Economic and Nutritional Effects of a Meat Tax: Results from a Basket-Based Choice Experiment

Working Paper

Alison Grant[1], Jayson Lusk[2], and Vincenzina Caputo[3]

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Abstract: A tax on consumer meat products is a policy instrument being considered by many state and national governments. Utilizing data from a basket-based choice experiment, which captures consumer substitution and complementary patterns within and outside of meat categories, a forecast of the economic and nutritional effects of this policy are constructed. Economic effects of a meat tax are consistent with theory – a greater negative effect accrues to lower income households than to higher income households. A meat tax enables an environment of decreased protein availability for low income households with an increase in total purchased carbohydrates. These results have implications for poverty intensification or an expanded poverty gap.

Keywords: Meat tax, consumer, food, income, poverty, basket-based choice experiment, multiple discrete choices

[1]Ph.D. Candidate, Department of Agricultural Economics, Purdue University
[2]Distinguished Professor and Head, Department of Agricultural Economics, Purdue University
[3]Assistant Professor, Department of Agricultural, Food, and Resource Economics, Michigan State University

"Scientists and world leaders increasingly agree that climate change is the biggest challenge that humanity faces, and the meat industry is one of the leading causes of it (PETA 2019)." People for the Ethical Treatment of Animals (PETA) is calling for an excise tax on retail meat products due to the environmental, health, and animal welfare impacts of animal production and consumption. Demands to tax meat – and in particular, beef – to fight climate change is gaining popularity in recent headlines. The New York Times (Coniff, 2018), Scientific American (de Witt, 2016; Heikkinen, 2016), The Guardian (Baggini, 2019; Carrington, 2018), and other popular news sources feature articles that make the case for a carbon tax on meat.

Modern food movement trends include discussion of not only what humans are putting into their bodies, but the environmental and health impacts that arise due to the production of the food they eat. The production side of the food system is becoming equally as important as consumption in individual food choice. Further, vegetarianism and meat replacements have been increasing in popularity. Beyond Meat, a company that sells plant-based meat substitutes to replace chicken meat, beef, and pork sausage, has grown rapidly in value, as sales revenue almost tripled over 2018 (Market Watch, 2018). Increasing alternative meat and protein consumption may be attributed to a host of reasons—one reason being reducing individual environmental impacts.

Measurement and discussion of the impacts of meat production are also present in the economic, health, nutrition, and animal science literature. Torneke, 2014; Sall and Gren, 2012; and Wirsenius et al, 2010 discuss the economic effects of a beef tax to producers. Springmann et al (2018) and Nordgren (2012) make the case for a climate tax on meat to reduce total meat consumption worldwide. All studies note that there is an environmental externality involved – health risks of meat overconsumption and environmental effects from livestock emissions.

These trends and relevant literature are cited in the U.S. Department of Agriculture (USDA) Scientific Report of the 2015 Dietary Guidelines Advisory Committee (USDA, 2015). Within this report, it was encouraged for the U.S. population to consume less red and processed meat to have a healthier and more sustainable diet (pg. 3). Later in 2015, the World Health Organization (WHO), International Agency for Research on Cancer (IARC) noted in their report that processed meats are carcinogenic to humans. They concluded this based on sufficient evidence in humans that the consumption of processed meats contributes to the increased risk of colorectal cancers (IARC, 2015). Since reports like these have been circulating in recent years, some meat

consumers have considered reducing meat in their diet, or removing it altogether (Vegetarian; Nielsen, 2018; Reinhart, 2018).

Greenhouse gas emissions (GHGE) from livestock production particularly has become a topic of discussion in social, political, and economic agendas (Hunter and Röös, 2016; GEAS, 2013; Havlík et al, 2013; Stackhouse-Lawson et al, 2012; Garnett, 2011; Fiala, 2007). Beef production has the largest impact on the environment through emissions than any other type of livestock (GEAS, 2013; Stackhouse-Lawson et al, 2012; Garnett, 2011; Fiala, 2007) Livestock production comprises of 14.5% of the total anthropogenic GHG emissions (FAO, 2019). This is approximately 7 gigatons of carbon dioxide equivalent per year.

On average, 300 kilograms of carbon dioxide equivalent GHGE are emitted per kilogram of beef protein produced, although there is very high variability in emission intensities due to various operation practices and different inputs that are used in production across the globe (FAO, 2019). The breakdown of GHGE are methane (44%), nitrous oxide (29%), and carbon dioxide (27%) (FAO, 2019). Once we consider only carbon dioxide, total livestock production accounts for 5% of total annual anthropogenic carbon dioxide emissions (IPCC, 2006), so beef production emits approximately 3% of global carbon dioxide emissions. Methane and nitrous oxide emissions have a larger proportional impact from beef production—44 and 53 percent of total annual global methane and nitrous oxide emissions, respectively (IPCC, 2006).

There are mixed results behind livestock production and its contribution to climate change. There is disagreement on how much of an environmental impact livestock is having compared to other sectors (Herrero et al, 2010), and the share of livestock emissions to total emissions varies across regions in the world (Pitesky et al, 2009). Regardless, many studies point to the US, in particular, as a country that overconsumes meat, and that a policy response may be necessary for this overconsumption (Miller, 2019; Van Zanten et al, 2019; Poore and Nemecek 2018).

This study attempts to address multiple facets of this debate. If individuals ought to reduce meat consumption for health and environmental reasons, what would a hypothetical world under a meat tax look like? Are individuals willing to change their preferences due to a price change in meat products? What are the economic and nutritional outcomes, by different income levels, on such a policy?

Income Level Effects of a Meat Tax

The impact of economic policies on poverty and income distribution is a topic that is heavily studied in the United States and around the globe. Bourguignon and da Silva (2003), Andreyeva, Long, and Brownell (2010), Härkänen,et al (2014), and a host of other studies have concluded that unit taxes, including unit taxes on food products, have greater negative welfare effects on lower income levels. This makes intuitive sense with economic theory: the smaller the budget, the larger the proportion of income within that budget that is allocated to essential goods, such as food products. When budget shares for food are higher, it is more likely that a consumer is affected by changes in prices within their budget allocation for food. The larger budget shares for food products is not the only reason why lower income levels may feel the effects of a product price increase more than higher income level groups. For relatively inelastic consumer goods, such as meat products, the consumer is faced with a choice to switch to an alternative good, if available, or continue to consume that good when the price rises. The choice to continue consuming the good when its price rises is more likely among consumers at higher income levels, in theory. Many empirical real-world evidence fits with this theory - Lusk and Tonsor (2016) find evidence to suggest that high-income consumers are less responsive to own-price changes for meat products than lower income consumers.

A tax on meat, or some increase in the price of meat products, can be compared to the recent interest in taxing sugar-sweetened beverages (SSB). The logic is that, since consuming sugar-sweetened beverages produces some negative health outcomes, a tax on the product can help shift consumers away from consuming those specific goods. Sharma et al (2014) and Debnam (2017) estimate an Almost Ideal Demand System (AIDS), first presented by Deaton and Muellbauer (1980), to compare the effects of a SSB tax on varying income levels. Our study differs from these analyses by implementing a price increase or tax that has not yet occurred, using the own-price, cross-price, and income elasticities derived from an AIDS model. Further, this study attempts to reveal how consumers at different income levels may respond to a hypothetical tax on meat, given their current preferences.

Utilizing survey data from a basket-based choice experiment (Caputo and Lusk, 2019), we are able to elicit consumers' willingness to pay using repeated choices for a bundle of food items at varying price levels. The choices within this basket of food items contains beef, pork, and

poultry products, as well as other produce products and grocery store items. The advantage of utilizing this data is to view any shifts in consumer behavior away from meat products entirely if a relative price increase occurs within a meat product category. Upon calculating own-price, cross-price, and expenditure elasticities, we are able to view behavioral changes by consumers when prices of specific food products change relative to others. Using demographic responses from each respondent, their household income level was linked to each product choice bundle that was made.

Similar to the SSB tax, there are calls for a policy response on meat consumption due to some evidence of the link between red and processed meat consumption and environmental and health consequences (Miller, 2019; Van Zanten, Van Ittersum, and De Boer, 2019; Poore and Nemecek, 2018). The price change of meat products is calculated, in a sense, by the pass-through greenhouse gas emissions resulting from meat production and the negative health outcome effects of consuming red and processed meats, which has been quantified as health-related deaths in the current literature (Springmann et al, 2018). The price change in this study for beef and pork products considers a positive environmental cost per unit of meat consumed. This can be seen as an externality or Pigouvian tax, and mimics how a meat tax might be implemented, if seriously considered as a policy response in the United States.

We examine two states of the world through the survey data: one in which the consumer faces the prices given in the choice experiment, and one in which a price shock occurs, mimicking a meat tax to beef, pork, and poultry products. These two states of the world are then compared in order to gain insight into any welfare effects of a meat tax. By dividing the analysis into groups of low, medium, and high income levels, the final result is the differences in effects derived from individuals in each income level.

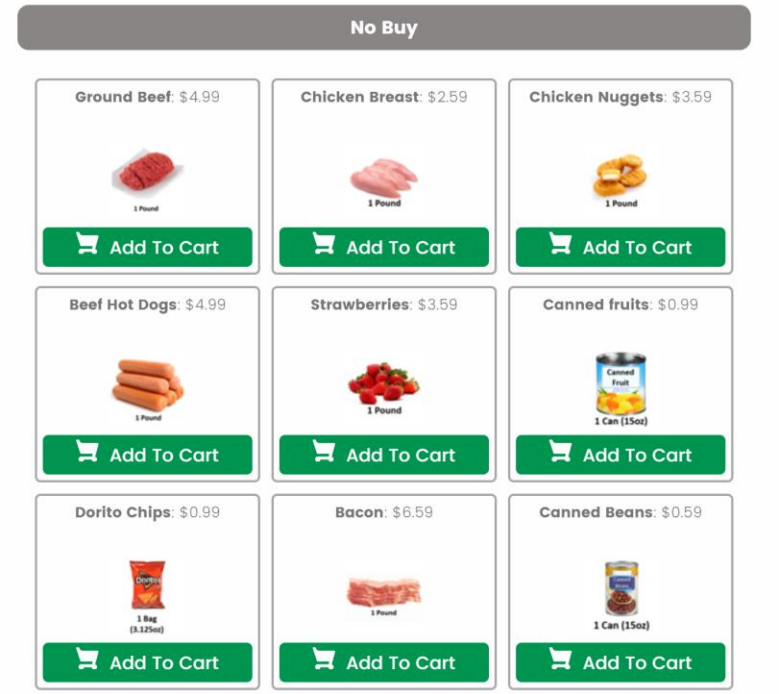
The contribution of this study is a new approach of utilizing choice experiment survey data within the AIDS model, which is a strategy that has not been revealed in past literature, to the best of our knowledge. The original survey design allows for a data selection process that minimizes standard errors, which is an advantage over using prices and quantities derived from market data. The second advantage of using this data is that it elicits willingness to pay for a basket of food items – the respondent has the choice between buying meat products, vegetables, fruits, or other various grocery items. Past literature on the effects of price changes in meat

products leave out the option for the consumer to substitute away from meat entirely to other known food categories. This survey enables consumers to have this option, which may be a more realistic view of the current choices that consumers face. Further, this study presents a hypothetical scenario – a meat tax has not yet been implemented, so it is a forecast of any welfare change differences accruing to different income groups. Previous studies using AIDS models have focused on estimating elasticities or effects of market price changes, but leave out any discussion of expected price changes due to a hypothetical tax or policy that is under consideration.

Data – Basket-Based Choice Experiment

Most choice experiments used for economic analysis have been implemented as a single discrete choice experiment. This requires an assumption that the consumer cannot substitute choices or make trade-offs outside of the product category. This may be too strong of an assumption for average consumers that make food purchases – there is a rich set of substitution and complementary patterns that consumers reveal when multiple food items can be chosen simultaneously at the grocery store. In an attempt to model the natural environment of the consumer at a grocery store or market, the new novel approach of a basket-based choice experiment has been introduced (Caputo and Lusk, 2019). Consumers have the option to choose a basket combination of items, a single item or multiple items, or no items at all. Evidence from this choice experiment reveal the weakness in the assumption made in single discrete choice experiments – an average of 4.4 items out of the possibility of 21 food items were chosen by survey respondents. An example of a food-basket choice question from this experiment is pictured in Figure 1. The full list of options that the respondents faced are: apples, bananas, strawberries, lettuce/salad, tomatoes, potatoes, ground beef, pork chop, chicken breast, beef hot dogs, bacon, chicken nuggets, frozen potatoes, canned beans, tomato soup, frozen fruits, canned fruits, dried fruits, granola bars, frozen pizza, and Doritos chips, resulting in a total of 21 food options and 1 “no buy” option.

Figure 1: Options for Grocery Items in the Basket-Based Choice Experiment



The option to make trade-offs between different food items is particularly important in the discussion of food policy. When the price rises for beef at the grocery store, for instance, consumers have the option to continue their purchase, buy a different meat product, or substitute away from meat altogether. If the goal is to measure the effects of a meat tax, it is important to consider these substitution patterns in other non-meat food categories. Revealing these patterns in consumer behavior may bring a more accurate view of the choices consumers make in the natural world.

Not only is identifying this substitution pattern a benefit for accuracy in data collection, it is a novel approach for use in an Almost Ideal Demand System (AIDS). Most meat demand systems studied in the literature either provide separability in meat products (the entire budget is exhausted by meat products) or employ weak separability by including an "other food" category. Even though weak separability allows the consumer to substitute away from meat products and perhaps decrease their total meat expenditure, it is not clear what item(s) they are substituting to, if any items at all. The respondent in this basket-based choice experiment has twenty-one food options. If the price rises for meat products, for instance, individuals are able to choose vegetables, fruits, or other protein options instead. Further, utilizing choice experiment data in an AIDS model is a novel approach in itself. Per capita consumption, or revealed market prices and

quantities, are the most common type of data that have been applied in prior AIDS literature. The benefit of using choice experiment data in an AIDS model lies in the original survey experiment design - an orthogonal fractional factorial design selects a smaller subset of all choice combinations to minimize standard errors. In effect, the experiment is designed to expose information about the most important features of consumer substitution and complement patterns. Just like any lab-based experiment, the investigator is able to control the environment to study the direct phenomena of interest. Market data utilized in AIDS models often produce large standard errors, since price and quantity levels are determined by many unexplained or unknown factors. Instead of attempting to explain the magnitude of effects of a meat tax with embedded unexplained factors, the experiment data allows for more robust results in the estimating equations.

The data is analyzed by separating the low-income individuals or households (annual household salary is less than $30,000 per year), medium-income (annual household salary is between $30,000 and $99,999), and high-income (annual household salary is greater than $100,000 per year).

Estimating Equations

An Almost Ideal Demand System (AIDS), first introduced by Deaton and Muellbauer (1980) is first constructed to determine budget share changes between pre-tax and tax scenarios. Following this, own-, cross-price, and expenditure elasticities are estimated to determine the complementarity or substitutability between food items. Simultaneous equations are estimated with budget shares as the dependent variable. The equation is derived from the expenditure function in the dual problem from consumer theory. The main equations used are as follows.

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln(X/P) \tag{1}$$

where w_i is the share associated with the *i*th good, α_i is the constant coefficient in the *i*th share equation, γ_{ij} is the slope coefficient associated with the *j*th good in the *i*th share equation, p_j is the price on the *j*th good. *X* is the total meat expenditure on the system of goods given by:

$$X = \sum_{i=1}^{n} p_i q_i \tag{2}$$

in which q_i is the quantity demanded for the *i*th good. *P* is the price index defined by a linear approximation of the nonlinear AIDS model by specifying a linear price index given by:

$$\ln P = \sum_{i=1}^{n} w_i \ln p_i \tag{3}$$

Conservation implies the following restrictions on the parameters in the nonlinear AIDS model:

$$\sum_{i=1}^{n} \alpha_i = 1, \sum_{i=1}^{n} \beta_i = 0, \sum_{i=1}^{n} \gamma_{ij} = 0 \tag{4}$$

Homogeneity is satisfied if and only if, for all *i:*

$$\sum_{j=1}^{n} \gamma_{ij} = 0 \tag{5}$$

and symmetry is satisfied if:

$$\gamma_{ij} = \gamma_{ji} \tag{6}$$

Twenty budget share equations are constructed and simultaneously estimated using the prices and quantities chosen by the choice experiment respondents. The elasticities were then calculated, with results in the Appendix. Welfare changes are then estimated and compared by income level using the measure of compensating variation.

Compensating Variation

The Compensating Variation (CV) is the amount of money that consumers would have to be compensated to make them as well off as before the tax shock. The CV is indicative of the magnitude of loss that the consumers must endure if the tax were implemented. $\hat{P}_j$ is the price of the food item inclusive of a meat tax, which will amount to a change in CV.

$$\Delta CV_i = -P_{i,0} Q_{i,0}(\hat{P}_i)(1 + 0.5 \sum_{j=1}^{21} \eta_{i,j,*} \hat{P}_j) \tag{1}$$

where $\eta_{i,j,*}$ is the compensated elasticity of demand ($\eta_{i,j,*} = \eta_{i,j} + \widehat{w}_j \eta_{i,E}$), $\eta_{i,j}$ is the uncompensated elasticity of good i with respect to the price of good j, $\widehat{w}_j$ is the expenditure share for good j, $\eta_{i,E}$ is the expenditure elasticity for good i, and $P_{i,0}$ and $Q_{i,0}$ are the prices and quantities of product i from the initial choice experiment. A total change in consumer welfare is found by the summation of the welfare changes across all commodities.

Tax Scenarios

We will view the tax under the lens of the theory presented by Pigou (1927). Prior literature has used Pigou (1927) in evaluating a market response to an environmental externality. The externality is the difference between the private (what the market accounts for) and social cost (intangible societal costs not accounted for in the market). In terms of livestock production, the consumer currently pays the retail price of the beef product at the grocery store. The price incorporates the value of production, as well as transportation and marketing of the product. What is not included in the price (if there is no tax involved), are any environmental or health impacts to society in producing or consuming that good, if any at all. For example, this could be GHGE and increased cancer risks. Determining the monetary value of this externality is currently a debate in the existing literature, as it is difficult to derive a value that differs by individual utility functions and time. We will assume prior estimates for this tax simulation.

The represented taxes will be implemented as hypothetical scenarios in the following order:

1. Social Cost of Carbon (SCC) per kg food tax
2. Only Red & Processed Meats tax
3. Denmark's Meat Tax Proposal
4. Sweden's Meat Tax Proposal
5. Lower value – Half of SCC estimate

Table 1: Meat Tax Scenario Simulations

	Quantity/Price per lb[1]	**1. SCC**	**2. SCC**	**3. Denmark**	**4. Sweden**	**5. Half SCC**
		$0.05179	*beef/processed*	*$0.03796*	*$0.15*	*$0.02590*
Ground Beef	1 pound	$1.41	$1.41	$1.03	$4.08	$0.70
Pork Chop	1 pound	$0.16	$0.00	$0.12	$0.48	$0.08
Chicken Breast	1 pound	$0.14	$0.00	$0.10	$0.41	$0.07
Beef Hot Dogs	1 pound	$1.41	$1.41	$1.03	$4.08	$0.70
Bacon	1 pound	$0.16	$0.16	$0.12	$0.48	$0.08
Chicken Nuggets	1 pound	$0.14	$0.04	$0.10	$0.41	$0.07

[1] Beef, pork, and poultry pass-through emissions from Poore and Nemecek (2018)

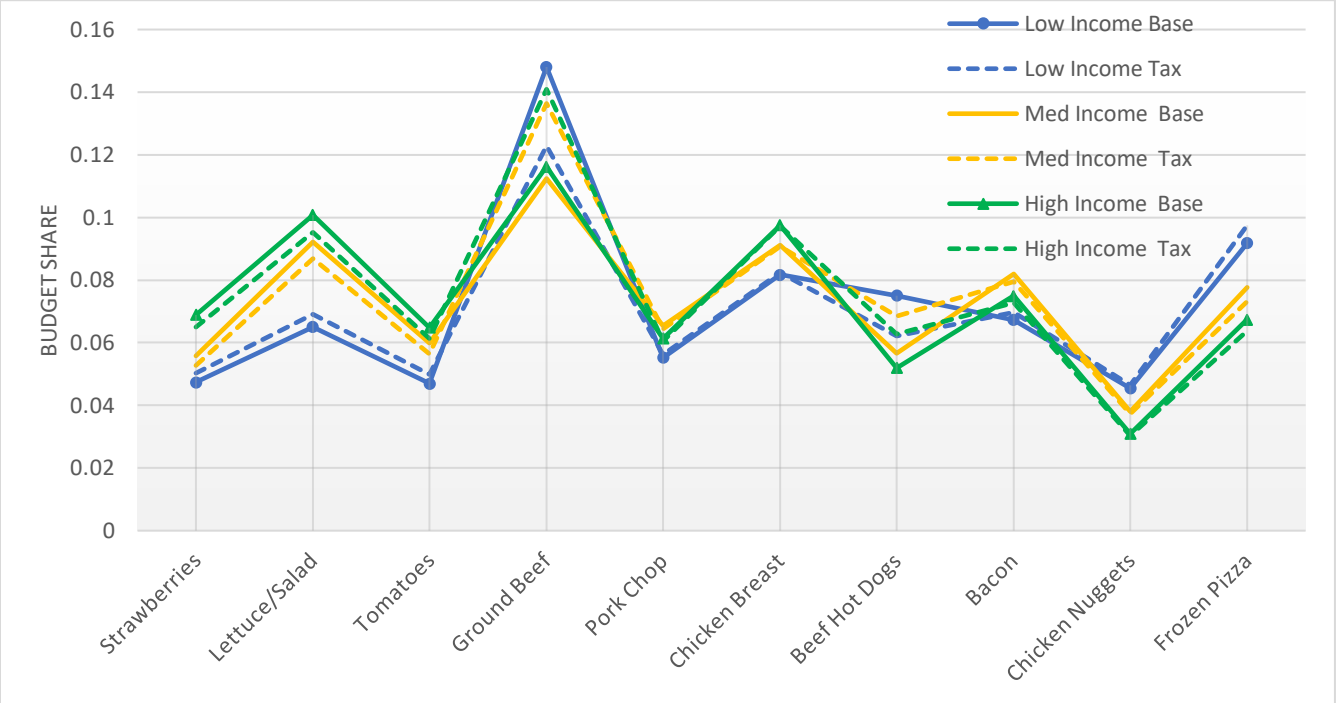
Tax simulations conducted and analyzed for the first scenario will be given, using the current SCC estimates. Other tax simulations to be added are taxes on fat or caloric content.

Results

Budget Share Effects by Income Levels

Figure 2 represents the budget shares in line graph form in order to view crossovers between income levels. The food groups not listed in Figure 1 were omitted due to low variation between base and tax scenarios, i.e. the food groups not listed here were not significantly impacted by the meat tax. One can compare the solid lines to the dashed lines which indicates the budget share change when consumers are subject to a tax. The salad and frozen pizza categories increased for low income individuals while ground beef shares decreased by a large magnitude relative to other changes within the budget. Medium and high-income individuals increased their ground beef shares – this in large part due to continued consumption at new prices. Medium and high-income individuals continued to show similar budget shares otherwise. The change in budget shares reveals that low income individuals substitute away from beef products when faced with a tax, while medium and high-income individuals continue consumption at new prices.

Figure 2: Budget Shares with a Meat Tax (Dashed Line) by Income Level



Own-, cross-price, and expenditure elasticities are listed in the Appendix. These elasticities identify the substitutability and complementarity between food items, which will be important for use in determining the welfare effects of a tax.

