AN EXAMINATION OF US HOUSEHOLD EXPENDITURES ON HEALTHY FOOD

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ABSTRACT

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This dissertation contains three chapters, each of which examine US household expenditures on healthy food. In the first chapter, determinants of households' expenditures on healthy food away from home (FAFH) are analyzed using the National Household Food Acquisition and Purchase Survey. For households purchasing FAFH, Cragg's double-hurdle model is used to analyze their decision to purchase healthy FAFH and the share of total FAFH expenditures to allocate to healthy FAFH. Results indicate households receiving SNAP food assistance benefits are less likely to purchase healthy FAFH when dining away from home and allocate less of their total FAFH dollars to healthy items. In contrast, the healthy FAFH participation and expenditure shares of low-income households not receiving SNAP benefits do not significantly differ from those of high-income households. Other significant findings include that healthy FAFH participation and expenditure shares vary with the healthiness of households' food at home purchases, FAFH retailer type, nutritional information and time constraints, as well as other basic demographic factors.

The second chapter examines whether specific nutrients garner price premiums in fruit beverages sold in the US. Using the National Household Food Acquisition and Purchase Survey, hedonic price models for fruit juice and fruit drinks are estimated to determine whether specific nutrients, product characteristics, packaging type and acquisition characteristics are associated with price premiums. Based on the results from

the hedonic price models, three generalizations are made about the price premiums for nutrients and sugar in fruit beverages: (1) all nutrients garner premium prices in fruit juice, (2) sugar and select nutrients garner price premiums in non-diet fruit drinks and (3) all nutrients and sugar are associated with price discounts in diet fruit drinks. Findings further suggest that product attributes such as brand, flavor, organic labels, diet labels and package type, and acquisition characteristics such as store type, region, season and payment type are associated with price premiums in fruit beverages.

The final chapter develops a group-based food diversity index, representative of diversity in household expenditures across food subgroups. This index is compared to the traditional product code-based food diversity index and applied to reassess expenditure and demographic determinants of food diversity demand. Results confirm that the group and product code indices capture different forms of food diversity. The indices are only moderately correlated and have varying means and skewness. Education, gender, age, household size, race, SNAP and food expenditures are found to significantly affect food diversity. However, the magnitude and direction of the effects vary between group and product code indices. Given these differences, it is essential that studies select a diversity index that corresponds to their objective. Results suggest that group-based indices are appropriate for informing food and nutrition policy, while product code-based indices are ideal for guiding food industry management decision-making.

I dedicate this dissertation to my father, Robert Leschewski, and my mother, Sandra Ryan. Thank you for your constant love, support and encouragement, and for all of the sacrifices you made so that I could pursue my education.

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KEY TO ABBREVIATIONS

%DV	Percentage recommended daily value
ACQ	Acquisition characteristics
CES	Consumer Expenditure Survey
DEM	Demographics
DGA	Dietary Guidelines for Americans
ERS	Economic Research Service
EXP	Expenditures
FAFH	Food away from home
FAH	Food at home
FNS	Food and Nutrition Service
FOODAPS	National Household Food Acquisition and Purchase Survey
FSA	Food Standards Agency
FSR	Full-service restaurant
HEI	Healthy Eating Index
HFD	Healthy Food Diversity
HPT	Household Production Theory
IMR	Inverse Mills ratio
IRI	Information Resource Inc.
NUTR	Nutrients
OLS	Ordinary Least Squares
PACK	Packaging
PROD	Product attributes

QSR	Quick-service restaurant
RDV	Recommended daily values
SNAP	Supplemental Nutrition Assistance Program
UK	United Kingdom
US	United States
USDA	United States Department of Agriculture
WIC	Women, Infants and Children

CHAPTER 1 DETERMINANTS OF HOUSEHOLD EXPENDITURES ON HEALTHY FOOD AWAY FROM HOME

1.1 Introduction

Over the course of three generations, US dining habits have undergone a major transformation, with Americans cooking at home less and dining out more. From 1954 to 2013, the share of food dollars Americans allocated to food away from home (FAFH) increased from 25% to 50% (US 2013b). Defined as ready-to-eat meals, snacks and drinks purchased outside of the home, FAFH comprises approximately 35% of Americans' caloric intake (Todd and Scharadin 2016; Lin and Guthrie 2012). Once synonymous with restaurants, alternative retailers such as supermarkets and convenience stores are expanding their FAFH offerings (Creel *et al*. 2008). In 2012, approximately 58%, 37%, 32% and 24% of households purchased FAFH from quick-service restaurants, grocery stores, convenience stores and sit-down restaurants, respectively (Data 2013).

The increasing role of FAFH in Americans' diets served as motivation for early studies on FAFH expenditures. Redman (1980), Kinsey (1983) and Yen (1993) focus on understanding the link between FAFH expenditures and demographic factors, placing particular emphasis on the effect of women entering the workforce. In the late 1980's and 1990's, the literature shifted to analyzing determinants of expenditures on different types of FAFH. McCracken and Brandt (1987) and Byrne *et al*. (1998) analyze FAFH expenditures by retailer type, distinguishing between quick-service and full-service restaurants, while Hiemstra and Kim (1995) and Jensen and Yen (1996) analyze FAFH expenditures by meal type, considering expenditures on breakfast, lunch, dinner and snacks.

Subsequent to these studies, FAFH has faced increasing scrutiny from the media, nutritionists and government. The nutrition literature find that FAFH consumption is associated with greater intake of calories, fat, cholesterol and sodium and lower intake of nutrients (Lin and Guthrie 2012; Jeffrey *et al*. 2006). Further, nutritionists find that FAFH consumption is linked to an increased risk for obesity (Kim *et al*. 2014). Mainstream media increased public awareness of FAFH's poor nutritional quality through books and documentaries such as *Fast Food Nation: The Dark Side of the All-American Meal* and *Super Size Me* (Bauer *et al*. 2012). