendix Table 3). That is, interpretation of whether beef and PBMAs are utility complements or substitutes hinges on whether prior purchase behaviors are included in the model. Model fit criteria and likelihood ratio tests suggest the model with prior purchases better fits the data, and as such, the conclusion of utility substitutes between beef and PBMA is likely a result of omitted variable bias and not accounting for habit formation.

[10] The positive and significant effect associated with the first stage residuals suggests the presence of endogeneity, which is accounted for by the control function approach, results from the first stage residuals are in Appendix Table 7.

[11] In the appendix (Appendix Table 3, Appendix Table 4) we show alternative specifications; Appendix Table 3 shows a model ignoring habit/variety and Appendix Table 4 shows a model that includes only the own product prior purchases. AIC model fit criteria indicate these models are inferior to the model reported in the main text.

Greater prior purchases of a product leads to higher utility of the same product, indicating habit formation for ground beef, turkey, chicken, and PBMAs. The own-product effect of cumulative past purchases for PBMAs is estimated at 21.881. Recalling that we scaled past purchases by 104 (the number of weeks in the dataset), a one-time increase in past purchases is equivalent to an increase in N_{ijt} of 1/104 = 0.0096. Thus, one additional prior purchase of PBMA results in the odds of current PBMA purchase of exp(21.881*0.0096) = 1.234. That is, the odds of choosing PBMA today increases by 23.4% for each additional time PBMA was purchased in the past. By contrast, an additional purchase of a PBMA in the past reduces the odds of selecting ground beef by 100*(1-exp(-0.961*0.0096)) = -0.01%.

For every additional time ground beef was purchased in the past, the odds of selecting ground beef in the present increases by 11% (100*(1-exp(10.878*0.0096)) = 11%), whereas the odds of selecting PBMA in the present *falls* by 4.2% (100*(1-exp(-4.457*0.0096)) = 4.2%). Thus, while previous research has correctly observed the same households who buy PBMA also buy ground beef (at least over some extended period of time), the results here show that "heavy buyers" of ground beef are less likely to choose a PBMA. More prior purchases of ground beef decreased the utility of purchasing ground turkey and PBMAs. Interestingly, we observed that more prior purchases of ground turkey increased the utility of subsequent purchases of ground chicken and PMBAs, while leading to disutility of subsequent ground beef purchases. More prior purchases of ground chicken increase the utility of ground turkey purchases but decrease the utility of ground beef purchases. There is an asymmetry: more prior purchases of PBMAs decreased the utility of ground turkey but more past ground turkey purchases increased the utility of PBMA purchases.

All time fixed effects are positive for turkey, beef, and chicken, indicating demand for these products was lowest in the base period corresponding to the final quarter of 2020. With respect to PBMAs, demand was higher in quarters 1 and 2 of 2020 than in the final quarter of 2020, and lower in 2018 or 2019 than the final quarter of 2020. This resembles the steady upward trend in PBMA purchases that occurred during the COVID-19 pandemic except for a couple of weeks in late March and early April of 2020 (Neuhofer and Lusk, 2022).

Single male households receive more utility from PBMAs than married households, while receiving less utility than married households for any meat option. Being a single male or single female household rather than a married household increases the odds of PBMA selection by 100*(1-exp(0.174)) = 19% or 100*(1-exp(0.115)) = 12.2%, respectively. Households with more members have higher demand for ground meat. Additionally, college educated, employed, and high income households receive more utility from PBMAs, ground turkey, and ground chicken, and receive less utility from ground beef selections than non-college educated, not employed, and middle income households. Low income households receive less utility from ground turkey, ground chicken, and PBMA purchases than middle income households. Younger households receive more utility than middle age households from purchases of PBMAs, ground turkey, and ground chicken, while older households receive more utility from purchases of ground beef. Households with children receive less utility from ground beef and PBMAs than households without children present, and minority race households are receiving more utility from PMBAs, ground turkey, and ground chicken purchases than white households, while receiving less utility from ground beef purchases.

Given their relatively high price and low market share, it is unsurprising that PBMAs have the most elastic demand with respect to own-price changes, followed by ground chicken,

ground turkey, and ground beef (see table 5).[12] A 1% price increase in PBMAs leads to a -3.795% reduction in the quantity of PBMA demanded. The cross price elasticities show that most of the products are weak complements. The strongest complementary relationship was observed between ground turkey and ground chicken. A 1% price increase in ground turkey price corresponds to a -0.088% reduction in ground chicken quantity demanded, while a 1% price increase in ground chicken price corresponds to a -0.016% reduction in ground turkey quantity demand.

The cross-price elasticity between PBMAs and ground beef is positive, indicating the two products are price substitutes. However, the effect is small. A 1% increase in the price of PBMAs corresponds to a 0.003% increase in the quantity of ground beef demanded. A 1% increase in the price of ground beef corresponds to a 0.021% increase in the quantity of PBMA demand.

Willingness-to-pay (WTP) estimates between products show that consumers are willing to pay more for ground beef than for ground turkey, chicken, and PBMAs (see table 6)[13]. Households were willing to pay the highest price premium for a basket only containing ground beef over a basket only containing ground chicken . WTP for a basket with only ground beef is $1.44 more than for a basket only containing a PBMA . Households are willing to pay a price premium of up to $4.08 for a basket only containing a PBMA over a basket only containing ground chicken and a premium of up to $1.33 for a basket only with a PBMA over a basket with only ground turkey.

[12]Values are calculated as arc-elasticities using the expression in equation (2), evaluated at average prices, demographic, and past purchase values.

[13] Our WTP estimates are estimated using the expression in equation (2), evaluated at average prices, demographic, and past purchase values.

As shown in table 6, household WTP is super-additive, which implies the value of having two products in a basket are more than the sum of the individual product WTPs in isolation. We find positive price premiums for all potential two product baskets, the highest of which was ground turkey and chicken ($2.27), and the lowest was ground beef and PBMAs ($0.43). This implies that households were willing to pay up to an additional $0.43 more for a basket with ground beef and a PBMA rather than what would have been implied by the linear sum of the individual WTP values.

To provide insights into the welfare benefits associated with the introduction of PBMAs, we calculate the compensating variation associated with removing PBMAs from the choice set.[14] To put this value in context, we also compare it to the welfare change associated with removing ground beef, turkey, or chicken. As shown in table 7, the most welfare is lost when ground beef is removed from the choice set (-$1083.26 million/year), followed by ground turkey (-$277.26 million/year), PBMAs (-$90.27 million/year), and ground chicken (-$45.14 million/year).

Discussion and Conclusions

We determine that households demand for PBMAs was higher in the time periods preceding the last quarter of 2020. Conversely, households were more likely to select one of the ground meat products in their basket prior to the final quarter of 2020. In general, we see an increase in PMBA purchases in 2020, especially after the initial shocks of the COVID-19 pandemic.

Controlling for prior purchases provides insight into the relationships between products. Our results show evidence of habit formation, as indicated by the significant and positive coefficients of the prior purchase effects. Prior purchases of ground turkey, ground chicken, and

[14] [14] Our CV estimates are estimated using the expression in equation (2), evaluated at average prices, demographic, and past purchase values.

PBMAs decrease the utility of subsequent ground beef purchases. We also find that more prior purchases of PBMAs decrease the utility of ground turkey selections, but that more prior purchases of ground turkey increase the utility of subsequent PBMA selections. We also find positive coefficients for ground turkey and chicken and vice versa. These results build on prior studies that merely showed that consumers who purchased a meat alternative were more likely to purchase them on another occasion (Cuffey et al., 2022; Neuhofer and Lusk, 2022). These results imply that as households increase their PBMA consumption that subsequent ground beef purchases become less likely, which implies that even though PBMA purchasing households are also likely to buy ground beef, that higher volumes of PBMA purchases may in time contribute to substitution from ground beef (Cuffey et al., 2022; Neuhofer and Lusk, 2022)

Our elasticity estimates differ from other revealed preference studies, such as, Zhao et al., (2022) which found that PMBAs were a price compliment to beef, and price substitutes to chicken and turkey. One difference is that their analysis focuses on all fresh meat, whereas we focus on the ground meat market. We observe similar elasticity estimates to Tonsor et al., (2022) who also estimated weak substitution between PBMAs and beef. A key common result with revealed preference studies is that PBMAs are more elastic in own-price effects than all other meats, thus making demand highly price sensitive (Zhao et al., 2022). Price reductions in PBMAs though would have a minor effect on global emissions, and are unlikely to reduce the size of U.S. cattle herds and emissions, leading some to suggest that other mitigation strategies are needed than PBMA adoption alone (Lusk et al., 2022)

The signs of our cross-product utility estimates and elasticity estimates show some apparent inconsistencies, where we observe that ground beef and PMBAs are utility complements yet are price substitutes. This resembles some of the results in (Song &

Chintagunta, 2006), where this is attested to the fact that the cross utility estimates are dependent on one parameter rather than all the parameters in the model as are used in the elasticity estimation. This implies that at the mean utility values, increases in the price of ground beef make a household more likely to purchase PBMAs and vice versa. The cross-product utility estimates just simply show utility increases when the products are purchased together and does not consider their relationship to prices or other covariates as in the elasticity estimates.

Our results provide some insight into the reasons for the recent sales declines in PBMA markets that have occurred after the last purchases recorded in our dataset. One common culprit for the sales decline was that relative prices between ground beef and PBMAs have remained high, along with changes in tastes and preferences (Reiley, 2022). Some market evidence suggests that relative price changes are not a primary driver for lower PBMA sales in terms of units and volume, as per-pound prices of refrigerated PBMAs have declined from 2021 levels in 2022, while meat prices increased due to inflation (Reorink, 2022).

While PBMA sales have stagnated in recent months, we estimate households derive $96.73 million/year in benefit from having these options available in the grocery store. Additionally, we observe that PBMAs are preferred to ground turkey and ground chicken at a price premium from our relative WTP estimates. These results imply that even if PBMAs are more expensive than ground turkey or chicken, that households on average would prefer if price parity is reached. We also observe that ground beef is preferred to PBMAs at a price premium of about $1.44. This estimate resembles other studies that consumers were willing to pay a price premium for a beef burger over PBMAs (Caputo et al., 2022; Carlsson et al., 2021; Tonsor et al., 2022; Van Loo et al., 2020). Some of these hypothetical studies estimated higher price premiums for beef over meat alternatives (Carlsson et al., 2021; Van Loo et al., 2020), while others

estimate a price premium resembling our results with a $1-$5 difference depending on information treatments and various plant-based products (Caputo et al., 2022; Tonsor et al., 2022).

Our study is not without limitations. The market for PBMAs is relatively new and in the midst of change. Our data range from November 2018-2020, thus not allowing us to capture more recent fluctuations in this market (Reorink, 2022; Watson, 2021). Another limitation is that a majority of the products are "random weight" and we are unable to deduce true per-pound price for these products and have to rely on average prices of observed brands. Some consequences of the high number of random weight entries are the lack of heterogeneity in prices, as well as increased difficulty of accounting for quality attributes of the products.

Additionally, some differences in our results may be due to PBMA classification, we limited the PBMAs in the dataset to products resembling ground meats and burgers, while other studies were more expansive in their selection of products (Cuffey et al., 2022; Zhao et al., 2022). While both studies used more PBMAs in their analysis, our product selection considers more direct substitutes for their corresponding product of ground meat. Additionally, the focus on ground meats is due to the rise in the newer novel PBMAs that imitate ground meats.

This study confirms the consensus on the demographic characteristics of PBMA consumers that they are more likely to be younger, higher income, with children, college educated and non-white (Bryant et al., 2019; Cuffey et al., 2022; Neuhofer and Lusk, 2022; Slade, 2018; Tonsor et al., 2022b; Van Loo et al., 2020).

Several questions still remain about the current state and future opportunities for the PBMA market in consumer demand. One untouched research area is food away from home as several restaurant chains, such as Kentucky Fried Chicken, Burger King, and Del Taco have

introduced PBMA options on their menu. To our knowledge, no revealed preference studies have been conducted to examine demand for PBMA in the food away from home market. Additionally, more research is needed in the realm of alternatives to traditional meat such as cultivated meat and fermented proteins (Ron and Smith, 2022). Furthermore, more insight is needed into markets for alternatives to other animal products and meats, particularly, sausage, chicken, and milk. The positives for the PBMA market that this study provides are that households that purchase PBMAs are engaging in habit forming behavior, and that PBMAs and ground beef are price substitutes.

References

Adamowicz, W. L. (1994). Habit Formation and Variety Seeking in a Discrete Choice Model of Recreation Demand. *Journal of Agricultural and Rseource Economics*, *19*(1), 19–31.

Adamowicz, W. L., & Swait, J. D. (2013). Are food choices really habitual? Integrating habits, variety-seeking, and compensatory choice in a utility-maximizing framework. *American Journal of Agricultural Economics*, *95*(1), 17–41. https://doi.org/10.1093/ajae/aas078

Alessie, R., & Kapteyn, A. (1991). Habit Formation , Interdependent Preferences and Demographic Effects in the Almost Ideal Demand System. *The Economic Journal*, *101*(406), 404–419.

Alston, J. M., Chalfant, J. A., & Piggott, N. E. (2001). Incorporating demand shifters in the Almost Ideal demand system. *Economics Letters*, *70*(1), 73–78. https://doi.org/10.1016/S0165-1765(00)00322-0

Beyond Meat. (2021). *Beyond Meat*. https://www.beyondmeat.com/

Boto-garcía, D. (2022). *Habit Formation in Tourism Traveling*. https://doi.org/10.1177/0047287520964597

Brooks, K., & Lusk, J. L. (2010). Stated and revealed preferences for organic and cloned milk: Combining choice experiment and scanner data. *American Journal of Agricultural Economics*, *92*(4), 1229–1241. https://doi.org/10.1093/ajae/aaq054

Bryant, C., Szejda, K., Parekh, N., Desphande, V., & Tse, B. (2019). A Survey of Consumer Perceptions of Plant-Based and Clean Meat in the USA, India, and China. *Frontiers in Sustainable Food Systems*, *3*. https://doi.org/10.3389/fsufs.2019.00011

Burger King. (2021). *Impossible Whopper*. https://www.bk.com/menu/picker-95eb0a67-9e69-4849-9bc6-6715b3790e9a

Caputo, V., & Lusk, J. L. (2022). The Basket-Based choice Experiment: A method for food demand policy analysis. *Food Policy*, *109*(July 2021), 102252. https://doi.org/10.1016/j.foodpol.2022.102252

Caputo, V., Sogari, G., & Van Loo, E. J. (2022). Do plant-based and blend meat alternatives taste like meat? A combined sensory and choice experiment study. *Applied Economic Perspectives and Policy*, *November 2021*, 1–20. https://doi.org/10.1002/aepp.13247

Caracciolo, F., Furno, M., D'Amico, M., Califano, G., & Di Vita, G. (2022). Variety seeking behavior in the wine domain: A consumers segmentation using big data. *Food Quality and Preference*, *97*(November 2021), 104481. https://doi.org/10.1016/j.foodqual.2021.104481

Carlsson, F. (2012). Non-Market Valuation: Stated Preference Mehtods. In J. L. Lusk, J. Roosen, & J. F. Shogren (Eds.), *The Oxford Handbook of the Economics of Food Consumption and Policy* (Online Edi, pp. 181–214). Oxford Academic. https://academic.oup.com/edited-volume/38577/chapter/334581859

Carlsson, F., Kataria, M., & Lampi, E. (2021). *How much does it take? Willingness to switch to meat substitutes* (Vol. 2473, Issue 798). https://ideas.repec.org/p/hhs/gunwpe/0798.html

Clark, M. A., Springmann, M., Hill, J., & Tilman, D. (2019). Multiple health and environmental impacts of foods. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(46), 23357–23362. https://doi.org/10.1073/pnas.1906908116

Clark, M., & Tilman, D. (2017). Comparative analysis of environmental impacts of agricultural

production systems, agricultural input efficiency, and food choice. *Environmental Research Letters*, *12*(6). https://doi.org/10.1088/1748-9326/aa6cd5

Cox, T. L., & Wohlgenant, M. K. (1986). Prices and Quality Effects in Cross-Sectional Demand Analysis. *American Journal of Agricultural Economics*, *68*(4), 908–919. https://doi.org/10.2307/1242137

Cuffey, J., Chenarides, L., Li, W., & Zhao, S. (2022). *Consumer Spending Patterns for Plant-Based Meat Alternatives*. *July 2021*, 3. https://doi.org/10.1002/aepp.13280

Deaton, A., & Muellbauer, J. (1980). An Almost Ideal Demand System. *The American Economic Review*, *70*(3), 312–326.

Eales, J. S., & Unnevehr, L. J. (1988). Demand for Beef and Chicken Products: Separability and Structural Change. *American Journal of Agricultural Economics*, *70*(3), 521–532. https://doi.org/10.2307/1241490

Eshel, G., Shepon, A., Makov, T., & Milo, R. (2014). Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(33), 11996–12001. https://doi.org/10.1073/pnas.1402183111

Fehér, A., Gazdecki, M., Véha, M., Szakály, M., & Szakály, Z. (2020). A comprehensive review of the benefits of and the barriers to the switch to a plant-based diet. *Sustainability (Switzerland)*, *12*(10), 1–18. https://doi.org/10.3390/su12104136

Godfray, H. C. J., Aveyard, P., Garnett, T., Hall, J. W., Key, T. J., Lorimer, J., Pierrehumbert, R. T., Scarborough, P., Springmann, M., & Jebb, S. A. (2018). Meat consumption, health, and

the environment. *Science (New York, N.Y.)*, *361*(6399). https://doi.org/10.1126/science.aam5324

Heien, D., & Wessells, C. R. (1990). Demand systems estimation with microdata: A censored regression approach. *Journal of Business and Economic Statistics*, *8*(3), 365–371. https://doi.org/10.1080/07350015.1990.10509807

Heller, M. C., Willits-Smith, A., Meyer, R., Keoleian, G. A., & Rose, D. (2018). Greenhouse gas emissions and energy use associated with production of individual self-selected US diets. *Environmental Research Letters*, *13*(4). https://doi.org/10.1088/1748-9326/aab0ac

Holt, M. T., & Goodwin, B. K. (1997). Generalized habit formation in an Inverse Almost Ideal Demand System: An application to meat expenditures in the U.S. *Empirical Economics*, *22*(2), 293–320. https://doi.org/10.1007/bf01205360

Ignaszewski, E. (2023). *2023 outlook: The state of the plant-based meat category*. https://gfi.org/blog/2023-outlook-the-state-of-the-plant-based-meat-category/

Impossible Foods. (2021). *Impossible*. https://impossiblefoods.com/

Kahn, B. E. (1995). Consumer variety-seeking among goods and services. An integrative review. In *Journal of Retailing and Consumer Services* (Vol. 2, Issue 3, pp. 139–148). https://doi.org/10.1016/0969-6989(95)00038-0

Kapteyn, A., Van De Geer, S., Van De Stadt, H., & Wansbeek, T. (1997). Interdependent preferences: An econometric analysis. *Journal of Applied Econometrics*, *12*(6), 665–686. https://doi.org/10.1002/(SICI)1099-1255(199711/12)12:6<665::AID-JAE437>3.0.CO;2-U

Little, A. (2022, October 7). The Plant-Based Meat Movement Is Down But Not Out. *The*

Washington Post. https://www.washingtonpost.com/business/energy/the-plant-based-meat-movement-is-down-but-not-out/2022/10/07/3144ab8e-4634-11ed-be17-89cbe6b8c0a5_story.html

Lusk, J., Blaustein-Rejto, D., Shah, S., & Tonsor, G. T. (2022). Impact of Plant-Based Meat Alternatives on Cattle Inventories and Greenhouse Gas Emissions. *Environmental Research Letters*, *17*(2). https://doi.org/10.2139/ssrn.3961790

Mak, A. H. N., Lumbers, M., Eves, A., & Chang, R. C. Y. (2012). Factors influencing tourist food consumption. *International Journal of Hospitality Management*, *31*(3), 928–936. https://doi.org/10.1016/j.ijhm.2011.10.012

McAlister, L., & Pessemier, E. (1982). Variety Seeking Behavior: An Interdisciplinary Review. *Journal of Consumer Research*, *9*(3), 311. https://doi.org/10.1086/208926

Mcfadden, D. (1974). *Conditional Logit Analysis of Qualitative Choice Behavior*.

Neuhofer, Z. T., & Lusk, J. L. (2022). Most plant - based meat alternative buyers also buy meat : an analysis of household demographics , habit formation , and buying behavior among meat alternative buyers. *Scientific Reports*, 1–11. https://doi.org/10.1038/s41598-022-16996-5

Olen, H. (2022, November 7). Falling sales suggest plant-based meat may be all hat, no cattle. *The Washington Post*. https://www.washingtonpost.com/opinions/2022/11/07/plant-based-meat-declining-sales/

Onwezen, M. C., Bouwman, E. P., Reinders, M. J., & Dagevos, H. (2021). A systematic review on consumer acceptance of alternative proteins: Pulses, algae, insects, plant-based meat alternatives, and cultured meat. *Appetite*, *159*(December 2020), 105058.

https://doi.org/10.1016/j.appet.2020.105058

Petrin, A., & Train, K. (2010). A control function approach to endogeneity in consumer choice models. *Journal of Marketing Research*, *47*(1), 3–13. https://doi.org/10.1509/jmkr.47.1.3

Pierani, P., & Tiezzi, S. (2009). Addiction and interaction between alcohol and tobacco consumption. *Empirical Economics*, *37*(1), 1–23. https://doi.org/10.1007/s00181-008-0220-3

Pollak, R. A. (1970). *Habit Formation and Dynamic Demand Functions*. *78*(4), 745–763.

Reiley, L. (2022, November 12). Alt-meat fever has cooled. Here's why. *The Washington Post2*. https://www.washingtonpost.com/business/2022/11/12/plant-based-meat-market/

Reorink, A.-M. (2022). *Despite Flat Pricing Trends, Refrigerated Plant-Based Meat Alternatives Struggle with Growth in June 2022; Frozen Adds Sales, but Not Units*. https://www.iriworldwide.com/IRI/media/Library/IRI-Meat-Alternatives-Update-Jun-2022.pdf

Reynolds, M. (2022, August 5). Plant-Based Burgers Aren't Denting People's Beef Addiction. *Wired*. https://www.wired.com/story/plant-based-meat-replacing-animal-meat/

Richards, T. J., & Bonnet, C. (2018). New empirical models in consumer demand. In *Routledge Handbook of Agricultural Economics* (pp. 488–511). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9781315623351-27/new-empirical-models-consumer-demand-timothy-richards-celine-bonnet

Ron, A., & Smith, A. (2022). *American National Competitiveness and the Future of Meat*. https://thebreakthrough.org/articles/american-national-competitiveness-and-the-future-of-

meat

Schaeffer, K. (2019). *Among U.S. couples, women do more cooking and grocery shopping than men*. Pew Research Center.

Slade, P. (2018). If you build it, will they eat it? Consumer preferences for plant-based and cultured meat burgers. *Appetite*. https://doi.org/10.1016/j.appet.2018.02.030

Song, I., & Chintagunta, P. K. (2006). Measuring cross-category price effects with aggregate store data. *Management Science, 52*(10), 1594–1609. https://doi.org/10.1287/mnsc.1060.0563

Springmann, M., Godfray, H. C. J., Rayner, M., & Scarborough, P. (2016). Analysis and valuation of the health and climate change cobenefits of dietary change. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(15), 4146–4151. https://doi.org/10.1073/pnas.1523119113

Tiffin, R., & Arnoult, M. (2010). The demand for a healthy diet: Estimating the almost ideal demand system with infrequency of purchase. *European Review of Agricultural Economics*, *37*(4), 501–521. https://doi.org/10.1093/erae/jbq038

Tonsor, G. T., Lusk, J. L., & Schroeder, T. C. (2022). Market potential of new plant-based protein alternatives: Insights from four US consumer experiments. *Applied Economic Perspectives and Policy*, *March*, 1–18. https://doi.org/10.1002/aepp.13253

Turow-Paul, E., & Egan, S. (2022, September 2). The hype over plant-based foods overlooks a key ingredient: Plants. *The Washington Post*. https://www.washingtonpost.com/food/2022/09/02/plant-based-foods-marketing-plants/

US Census Bureau. (2022). *Quick Facts*. https://www.census.gov/quickfacts/fact/table/US/HSD410221

Valinsky, J. (2022). *KFC's new menu item tastes like chicken (but isn't)*. CNN Business2. https://www.cnn.com/2022/01/04/business/kfc-beyond-fried-chicken-launch/index.html

Van Loo, E. J., Caputo, V., & Lusk, J. L. (2020). Consumer preferences for farm-raised meat, lab-grown meat, and plant-based meat alternatives: Does information or brand matter? *Food Policy*, *95*(August 2019), 101931. https://doi.org/10.1016/j.foodpol.2020.101931

Verplanken, B. (2018). The psychology of habit: Theory, mechanisms, change, and contexts. In *The Psychology of Habit: Theory, Mechanisms, Change, and Contexts*. https://doi.org/10.1007/978-3-319-97529-0

Watson, E. (2021). IRI: US retail sales of refrigerated plant-based meat -3.1% YoY in Q3 as Beyond meat predicts slower sales. *Food Navigator*. https://www.foodnavigator-usa.com/Article/2021/10/25/IRI-US-retail-sales-of-refrigerated-plant-based-meat-3.1-YoY-as-Beyond-Meat-predicts-slower-sales-in-Q3#

Xu, M., Meng, Q., Liu, K., & Yamamoto, T. (2017). *Joint charging mode and location choice model for battery electric vehicle users*. *103*, 68–86. https://doi.org/10.1016/j.trb.2017.03.004

Yen, S. T., & Lin, B.-H. (2006). A Sample Selection Approach to Censored Demand Systems. *American Journal of Agricultural Economics*, *88*(August), 742–749. https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1467-8276.2006.00892.x

Zhao, S., Wang, L., Hu, W., & Zheng, Y. (2022). Meet the meatless: Demand for new generation

plant-based meat alternatives. *Applied Economic Perspectives and Policy*, *June 2021*, 1–18. https://doi.org/10.1002/aepp.13232

Zheng, Y., Li, Y., Satija, A., Pan, A., Sotos-Prieto, M., Rimm, E., Willett, W. C., & Hu, F. B. (2019). Association of changes in red meat consumption with total and cause specific mortality among US women and men: Two prospective cohort studies. *The BMJ*, *365*. https://doi.org/10.1136/bmj.l2110

Table 1. Products in Basket

Product	% of Times Chosen	Average Price ($/lb.)	% of Times Chosen Conditional on Buying a Product
Ground Turkey	2.58%	$3.39	22.51%
PBMA	0.88%	$6.57	7.71%
Ground Chicken	0.43%	$3.75	3.77%
Ground Beef	8.08%	$3.82	70.45%
No Buy	88.53%	----	---

Table 2. Baskets and Choice Probabilities

Basket	Ground Turkey	Ground Beef	Ground Chicken	PBMA	None	Number of Observations	Percent of Times Chosen	Percent of Times Chosen Conditional on Buying a Product
1	---	Yes	---	---	---	310,525	7.69%	67.03%
2	---	---	Yes	---	---	12,643	0.31%	2.73%
3	Yes	---	---	---	---	88,903	2.20%	19.19%
4	---	---	---	Yes	---	31,212	0.77%	6.74%
5	---	Yes	Yes	---	---	2,080	0.05%	0.45%
6	Yes	Yes	---	---	---	10,950	0.27%	2.36%
7	---	Yes	---	Yes	---	2,232	0.06%	0.48%
8	Yes	---	Yes	---	---	2,063	0.05%	0.45%
9	---	---	Yes	Yes	---	223	0.01%	0.04%
10	Yes	---	---	Yes	---	1,764	0.04%	0.38%
11	Yes	Yes	Yes	---	---	360	0.01%	0.08%
12	Yes	Yes	---	Yes	---	187	0.00%	0.04%
13	Yes	---	Yes	Yes	---	62	0.00%	0.01%
14	---	Yes	Yes	Yes	---	21	0.00%	0.00%
15	Yes	Yes	Yes	Yes	---	7	0.00%	0.00%
16	---	---	---	---	Yes	3,576,856	88.53%	

Table 3. Demographics

Characteristic	Levels	For household head (HH) or entire household (EH)	Number of households	% in Category
Age	Young (<35)		2,231	5.74%
	Middle Age (35-64)	HH	23,875	61.46%
	Old (65+)		12,741	32.80%
Household size	1		8,844	22.77%
	2		17,663	45.47%
	3	EH	5,343	13.75%
	4		4,212	10.84%
	5+		2,785	7.17%
Marital Status	Married		25,938	66.77%
	Single Female	EH	10,320	26.57%
	Single Male		2,589	6.66%
Education level	College	HH	16,204	41.71%
Employment	Employed	EH	27,799	71.56%
Household Income	Low (<$45,000)		12,195	31.39%
	Middle ($45,000-$99,999)	EH	17,749	45.69%
	High (>$100,000		8,903	22.92%
Household Race	Minority Race	HH	8,071	20.78%
Presence of Children	Children present	EH	7,776	20.02%

Table 4. MVL Estimates with Demographics, Time Fixed-Effects, Cross-Product Relationships, and Cumulative Prior Purchases of Products

Variable	Turkey	Beef	Chicken	PBMA	None
		Cross-Product Relationships			
Ground Turkey	---	0.565*	1.349*	0.643*	---
		(0.008)	(0.019)	(0.019)	
Ground Beef	0.565*	---	0.677*	0.258*	---
	(0.008)		(0.017)	(0.016)	
Ground Chicken	1.349*	0.677*	---	0.298*	---
	(0.019)	(0.017)		(0.05)	
PBMA	0.643*	0.258*	0.298*	---	---
	(0.019)	(0.016)	(0.050)		
		Base Utilities			
Constant	-3.006*	-1.385*	-4.267*	-1.269*	2.189*
	(0.118)	(0.131)	(0.139)	(0.240)	(0.010)
Price	-0.594*	-0.594*	-0.594*	-0.594*	---
	(0.033)	(0.033)	(0.033)	(0.033)	
Residuals	0.547*	0.505*	0.380*	0.601*	---
	(0.035)	(0.035)	(0.055)	(0.034)	
2018 Q4	0.936*	0.963*	0.480*	-0.297*	0.139*
	(0.023)	(0.016)	(0.053)	(0.048)	(0.009)
2019 Q1	1.081*	1.014*	0.707*	-0.128*	-0.041*
	(0.022)	(0.015)	(0.048)	(0.047)	(0.008)
2019 Q2	0.885*	0.889*	0.568*	-0.078	-0.011
	(0.022)	(0.014)	(0.048)	(0.048)	(0.008)
2019 Q3	0.755*	0.734*	0.540*	0.051	0.004
	(0.021)	(0.013)	(0.048)	(0.042)	(0.008)
2019 Q4	0.583*	0.515*	0.291*	-0.036	0.099*
	(0.021)	(0.012)	(0.048)	(0.038)	(0.009)
2020 Q1	0.630*	0.543*	0.440*	0.156*	-0.095*
	(0.021)	(0.012)	(0.046)	(0.037)	(0.008)
2020 Q2	0.473*	0.513*	0.287*	0.078*	-0.149*
	(0.020)	(0.011)	(0.047)	(0.034)	(0.008)
2020 Q3	0.084*	0.180*	0.008	0.064	-0.028*
	(0.021)	(0.011)	(0.048)	(0.034)	(0.008)
Single Female	0.040*	-0.186*	0.040	0.115*	0.219*
	(0.009)	(0.006)	(0.023)	(0.016)	(0.004)
Single Male	-0.123*	-0.252*	-0.227*	0.174*	0.275*
	(0.017)	(0.009)	(0.044)	(0.026)	(0.008)
Household Size	0.037*	0.071*	0.026*	-0.011	-0.117*
	(0.005)	(0.003)	(0.011)	(0.008)	(0.002)
College	0.135*	-0.092*	0.119*	0.257*	0.057*
	(0.007)	(0.004)	(0.017)	(0.012)	(0.003)
Employed	0.085*	-0.046*	0.135*	0.071*	-0.004
	(0.010)	(0.005)	(0.025)	(0.017)	(0.004)

High Income	0.066*	-0.013*	0.112*	0.125*	0.011*
	(0.008)	(0.005)	(0.02)	(0.014)	(0.004)
Children	0.009	-0.095*	0.011	-0.054*	0.138*
	(0.012)	(0.007)	(0.027)	(0.02)	(0.006)
Low Income	-0.115*	-0.007	-0.152*	-0.113*	0.042*
	(0.009)	(0.005)	(0.021)	(0.015)	(0.004)
Young	0.101*	-0.142*	0.131*	0.159*	0.067*
	(0.013)	(0.009)	(0.031)	(0.022)	(0.007)
Old	-0.078*	0.050*	-0.221*	-0.157*	-0.013*
	(0.009)	(0.005)	(0.023)	(0.016)	(0.004)
Non-White	0.177*	-0.146*	0.131*	0.062*	0.110*
	(0.008)	(0.005)	(0.019)	(0.014)	(0.004)
		Prior Purchase Effects			
Cumulative Prior Ground Turkey Purchases	16.442*	-1.946*	1.572*	1.535*	---
	(0.049)	(0.063)	(0.134)	(0.115)	
Cumulative Prior Ground Beef Purchases	-2.053*	10.878*	-0.055	-4.457*	---
	(0.072)	(0.027)	(0.144)	(0.147)	
Cumulative Prior Ground Chicken Purchases	1.017*	-0.733*	24.853*	-0.110	---
	(0.165)	(0.159)	(0.155)	(0.352)	
Cumulative Prior PBMA Purchases	-0.961*	-4.410*	0.153	21.881*	---
	(0.166)	(0.155)	(0.374)	(0.095)	
Log-Likelihood				-6,271,689	
AIC				6,271,943	

A * denotes significance at the 5% level . Base utility estimates are relative to 2020 Q4, married, not college educated, not employed, middle income, without children, middle age, and white.