Welfare Effects by Income Levels

Table 2 indicates that this meat tax simulation is consistent with theory: low income levels experience the effects of taxation much more than higher income individuals. Taxes on ground beef cause dramatic negative effects to low income individuals and make up a large part of the total change in compensating variation. Low income households would need to be compensated $13.54 per grocery visit in order to remain at their pre-tax consumption levels, whereas medium and high-income individuals would need to be compensated to a lesser extent. When describing this budget decrease, it is important to compare these losses to the average income in each category, as well as average food budget percentages. For low income consumers, food budget losses are approximately 50% of their entire budget per grocery visit, while medium and high-income individuals are only affected by 7% and 4% of their food budget, respectively. The stark contrast in economic effects to this demographic factor of income could result in an increase in poverty levels and an expanded poverty gap.

Table 2: Welfare Effects by Income Level using the Measure of Compensating Variation

NONLINEAR ITSUR ESTIMATES	**INCOME LEVEL**		
	Low	**Med**	**High**
APPLES	-$77.55	-$84.98	-$80.92
BANANAS	-$6.58	-$5.28	-$17.67
STRAWBERRIES	-$161.51	-$160.54	-$141.07
LETTUCE/SALAD	-$112.92	-$126.64	-$267.72
TOMATOES	-$133.85	-$144.14	-$133.99
POTATOES	-$98.20	-$92.84	-$143.00
GROUND BEEF	-$811.38	-$701.82	-$423.76
PORK CHOP	-$160.04	-$166.48	-$145.71
CHICKEN BREAST	-$226.38	-$241.00	-$402.18
BEEF HOT DOGS	-$119.53	-$82.67	-$410.60
BACON	-$139.94	-$121.25	-$88.23
CHICKEN NUGGETS	-$266.93	-$193.87	-$154.15
FROZEN POTATOES	-$18.34	-$16.23	-$75.84
CANNED BEANS	-$22.00	-$18.59	-$55.65
TOMATO SOUP	-$2.97	-$1.44	-$0.97
FROZEN FRUITS	$7.53	$17.03	-$95.25
CANNED FRUITS	-$30.70	-$20.08	-$26.54
DRIED FRUITS	$86.60	$89.35	-$50.76
GRANOLA BARS	-$131.19	-$74.94	-$100.79
FROZEN PIZZA	-$944.78	-$673.52	$375.89
DORITOS CHIPS	$92.93	$70.23	-$31.70
TOTAL CV	**-$3,277.72**	**-$2,749.69**	**-$2,470.60**
# INDIVIDUALS	**242**	**635**	**261**
PER INDIVIDUAL	**-$13.54**	**-$4.33**	**-$9.47**
LOSS AS % OF FOOD BUDGET	**48%**	**7%**	**4%**

Nutritional Impacts of a Meat Tax

Since low income households show evidence of re-allocating their budgets to leafy greens and frozen pizzas when faced with a meat tax, the next steps are to relate food quantity changes to macronutrient changes, using the nutritional profiles of each item in the choice experiment. This includes changes in kilocalories, proteins, and carbohydrates. Expected results for low income households are an increase in total carbohydrates and a decrease in total proteins. This can have implications for the health status of individuals if meat-based proteins become more expensive.

Summary of Results

Economic effects of a meat tax are consistent with theory – a greater negative effect accruing to lower income levels than to higher income levels, based on relative elasticity differences for meat and other grocery store products for these income groups. Macro outcomes on poverty levels can be constructed by considering the magnitude of this difference. The nutritional impact of a meat tax is expected to result in a decrease in protein availability for low income households with an increase in total purchased carbohydrates. Further work will be to determine some probability of a meat tax expanding the poverty gap or the relationship between a meat tax and poverty intensification.

Appendix

Table A1: Uncompensated Elasticities - Low Income

Items	Apples	Bananas	Strawberries	Lettuce/Salad	Tomatoes	Potatoes	Ground Beef	Pork Chop	Chicken Breast	Beef Hot Dogs
Apples	-0.281	-0.007	-0.128	-0.073	-0.259	-0.241	-0.316	-0.094	-0.230	-0.083
Bananas	0.017	-0.107	0.028	0.126	-0.060	-0.050	-0.064	-0.185	-0.134	0.076
Strawberries	-0.044	0.006	-0.537	0.004	-0.083	-0.090	0.002	0.076	-0.087	0.010
Lettuce/Salad	-0.005	0.029	0.005	-0.418	-0.031	-0.009	-0.093	-0.037	-0.111	-0.149
Tomatoes	-0.110	-0.025	-0.081	-0.042	-0.308	-0.028	-0.077	-0.162	-0.044	-0.080
Potatoes	-0.086	-0.009	-0.057	0.034	0.005	-0.257	-0.043	-0.044	0.041	0.136
Ground Beef	-0.031	-0.004	0.028	-0.018	-0.008	-0.027	-0.285	-0.114	-0.046	0.025
Pork Chop	-0.011	-0.055	0.090	-0.017	-0.125	-0.052	-0.260	-0.537	-0.024	-0.079
Chicken Breast	-0.032	-0.020	-0.016	-0.044	0.008	0.025	-0.042	0.001	-0.337	0.025
Beef Hot Dogs	-0.011	0.020	0.013	-0.162	-0.062	0.076	-0.004	-0.091	-0.021	-0.370
Bacon	0.035	0.013	-0.058	-0.031	-0.037	-0.181	-0.270	-0.030	-0.112	-0.233
Chicken Nuggets	-0.113	-0.057	-0.176	-0.028	-0.126	-0.100	-0.198	0.071	0.052	0.117
Frozen Potatoes	-0.131	0.038	0.158	0.192	0.089	0.124	-0.113	0.057	0.075	-0.189
Canned Beans	0.128	-0.047	-0.016	-0.014	-0.066	0.026	-0.389	-0.077	0.140	0.000
Tomato Soup	-0.120	0.044	0.031	-0.111	0.001	-0.149	-0.541	-0.301	-0.235	0.355
Frozen Fruits	-0.062	-0.003	0.241	-0.035	0.010	-0.103	-0.433	0.037	-0.217	-0.054
Canned Fruits	0.194	0.048	-0.025	-0.038	0.170	-0.141	-0.081	-0.122	-0.052	-0.439
Dried Fruits	0.024	-0.057	-0.183	-0.116	0.017	0.030	-0.180	0.780	-0.131	-0.192
Granola Bar	0.009	-0.095	-0.008	-0.152	-0.194	-0.028	0.022	0.101	0.017	0.009
Frozen Pizza	0.051	-0.066	-0.087	-0.132	0.004	-0.018	0.134	-0.088	-0.094	-0.065
Dorito Chips	0.165	-0.213	-0.280	-0.422	0.015	-0.052	0.447	-0.281	-0.296	-0.205