Table 5. Elasticity Estimates

Quantity of/Price Change	Ground Turkey	Ground Beef	Ground Chicken	PBMA
Ground Turkey	-1.942*[a] (0.107) [-2.147, -1.728]	-0.037* (0.003) [-0.048, -0.034]	-0.016* (0.001) [-0.019, -0.015]	-0.011* (0.001) [-0.014, - 0.010]
Ground Beef	-0.010 (0.001) [-0.012, -0.008]	-2.031* (0.113) [-2.248, -1.809]	-0.003* (0.000) [-0.004, -0.003]	0.003* (0.001) (0.002, 0.004]
Ground Chicken	-0.088* (0.006) [-0.100, -0.078]	-0.073* (0.006) [-0.089, -0.064]	-2.193* (0.121) [-2.425, -1.952]	-0.000 (0.002) [-0.004, 0.002]
PBMA	-0.017* (0.002) [-0.022, -0.015]	0.021* (0.004) [0.011, 0.025]	0.000 (0.000) [-0.001, 0.001]	-3.795* (0.208) [-4.193, -3.381]
No Purchase	0.053* (0.003) [0.046, 0.058]	0.217* (0.012) [0.189, 0.236]	0.010* (0.001) [0.009, 0.011]	0.033* (0.002) [0.029, 0.036]

[a] * denotes significance at the 5% level.

Table 6. Relative Willingness to Pay Estimates Between Products and Willingness to Pay for Additional Product in Basket

Product A	Product B	WTP for A over B	Change in WTP when both A and B are jointly in the basket
Turkey	Beef	-$2.769*[a] (0.133) [-3.059, -2.544]	$0.951* (0.056) [0.855, 1.077]
Turkey	Chicken	$2.749* (0.178) [2.448, 3.164]	$2.271* (0.133) [2.051, 2.584]
Turkey	PBMA	-$1.333* (0.104) [-1.506, -1.098]	$1.082* (0.070) [0.964, 1.238]
Beef	Chicken	$5.519* (0.310) [4.999, 6.206]	$1.140* (0.070) [1.017, 1.286]
Beef	PBMA	$1.436* (0.237) [1.035, 1.962]	$0.434* (0.037) [0.367, 0.516]
Chicken	PBMA	-$4.082* (0.076) [-4.252, -3.954]	$0.502* (0.086) [0.332, 0.677]

[a]* represents significance at the 5% level, the value in () is the standard error estimates and the [ ] values represent a 95% confidence interval.

Table 7. Welfare Effects Associated with the Removal of a Retail Grocery Choice Option for U.S. Population

Option Removed	**Welfare Loss (Million $ per year)**
Ground Turkey	-277.26 [-322.40, -257.92]
Ground Beef	-1083.26 [-1225.12, -973.65]
Ground Chicken	-45.14 [-51.58,-43.20]
Ground PBMA	-90.27 [-103.17, -83.82]

[a] numbers in brackets [ ] values represent a 95% confidence interval. To estimate the value of the products for the population we multiply the individual estimates by 52 weeks in a year and the number of households in the U.S. population (124 million)(US Census Bureau, 2022).

Appendix Table 1. Expanded Basket Product List

Type	Form	Store Location	Product Number	Share
Turkey	Random Weight	N/A	1	0.30%
	General Ground	Refrigerated	2	1.88%
	General Ground	Frozen	3	0.19%
	Burger	Refrigerated	4	0.07%
	Burger	Frozen	5	0.20%
PBMA	General Ground	Refrigerated	6	0.04%
	General Ground	Frozen	7	0.06%
	Burger	Refrigerated	8	0.18%
	Burger	Frozen	9	0.64%
Chicken	Random Weight	N/A	10	0.12%
	General Ground	Refrigerated	11	0.31%
	Burger	Refrigerated	12	0.00%
	Burger	Frozen	13	0.00%
Beef	Random Weight	N/A	14	7.08%
	General Ground	Refrigerated	15	0.00%
	General Ground	Frozen	16	0.10%
	Burger	Frozen	17	1.00%
	None	---	---	88.53%

Appendix Table 2. Expanded Basket Model

Utility/Product	1	2	3	4	5	6	7	8	9
Constant	-4.357* (0.031)	-2.353* (0.031)	-5.492* (0.02)	-5.357* (0.043)	-4.779* (0.032)	-5.109* (0.054)	-5.394* (0.047)	-1.655* (0.089)	-2.314* (0.052)
1	0	0.916* (0.03)	0.188 (0.129)	0.979* (0.126)	1.19* (0.075)	-0.402 (0.345)	0.253 (0.223)	0.581* (0.109)	0.742* (0.055)
2	0.916* (0.03)	0	0.6* (0.043)	2.276* (0.035)	1.741* (0.026)	0.271* (0.099)	0.255* (0.088)	0.777* (0.041)	0.699* (0.023)
3	0.188 (0.129)	0.6* (0.043)	0	-0.714 (0.382)	2.04* (0.063)	0.636* (0.296)	-0.136 (0.355)	-0.221 (0.206)	0.225* (0.088)
4	0.979* (0.126)	2.276* (0.035)	-0.714 (0.382)	0	0.637* (0.155)	-0.046 (0.498)	-0.106 (0.482)	1.122* (0.159)	0.753* (0.1)
5	1.19* (0.075)	1.741* (0.026)	2.04* (0.063)	0.637* (0.155)	0	1.123* (0.196)	-0.009 (0.253)	0.512* (0.123)	1.455* (0.046)
6	-0.402 (0.345)	0.271* (0.099)	0.636* (0.296)	-0.046 (0.498)	1.123* (0.196)	0	1.524* (0.149)	4.921* (0.046)	1.825* (0.068)
7	0.253 (0.223)	0.255* (0.088)	-0.136 (0.355)	-0.106 (0.482)	-0.009 (0.253)	1.524* (0.149)	0	2.588* (0.072)	3.27* (0.041)
8	0.581* (0.109)	0.777* (0.041)	-0.221 (0.206)	1.122* (0.159)	0.512* (0.123)	4.921* (0.046)	2.588* (0.072)	0	2.167* (0.035)
9	0.742* (0.055)	0.699* (0.023)	0.225* (0.088)	0.753* (0.1)	1.455* (0.046)	1.825* (0.068)	3.27* (0.041)	2.167* (0.035)	0
10	2.659* (0.047)	0.876* (0.046)	0.022 (0.224)	0.991* (0.184)	0.331 (0.17)	0.343 (0.374)	-0.771 (0.608)	0.912* (0.148)	0.174 (0.111)
11	0.448* (0.081)	1.966* (0.019)	1.438* (0.068)	2.166* (0.064)	1.187* (0.064)	0.527* (0.226)	-0.748* (0.345)	0.129 (0.126)	0.787* (0.051)
12	0.956* (0.469)	0.959* (0.183)	-0.179 (1.035)	2.558* (0.298)	0.078 (0.747)	-0.029 (2.209)	-0.044 (1.921)	0.194 (0.978)	0.889* (0.355)
13	-0.144 (1.165)	4.229* (0.176)	-0.065 (1.765)	-0.069 (1.495)	-0.13 (1.183)	-0.023 (2.654)	-0.015 (3.01)	0.282 (1.404)	0.413 (0.725)
14	0.967* (0.017)	0.133* (0.01)	-0.085* (0.033)	0.119* (0.047)	-0.16* (0.033)	-0.128 (0.073)	-0.726* (0.081)	-0.194* (0.036)	-0.299* (0.02)
15	1.507* (0.353)	0.942* (0.184)	0.128 (0.85)	0.59 (0.927)	0.41 (0.668)	-0.053 (1.71)	-0.063 (1.643)	0.799 (0.634)	0.2 (0.433)
16	0.666* (0.147)	0.236* (0.07)	3.516* (0.047)	-0.846 (0.598)	0.104 (0.179)	-0.492 (0.714)	-0.635 (0.651)	-0.708 (0.383)	-0.309* (0.157)
17	0.059 (0.06)	0.429* (0.021)	1.033* (0.046)	0.081 (0.119)	1.741* (0.034)	-0.412* (0.208)	0.451* (0.115)	0.157* (0.076)	0.47* (0.035)
Price	-0.473*	-0.473*	-0.473*	-0.473*	-0.473*	-0.473*	-0.473*	-0.473*	-0.473*

	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Residuals	0.362*	0.418*	0.602*	0.441*	0.331*	0.492*	0.478*	0.476*	0.47*
	(0.147)	(0.024)	(0.124)	(0.061)	(0.071)	(0.03)	(0.094)	(0.022)	(0.024)
		Log-Likelihood					-7,351,768		
		AIC					7,352,112		

A * denotes significance at the 5% level.

Appendix Table 2 Continued. Expanded Basket Model

Utility/Product	10	11	12	13	14	15	16	17	None
Constant	-5.159* (0.036)	-4.186* (0.034)	-8.437* (0.085)	-9.03* (0.174)	-0.765* (0.034)	-7.179* (0.073)	-5.459* (0.033)	-2.812* (0.035)	2.044* (0.002)
1	2.659* (0.047)	0.448* (0.081)	0.956* (0.469)	-0.144 (1.165)	0.967* (0.017)	1.507* (0.353)	0.666* (0.147)	0.059 (0.06)	---
2	0.876* (0.046)	1.966* (0.019)	0.959* (0.183)	4.229* (0.176)	0.133* (0.01)	0.942* (0.184)	0.236* (0.07)	0.429* (0.021)	---
3	0.022 (0.224)	1.438* (0.068)	-0.179 (1.035)	-0.065 (1.765)	-0.085* (0.033)	0.128 (0.85)	3.516* (0.047)	1.033* (0.046)	---
4	0.991* (0.184)	2.166* (0.064)	2.558* (0.298)	-0.069 (1.495)	0.119* (0.047)	0.59 (0.927)	-0.846 (0.598)	0.081 (0.119)	---
5	0.331 (0.17)	1.187* (0.064)	0.078 (0.747)	-0.13 (1.183)	-0.16* (0.033)	0.41 (0.668)	0.104 (0.179)	1.741* (0.034)	---
6	0.343 (0.374)	0.527* (0.226)	-0.029 (2.209)	-0.023 (2.654)	-0.128 (0.073)	-0.053 (1.71)	-0.492 (0.714)	-0.412* (0.208)	---
7	-0.771 (0.608)	-0.748* (0.345)	-0.044 (1.921)	-0.015 (3.01)	-0.726* (0.081)	-0.063 (1.643)	-0.635 (0.651)	0.451* (0.115)	---
8	0.912* (0.148)	0.129 (0.126)	0.194 (0.978)	0.282 (1.404)	-0.194* (0.036)	0.799 (0.634)	-0.708 (0.383)	0.157* (0.076)	---
9	0.174 (0.111)	0.787* (0.051)	0.889* (0.355)	0.413 (0.725)	-0.299* (0.02)	0.2 (0.433)	-0.309* (0.157)	0.47* (0.035)	---
10	0	1.395* (0.083)	0.501 (0.744)	-0.054 (1.763)	1.16* (0.025)	-0.145 (1.134)	-0.422 (0.388)	0.046 (0.094)	---
11	1.395* (0.083)	0	3.752* (0.147)	-0.24 (0.886)	0.263* (0.022)	1.41* (0.339)	0.919* (0.115)	0.473* (0.048)	---
12	0.501 (0.744)	3.752* (0.147)	0	0.007 (7.752)	0.492* (0.154)	0.001 (4.318)	-0.083 (1.47)	1.274* (0.254)	---
13	-0.054 (1.763)	-0.24 (0.886)	0.007 (7.752)	0	1.102* (0.218)	0.006 (7.59)	-0.025 (2.733)	-0.348 (0.885)	---
14	1.16* (0.025)	0.263* (0.022)	0.492* (0.154)	1.102* (0.218)	0	-1.223* (0.272)	-0.498* (0.053)	0.419* (0.012)	---
15	-0.145 (1.134)	1.41* (0.339)	0.001 (4.318)	0.006 (7.59)	-1.223* (0.272)	0	-0.116 (1.275)	0.179 (0.368)	---
16	-0.422 (0.388)	0.919* (0.115)	-0.083 (1.47)	-0.025 (2.733)	-0.498* (0.053)	-0.116 (1.275)	0	1.862* (0.045)	---
17	0.046	0.473*	1.274*	-0.348	0.419*	0.179	1.862*	0	---

	(0.094)	(0.048)	(0.254)	(0.885)	(0.012)	(0.368)	(0.045)		
Price	-0.473*	-0.473*	-0.473*	-0.473*	-0.473*	-0.473*	-0.473*	-0.473*	---
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	
Residuals	0.601*	0.49*	0.534*	0.508	0.476*	0.475*	0.292	0.482*	---
	(0.12)	(0.067)	(0.117)	(0.323)	(0.026)	(0.047)	(0.176)	(0.034)	
Log-Likelihood							-7,351,768		
AIC							7,352,112		

A * denotes significance at the 5% level.

Appendix Table 3. MVL with No Habit or Variety Seeking Effects

Variable	Turkey	Beef	Chicken	PBMA	None
		Cross Product Relationships			
Ground Turkey	0	0.351* (0.007)	1.747* (0.016)	0.763* (0.016)	---
Ground Beef	0.351* (0.007)	0	0.603* (0.016)	-0.16* (0.015)	---
Ground Chicken	1.747* (0.016)	0.603* (0.016)	0	0.532* (0.041)	---
PBMA	0.763* (0.016)	-0.16* (0.015)	0.532* (0.041)	0	---
		Base Utilities			
Constant	-2.94* (0.125)	-1.169* (0.141)	-4.493* (0.145)	-2.348* (0.257)	2.189* (0.01)
Price	-0.342* (0.035)	-0.342* (0.035)	-0.342* (0.035)	-0.342* (0.035)	---
Residuals	0.277* (0.039)	0.281* (0.037)	0.216* (0.071)	0.337* (0.039)	---
2018 Q4	-0.12* (0.02)	-0.197* (0.015)	-0.28* (0.046)	-0.859* (0.046)	0.139* (0.009)
2019 Q1	0.077* (0.018)	-0.049* (0.014)	-0.03 (0.04)	-0.671* (0.045)	-0.041* (0.008)
2019 Q2	-0.026 (0.018)	-0.049* (0.013)	-0.111* (0.041)	-0.583* (0.045)	-0.011 (0.008)
2019 Q3	-0.047* (0.018)	-0.062* (0.012)	-0.069 (0.041)	-0.433* (0.04)	0.005 (0.008)
2019 Q4	-0.078* (0.018)	-0.136* (0.011)	-0.184* (0.041)	-0.472* (0.034)	0.099* (0.009)
2020 Q1	0.102* (0.017)	0.04* (0.011)	0.046 (0.04)	-0.184* (0.034)	-0.094* (0.008)
2020 Q2	0.119* (0.017)	0.166* (0.01)	0.035 (0.04)	-0.158* (0.029)	-0.149* (0.008)
2020 Q3	-0.028 (0.017)	0.04* (0.01)	-0.055 (0.041)	-0.029 (0.03)	-0.028* (0.008)
Single Female	0.009 (0.009)	-0.323* (0.005)	-0.017 (0.022)	0.109* (0.015)	0.218* (0.004)
Single Male	-0.116* (0.016)	-0.396* (0.009)	-0.21* (0.04)	0.441* (0.023)	0.275* (0.008)
Household Size	0.066* (0.004)	0.151* (0.003)	0 (0.011)	-0.012 (0.008)	-0.117* (0.002)
College	0.197* (0.007)	-0.191* (0.004)	0.105* (0.016)	0.311* (0.012)	0.057* (0.003)
Employed	0.16* (0.01)	-0.067* (0.005)	0.27* (0.024)	0.156* (0.016)	-0.004 (0.004)