Table A1: Uncompensated Elasticities - Low Income (Continued)

Items	Bacon	Chicken Nuggets	Frozen Potatoes	Canned Beans	Tomato Soup	Frozen Fruits	Canned Fruits	Dried Fruits	Granola Bars	Frozen Pizza	Dorito Chips
Apples	0.053	-0.233	-0.178	0.096	-0.051	-0.087	0.144	0.017	-0.005	0.116	-0.096
Bananas	0.082	-0.127	0.031	-0.042	0.034	0.016	0.056	-0.049	-0.195	-0.335	-0.006
Strawberries	-0.065	-0.151	0.052	0.001	0.012	0.162	-0.011	-0.065	0.008	-0.168	-0.153
Lettuce/Salad	-0.014	-0.006	0.043	0.004	-0.010	-0.001	-0.011	-0.022	-0.075	-0.181	0.007
Tomatoes	-0.032	-0.104	0.019	-0.019	0.007	0.021	0.069	0.023	-0.145	0.013	0.037
Potatoes	-0.192	-0.050	0.055	0.034	-0.018	-0.029	-0.051	0.043	0.020	0.035	0.034
Ground Beef	-0.101	-0.039	-0.038	-0.048	-0.034	-0.079	-0.008	-0.006	0.044	0.159	0.039
Pork Chop	0.008	0.090	0.009	-0.012	-0.045	0.047	-0.040	0.326	0.107	-0.110	0.005
Chicken Breast	-0.028	0.075	0.014	0.059	-0.016	-0.045	-0.006	-0.004	0.054	-0.039	-0.010
Beef Hot Dogs	-0.239	0.103	-0.102	0.009	0.066	-0.011	-0.142	-0.051	0.024	-0.091	0.018
Bacon	0.015	-0.034	0.012	-0.029	-0.023	-0.024	0.069	-0.274	0.083	-0.155	-0.075
Chicken Nuggets	-0.053	-0.363	-0.128	0.036	0.033	-0.133	-0.115	0.057	0.022	-0.028	-0.126
Frozen Potatoes	0.123	-0.174	-0.339	0.014	0.047	-0.147	-0.071	0.271	-0.005	-0.113	0.072
Canned Beans	-0.105	0.073	-0.019	-0.366	0.027	-0.227	-0.071	-0.194	-0.144	-0.109	-0.033
Tomato Soup	-0.177	0.132	0.072	0.050	-0.364	0.125	-0.143	0.018	0.327	-0.643	-0.065
Frozen Fruits	-0.069	-0.209	-0.159	-0.154	0.043	-0.068	0.007	0.245	-0.207	-0.500	0.136
Canned Fruits	0.248	-0.259	-0.103	-0.070	-0.070	0.018	-0.376	0.342	-0.059	-0.196	-0.028
Dried Fruits	-0.908	0.102	0.270	-0.192	0.007	0.343	0.310	-1.073	-0.335	-0.254	-0.037
Granola Bar	0.131	0.020	-0.039	-0.072	0.084	-0.152	-0.033	-0.169	-0.480	-0.369	-0.066
Frozen Pizza	-0.096	-0.003	-0.057	-0.016	-0.062	-0.146	-0.041	-0.043	-0.143	-0.117	-0.042
Dorito Chips	-0.308	-0.007	-0.182	-0.051	-0.202	-0.473	-0.132	-0.138	-0.463	-0.155	-0.480

Table A2: Uncompensated Elasticities – Medium Income

Item	Apples	Bananas	Strawberries	Lettuce/Salad	Tomatoes	Potatoes	Ground Beef	Pork Chop	Chicken Breast	Beef Hot Dogs
Apples	-0.408	0.043	-0.051	0.028	-0.072	-0.026	-0.135	-0.080	-0.122	0.000
Bananas	0.090	-0.236	-0.081	-0.055	-0.002	-0.015	-0.051	-0.063	-0.087	-0.163
Strawberries	-0.036	-0.031	-0.452	-0.068	-0.059	-0.047	-0.097	-0.056	-0.095	0.054
Lettuce/Salad	0.022	-0.007	-0.006	-0.245	0.006	-0.001	-0.090	0.007	-0.083	-0.023
Tomatoes	-0.023	0.004	-0.016	0.017	-0.287	-0.042	-0.077	-0.088	-0.045	-0.008
Potatoes	-0.012	-0.007	-0.033	-0.025	-0.072	-0.323	-0.051	-0.067	-0.067	-0.065
Ground Beef	-0.052	-0.019	-0.061	-0.153	-0.097	-0.052	-0.631	-0.005	-0.037	0.005
Pork Chop	-0.029	-0.015	-0.019	-0.001	-0.092	-0.043	0.076	-0.526	0.090	-0.058
Chicken Breast	-0.044	-0.021	-0.049	-0.127	-0.062	-0.046	-0.001	0.041	-0.426	-0.077
Beef Hot Dogs	-0.014	-0.058	0.042	-0.113	-0.062	-0.084	0.014	-0.113	-0.156	-0.423
Bacon	-0.075	-0.033	-0.078	-0.126	-0.097	-0.032	-0.055	-0.049	-0.045	-0.085
Chicken Nuggets	0.005	-0.037	0.056	-0.036	-0.005	-0.030	-0.265	0.041	0.061	-0.133
Frozen Potatoes	0.100	0.103	-0.056	0.198	0.040	0.112	-0.037	-0.015	0.006	-0.070
Canned Beans	-0.044	0.008	-0.102	-0.055	0.079	-0.015	0.108	-0.078	0.021	-0.122
Tomato Soup	0.083	0.146	-0.144	-0.073	0.025	0.045	-0.296	0.122	-0.122	0.185
Frozen Fruits	0.017	0.001	0.090	-0.075	0.034	0.093	0.031	0.045	-0.166	-0.029
Canned Fruits	0.033	-0.022	-0.204	-0.137	-0.101	-0.150	-0.370	0.059	-0.211	-0.048
Dried Fruits	0.022	-0.036	0.024	-0.019	0.011	0.048	-0.164	0.248	-0.103	-0.243
Granola Bar	-0.132	-0.111	-0.152	-0.218	-0.186	-0.134	0.112	-0.049	-0.108	0.032
Frozen Pizza	0.008	0.029	-0.013	-0.157	0.048	-0.062	0.053	-0.196	-0.053	0.070
Dorito Chips	0.060	0.117	0.001	-0.368	0.256	-0.142	0.227	-0.545	-0.083	0.258