High Income	0.1*	-0.054*	0.039*	0.076*	0.011*
	(0.008)	(0.005)	(0.019)	(0.013)	(0.004)
Low Income	-0.143*	0.006	-0.163*	-0.155*	0.042*
	(0.008)	(0.005)	(0.02)	(0.014)	(0.004)
Children	0.056*	-0.217*	0.042	-0.081*	0.138*
	(0.011)	(0.007)	(0.026)	(0.019)	(0.006)
Young	0.195*	-0.217*	0.149*	0.229*	0.067*
	(0.012)	(0.009)	(0.029)	(0.021)	(0.007)
Old	-0.109*	0.082*	-0.249*	-0.208*	-0.013*
	(0.009)	(0.005)	(0.022)	(0.015)	(0.004)
Non-white	0.228*	-0.285*	0.237*	0.073*	0.11*
	(0.007)	(0.005)	(0.018)	(0.013)	(0.004)
Log-Likelihood			-6,674,105		
AIC			6,674,327		

A * denotes significance at the 5% level. The values are relative to 2020 Q4, married, not college educated, not employed, middle income, without children, middle age, and white.

Appendix Table 4. MVL Estimates with Demographics, Time Fixed-Effects, Cross-Product Relationships, and Cumulative Own-Product Prior Purchases with No Cross Product Habit Effects

Variable	Turkey	Beef	Chicken	PBMA	None
Cross-Product Relationships					
Ground Turkey	0	0.453* (0.008)	1.436* (0.018)	0.703* (0.018)	---
Ground Beef	0.453* (0.008)	0	0.635* (0.016)	0.046* (0.015)	---
Ground Chicken	1.436* (0.018)	0.634* (0.016)	0	0.328* (0.047)	---
PBMA	0.703* (0.018)	0.046* (0.015)	0.328* (0.047)	0	---
Base Utilities					
Constant	-3.063* (0.118)	-1.353* (0.131)	-4.156* (0.139)	-1.303* (0.241)	2.188* (0.01)
Price	-0.618* (0.033)	-0.618* (0.033)	-0.618* (0.033)	-0.618* (0.033)	---
Residuals	0.572* (0.035)	0.529* (0.035)	0.461* (0.055)	0.626* (0.034)	---
2018 Q4	1.080* (0.023)	1.029* (0.016)	0.457* (0.052)	-0.115* (0.048)	0.140* (0.009)
2019 Q1	1.208* (0.021)	1.073* (0.015)	0.696* (0.047)	0.024 (0.046)	-0.040* (0.008)
2019 Q2	0.989* (0.021)	0.937* (0.014)	0.567* (0.047)	0.040 (0.047)	-0.010 (0.008)
2019 Q3	0.839* (0.021)	0.773* (0.013)	0.539* (0.047)	0.140* (0.042)	0.005 (0.008)
2019 Q4	0.650* (0.021)	0.545* (0.012)	0.311* (0.048)	0.031 (0.037)	0.099* (0.009)
2020 Q1	0.679* (0.020)	0.565* (0.012)	0.459* (0.047)	0.203* (0.037)	-0.094* (0.008)
2020 Q2	0.504* (0.020)	0.527* (0.011)	0.319* (0.047)	0.105* (0.034)	-0.148* (0.008)
2020 Q3	0.094* (0.021)	0.184* (0.011)	0.045 (0.048)	0.063* (0.034)	-0.028* (0.008)
Single Female	0.052* (0.009)	-0.187* (0.006)	0.031 (0.023)	0.143* (0.016)	0.218* (0.004)
Single Male	-0.110* (0.017)	-0.254* (0.009)	-0.271* (0.044)	0.215* (0.026)	0.275* (0.008)
Household Size	0.028* (0.005)	0.068* (0.003)	0.026* (0.011)	-0.031* (0.008)	-0.117* (0.002)
College	0.144* (0.007)	-0.098* (0.004)	0.120* (0.017)	0.278* (0.012)	0.057* (0.003)
Employed	0.087*	-0.050*	0.130*	0.082*	-0.004

	(0.010)	(0.005)	(0.025)	(0.017)	(0.004)
High Income	0.070*	-0.016*	0.139*	0.139*	0.011*
	(0.008)	(0.005)	(0.020)	(0.014)	(0.004)
Children	0.023	-0.095*	0.010	-0.022	0.138*
	(0.011)	(0.007)	(0.027)	(0.020)	(0.006)
Low Income	-0.112*	-0.002	-0.155*	-0.116*	0.042*
	(0.009)	(0.005)	(0.021)	(0.015)	(0.004)
Young	0.107*	-0.150*	0.166*	0.185*	0.067*
	(0.013)	(0.009)	(0.031)	(0.022)	(0.007)
Old	-0.079*	0.054*	-0.224*	-0.164*	-0.013*
	(0.009)	(0.005)	(0.023)	(0.016)	(0.004)
Non-White	0.194*	-0.15*	0.131*	0.100*	0.110*
	(0.008)	(0.005)	(0.019)	(0.014)	(0.004)
	Prior Purchase Effects				
Prior Own-Product Purchases	16.532*	10.931*	25.191*	22.450*	---
	(0.048)	(0.027)	(0.152)	(0.094)	
Log-Likelihood				-6,276,122	
AIC				6,276,352	

A * denotes significance at the 5% level. The values are relative to 2020 Q4, married, not college educated, not employed, middle income, without children, middle age, and white.

Appendix Table 5. MVL Estimates with Demographics, Time Fixed-Effects, Cross-Product Relationships, and Prior Three Period Lag

Utility/Product	Turkey	Beef	Chicken	PBMA	None
		Cross Product Relationships			
Ground Turkey	0	0.512* (0.008)	1.299* (0.018)	0.657* (0.018)	---
Ground Beef	0.512* (0.008)	0	0.659* (0.016)	0.12* (0.015)	---
Ground Chicken	1.299* (0.018)	0.659* (0.016)	0	0.379* (0.044)	---
PBMA	0.657* (0.018)	0.12* (0.015)	0.379* (0.044)	0	---
		Base Utilities			
Constant	-3.388* (0.113)	-1.665* (0.127)	-4.954* (0.132)	-3.104* (0.231)	2.189* (0.01)
Price	-0.287* (0.032)	-0.287* (0.032)	-0.287* (0.032)	-0.287* (0.032)	---
Residuals	0.232* (0.034)	0.216* (0.033)	0.278* (0.052)	0.267* (0.033)	---
2018 Q4	-0.125* (0.02)	-0.182* (0.014)	-0.217* (0.047)	-0.715* (0.044)	0.139* (0.009)
2019 Q1	0.048* (0.018)	-0.046* (0.014)	-0.009 0.041)	-0.505* (0.043)	-0.041* (0.008)
2019 Q2	-0.034 (0.018)	-0.052* (0.013)	-0.072 (0.042)	-0.44* (0.043)	-0.011 (0.008)
2019 Q3	-0.045* (0.018)	-0.071* (0.012)	-0.048 (0.042)	-0.351* (0.038)	0.005 (0.008)
2019 Q4	-0.088* (0.018)	-0.128* (0.011)	-0.138* (0.042)	-0.366* (0.033)	0.099* (0.009)
2020 Q1	0.079* (0.018)	0.043* (0.011)	0.062 (0.041)	-0.144* (0.033)	-0.094* (0.008)
2020 Q2	0.069* (0.017)	0.113* (0.01)	0.013 (0.041)	-0.103* (0.03)	-0.149* (0.008)
2020 Q3	-0.034 (0.018)	0.022* (0.01)	-0.029 (0.041)	-0.049 (0.03)	-0.028* (0.008)
Single Female	-0.004 (0.009)	-0.256* (0.005)	0 (0.022)	0.068* (0.015)	0.218* (0.004)
Single Male	-0.096* (0.017)	-0.311* (0.009)	-0.174* (0.041)	0.324* (0.024)	0.276* (0.008)
Household Size	0.055* (0.004)	0.124* (0.003)	-0.005 (0.011)	0.009 (0.008)	-0.117* (0.002)
College	0.133* (0.007)	-0.151* (0.004)	0.072* (0.017)	0.205* (0.012)	0.057* (0.003)
Employed	0.12* (0.01)	-0.051* (0.005)	0.212* (0.024)	0.114* (0.016)	-0.004 (0.004)