Table A2: Uncompensated Elasticities – Medium Income (Continued)

Item	Bacon	Chicken Nuggets	Frozen Potatoes	Canned Beans	Tomato Soup	Frozen Fruits	Canned Fruits	Dried Fruits	Granola Bar	Frozen Pizza	Dorito Chips
Apples	-0.176	-0.003	0.052	-0.033	0.018	0.007	0.026	0.008	-0.077	0.047	-0.001
Bananas	-0.124	-0.087	0.129	0.017	0.074	-0.001	-0.005	-0.051	-0.139	0.182	-0.057
Strawberries	-0.113	0.020	-0.051	-0.048	-0.028	0.033	-0.046	-0.004	-0.042	-0.010	-0.012
Lettuce/Salad	-0.060	-0.009	0.037	-0.005	-0.008	-0.022	-0.005	-0.004	-0.016	-0.075	0.022
Tomatoes	-0.074	0.006	0.005	0.041	0.003	0.023	-0.006	0.007	-0.034	0.126	-0.012
Potatoes	-0.023	-0.027	0.034	-0.004	0.005	0.053	-0.031	0.016	-0.033	-0.061	-0.026
Ground Beef	-0.058	-0.117	-0.040	0.011	-0.031	-0.015	-0.044	-0.050	0.051	0.027	-0.055
Pork Chop	-0.018	0.025	-0.021	-0.021	0.014	0.020	0.028	0.081	0.024	-0.184	-0.005
Chicken Breast	-0.026	0.014	-0.022	0.004	-0.017	-0.067	-0.024	-0.034	0.003	-0.024	-0.022
Beef Hot Dogs	-0.137	-0.115	-0.060	-0.060	0.020	-0.038	-0.008	-0.111	0.041	0.089	-0.037
Bacon	-0.527	-0.006	-0.070	-0.025	0.007	0.007	0.032	-0.025	-0.047	0.071	0.054
Chicken Nuggets	0.028	-0.293	-0.057	-0.061	0.044	-0.027	-0.081	-0.065	-0.062	0.297	-0.093
Frozen Potatoes	-0.151	-0.067	-0.323	0.069	-0.032	0.102	0.050	0.015	0.031	-0.151	0.063
Canned Beans	-0.068	-0.109	0.047	-0.312	0.001	-0.052	0.002	0.066	-0.054	-0.301	0.032
Tomato Soup	0.126	0.205	-0.096	0.016	-0.357	-0.238	0.071	-0.170	0.099	-0.123	0.056
Frozen Fruits	0.063	-0.032	0.063	-0.033	-0.069	-0.281	0.023	-0.064	-0.037	-0.226	-0.107
Canned Fruits	0.145	-0.251	0.040	-0.014	0.031	0.017	-0.407	-0.068	0.022	0.017	-0.058
Dried Fruits	-0.044	-0.108	0.002	0.078	-0.068	-0.087	-0.028	-0.292	-0.105	0.112	0.158
Granola Bar	-0.235	-0.150	-0.027	-0.079	0.015	-0.093	0.000	-0.124	-0.390	-0.197	-0.113
Frozen Pizza	0.067	0.123	-0.075	-0.098	-0.021	-0.108	0.008	0.016	-0.040	-0.815	-0.083
Dorito Chips	0.282	0.454	-0.192	-0.295	-0.053	-0.308	0.030	0.086	-0.149	-0.246	-0.216

Table A3: Uncompensated Elasticities – High Income

Item	Apples	Bananas	Strawberries	Lettuce/Salad	Tomatoes	Potatoes	Ground Beef	Pork Chop	Chicken Breast	Beef Hot Dogs
Apples	-0.332	-0.012	-0.045	-0.066	0.005	-0.121	0.043	0.045	-0.078	-0.134
Bananas	-0.036	-0.195	-0.031	-0.059	-0.125	-0.075	-0.354	-0.098	-0.079	-0.196
Strawberries	-0.036	-0.008	-0.396	-0.032	-0.043	-0.054	0.026	-0.104	-0.094	-0.147
Lettuce/Salad	-0.009	0.002	0.027	-0.279	0.020	-0.010	-0.127	0.004	0.003	0.004
Tomatoes	0.004	-0.029	-0.025	-0.009	-0.244	-0.048	-0.118	-0.109	-0.083	-0.107
Potatoes	-0.095	-0.022	-0.055	-0.059	-0.063	-0.316	-0.202	-0.096	-0.121	-0.032
Ground Beef	-0.021	-0.066	-0.029	-0.245	-0.127	-0.131	-0.533	-0.168	-0.121	0.125
Pork Chop	0.002	-0.036	-0.144	-0.104	-0.160	-0.111	-0.290	-0.510	-0.046	0.111
Chicken Breast	-0.030	-0.009	-0.045	-0.037	-0.055	-0.061	-0.034	0.015	-0.342	-0.048
Beef Hot Dogs	-0.123	-0.073	-0.217	-0.096	-0.174	-0.062	0.315	0.136	-0.152	-0.381
Bacon	-0.049	0.047	-0.080	-0.049	0.085	0.065	-0.147	-0.028	0.047	-0.027
Chicken Nuggets	-0.051	0.007	-0.106	-0.276	-0.166	-0.256	-0.153	-0.218	-0.330	-0.167
Frozen Potatoes	-0.197	-0.159	0.131	0.028	-0.021	0.131	-0.083	0.100	-0.152	-0.328
Canned Beans	0.076	0.035	-0.021	-0.037	-0.075	0.050	0.000	-0.147	-0.006	-0.129
Tomato Soup	-0.195	-0.259	-0.127	-0.050	-0.163	-0.023	-0.735	0.535	-0.422	-0.193
Frozen Fruits	0.160	-0.055	-0.163	-0.315	-0.010	-0.056	0.170	0.050	-0.279	0.499
Canned Fruits	-0.172	0.054	0.168	0.122	-0.147	-0.033	-0.183	-0.060	-0.040	-0.106
Dried Fruits	0.063	-0.094	-0.295	-0.287	-0.201	-0.094	0.021	-0.002	-0.271	-0.225
Granola Bar	-0.180	-0.010	0.160	-0.281	-0.124	-0.178	-0.017	0.147	-0.202	-0.531
Frozen Pizza	0.115	0.114	0.035	0.265	0.135	0.325	0.093	0.032	0.231	0.104
Dorito Chips	-0.009	0.294	-0.404	-0.735	-0.259	0.648	0.458	-0.020	-0.287	0.222

Table A3: Uncompensated Elasticities – High Income (Continued)

Item	Bacon	Chicken Nuggets	Frozen Potatoes	Canned Beans	Tomato Soup	Frozen Fruits	Canned Fruits	Dried Fruits	Granola Bar	Frozen Pizza	Dorito Chips
Apples	-0.112	0.000	-0.097	0.031	-0.034	0.131	-0.069	0.095	-0.119	0.027	-0.070
Bananas	0.163	0.044	-0.171	0.026	-0.106	-0.050	0.038	-0.119	-0.008	0.243	0.014
Strawberries	-0.125	-0.016	0.024	-0.018	-0.013	-0.033	0.029	-0.089	0.075	-0.157	0.025
Lettuce/Salad	-0.022	-0.032	0.007	-0.006	0.002	-0.034	0.021	-0.026	-0.052	0.033	-0.013
Tomatoes	0.082	-0.038	-0.011	-0.029	-0.015	0.028	-0.036	-0.045	-0.039	-0.031	0.017
Potatoes	0.086	-0.122	0.044	0.013	0.000	0.004	-0.012	-0.010	-0.089	0.281	0.000
Ground Beef	-0.181	-0.029	-0.035	-0.025	-0.050	0.044	-0.040	0.025	-0.015	-0.181	-0.025
Pork Chop	-0.103	-0.091	0.012	-0.066	0.062	0.034	-0.028	0.026	0.066	-0.183	-0.029
Chicken Breast	0.021	-0.064	-0.033	-0.008	-0.029	-0.037	-0.008	-0.035	-0.043	-0.011	0.015
Beef Hot Dogs	-0.102	-0.078	-0.130	-0.066	-0.029	0.249	-0.042	-0.101	-0.297	-0.078	-0.012
Bacon	-0.213	0.007	0.081	-0.051	-0.022	-0.242	-0.076	0.124	0.107	-0.221	-0.034
Chicken Nuggets	-0.098	-0.017	-0.044	0.039	-0.049	-0.013	-0.015	-0.085	-0.083	-0.020	-0.102
Frozen Potatoes	0.344	-0.027	-0.346	-0.041	0.034	-0.161	0.000	-0.130	-0.271	0.474	0.064
Canned Beans	-0.190	0.115	-0.038	-0.378	-0.010	-0.103	-0.004	0.107	0.008	0.313	-0.109
Tomato Soup	-0.270	-0.180	0.071	-0.040	-0.440	0.276	-0.067	1.101	0.093	-0.211	-0.007
Frozen Fruits	-0.864	-0.017	-0.148	-0.114	0.077	-0.441	-0.125	-0.265	-0.058	0.055	-0.290
Canned Fruits	-0.389	0.015	-0.002	-0.009	-0.029	-0.169	-0.245	0.315	0.177	-0.001	0.017
Dried Fruits	0.177	-0.097	-0.112	0.032	0.262	-0.222	0.130	-0.514	-0.066	-0.590	-0.090
Granola Bar	0.219	-0.066	-0.184	-0.013	0.022	-0.031	0.079	-0.038	-0.428	0.009	0.179
Frozen Pizza	-0.072	0.110	0.167	0.131	-0.001	0.113	0.036	-0.138	0.094	-0.250	0.015
Dorito Chips	-1.377	0.606	0.355	0.183	-0.050	0.571	-0.077	-0.236	0.245	-0.133	-0.169

Table A4: Expenditure Elasticities for Each Income Level

Food Item	Low	Medium	High
Apples	1.936	0.953	0.912
Bananas	0.890	0.724	1.175
Strawberries	1.122	1.189	1.186
Lettuce/Salad	1.083	0.563	0.485
Tomatoes	1.070	0.478	0.883
Potatoes	0.399	0.819	0.866
Ground Beef	0.591	1.423	1.826
Pork Chop	0.684	0.672	1.589
Chicken Breast	0.380	1.026	0.879
Beef Hot Dogs	1.027	1.384	1.512
Bacon	1.338	1.202	0.676
Chicken Nuggets	1.359	0.716	2.205
Frozen Potatoes	0.022	0.012	0.609
Canned Beans	1.483	0.948	0.542
Tomato Soup	1.692	0.440	1.305
Frozen Fruits	1.554	0.659	2.190
Canned Fruits	1.039	1.678	0.716
Dried Fruits	1.775	0.595	2.475
Granola Bars	1.462	2.336	1.470
Frozen Pizza	1.128	1.299	-1.654
Doritos Chips	1.344	0.958	1.213

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