High Income	0.071* (0.008)	-0.04* (0.005)	0.021 (0.019)	0.042* (0.014)	0.011* (0.004)
Children	0.028* (0.011)	-0.173* (0.007)	0.038 (0.026)	-0.084* (0.02)	0.138* (0.006)
Low Income	-0.103* (0.008)	0.002 (0.005)	-0.126* (0.02)	-0.116* (0.014)	0.042* (0.004)
Young	0.13* (0.013)	-0.169* (0.009)	0.07* (0.03)	0.149* (0.021)	0.066* (0.007)
Old	-0.077* (0.009)	0.059* (0.005)	-0.194* (0.022)	-0.15* (0.015)	-0.013* (0.004)
Prior Purchase Effects					
Non-white	0.145* (0.008)	-0.225* (0.005)	0.18* (0.018)	0.035* (0.013)	0.11* (0.004)
Prior Ground Turkey Purchases over last 3 weeks	2.305* (0.007)	-0.295* (0.008)	0.423* (0.022)	0.027 (0.02)	---
Prior Ground Beef Purchases over last 3 weeks	-0.324* (0.009)	1.081* (0.004)	-0.144* (0.02)	-0.55* (0.017)	---
Prior Ground Chicken Purchases over last 3 weeks	0.377* (0.019)	-0.067* (0.017)	3.428* (0.018)	0.057 (0.045)	---
Prior PBMA Purchases over last 3 weeks	0.053* (0.019)	-0.5* (0.016)	0.256* (0.042)	3.306* (0.012)	---

A * denotes significance at the 5% level. The values are relative to 2020 Q4, married, not college educated, not employed, middle income, without children, middle age, and white.

Appendix Table 6. Elasticities from Appendix Table 3 and Appendix Table 4

Appendix Table 3				
Ground Turkey	-1.119*	-0.021*	-0.021*	-0.017*
	(0.203)	(0.004)	(0.003)	(0.003)
Ground Beef	-0.006*	-1.181*	-0.003*	0.005*
	(0.001)	(0.214)	(0.001)	(0.001)
Ground Chicken	-0.114*	-0.061*	-1.267*	-0.013*
	(0.019)	(0.010)	(0.229)	(0.003)
PBMA	-0.026*	0.029*	-0.004*	-2.199*
	(0.004)	(0.004)	(0.001)	(0.396)
No Purchase	0.033*	0.117*	0.006*	0.021*
	(0.006)	(0.021)	(0.001)	(0.003)
Appendix Table 4				
Ground Turkey	-2.021*	-0.022*	-0.020*	-0.015*
	(0.103)	(0.002)	(0.000)	(0.001)
Ground Beef	-0.005*	-2.119*	-0.003*	0.008*
	(0.000)	(0.109)	(0.000)	(0.000)
Ground Chicken	-0.104*	-0.072*	-2.281*	-0.002*
	(0.001)	(0.001)	(0.116)	(0.002)
PBMA	-0.024*	0.051*	-0.001*	-3.945*
	(0.002)	(0.000)	(0.000)	(0.200)
No Purchase	0.054*	0.219*	0.010*	0.035*
	(0.003)	(0.011)	(0.001)	(0.001)

A * denotes significance at the 5% level.

Appendix Table 7: First stage regressions of price determinants

Variables/Dependent Variable	Ground Turkey Price	Ground Beef Price	Ground Chicken Price	PBMA Price
Intercept	2.375* (0.006)	4.246* (0.005)	3.704* (0.004)	3.806* (0.011)
Wholesale Prices Lagged Two Weeks				
Primal Chuck	-0.043* (0.000)	0.006* (0.000)	-0.001* (0.000)	0.171* (0.001)
Soybean Meal	3.176* (0.018)	-2.748* (0.015)	2.237* (0.011)	5.643* (0.036)
Turkey Hens	0.505* (0.004)	0.097* (0.003)	-0.297* (0.002)	2.178* (0.006)
Chicken Breast	0.015* (0.001)	0.105* (0.001)	0.065* (0.001)	-0.417* (0.002)
Time Period Fixed Effects				
2018 Q4	0.102* (0.001)	-0.207* (0.001)	-0.174* (0.001)	-0.203* (0.003)
2019 Q1	0.108* (0.001)	-0.290* (0.001)	-0.187* (0.001)	-0.223* (0.003)
2019 Q2	0.082* (0.001)	-0.354* (0.001)	-0.187* (0.001)	-0.044* (0.002)
2019 Q3	0.069* (0.001)	-0.388* (0.001)	-0.066* (0.001)	-0.002 (0.002)
2019 Q4	0.141* (0.001)	-0.279* (0.001)	-0.142* (0.001)	0.080* (0.002)
2020 Q1	0.167* (0.001)	-0.173* (0.001)	-0.035* (0.001)	0.005* (0.002)
2020 Q2	0.214* (0.001)	-0.120* (0.001)	0.044* (0.001)	0.043* (0.002)
2020 Q3	0.089* (0.001)	-0.061* (0.001)	0.070* (0.001)	-0.100* (0.001)
Base Demographics				
Single Female	-0.00002 (0.00070)	-0.000003 (0.00010)	0.000003 (0.00014)	-0.00001 (0.00029)
Single Male	0.00001 (0.00011)	0.00001 (0.00017)	0.00001 (0.00022)	-0.00003 (0.00047)
Household Size	0.00001 (0.00004)	0.00001 (0.00005)	0.000002 (0.00013)	-0.00003 (0.00015)

College	0.00001 (0.00005)	0.00001 (0.00008)	-0.00001 (0.00011)	0.00002 (0.00023)
Employed	-0.000003 (0.00007)	-0.00001 (0.00010)	-0.00001 (0.00013)	-0.00002 (0.00029)
High Income	-0.00002 (0.00007)	-0.00001 (0.00010)	-0.000004 (0.00013)	0.00001 (0.00027)
Children	-0.00001 (0.00009)	-0.000005 (0.00014)	0.00001 (0.00018)	0.00002 (0.00038)
Low Income	0.000004 (0.00006)	0.00001 (0.00002)	-0.00001 (0.00012)	-0.00006 (0.00026)
Young	0.00002 (0.00011)	0.00002 (0.00016)	-0.00001 (0.00021)	0.00004 (0.00045)
Old	-0.00001 (0.00007)	0.00001 (0.00010)	-0.00001 (0.00013)	-0.00003 (0.00027)
Non-White	0.00001 (0.00006)	-0.00002 (0.00010)	-0.000002 (0.00012)	0.00001 (0.00026)
Non-Imputed Price Observations and Demographic Interactions				
Non-Imputed Price Observation (NP)	0.105* (0.017)	0.107* (0.025)	0.143* (0.043)	-0.175* (0.066)
NP * Single Female	0.104* (0.010)	0.089* (0.017)	0.117* (0.025)	0.108* (0.037)
NP * Single Male	-0.002 (0.018)	0.076* (0.029)	0.037 (0.046)	0.101 (0.058)
NP * Household Size	-0.090* (0.005)	-0.071* (0.007)	-0.104* (0.012)	-0.001 (0.018)
NP * College	0.043* (0.008)	0.051* (0.012)	0.063* (0.019)	0.013 (0.029)
NP * Employed	0.059* (0.011)	0.073* (0.016)	0.013 (0.029)	0.201* (0.039)
NP * High Income	0.251* (0.009)	0.237* (0.015)	0.232* (0.023)	0.173* (0.034)
NP * Children	0.066* (0.011)	-0.032 (0.018)	0.128* (0.03)	-0.179* (0.045)
NP * Low Income	-0.209* (0.009)	-0.187* (0.014)	-0.186* (0.021)	-0.240* (0.033)
NP * Young	0.050* (0.013)	-0.079* (0.024)	0.032 (0.032)	0.100 (0.052)
NP * Old	0.093* (0.01)	0.095* (0.015)	0.145* (0.026)	-0.115* (0.037)
NP * Non-White	-0.132* (0.008)	-0.093* (0.014)	-0.163* (0.019)	0.25* (0.033)

A * denotes significance at the 5% level.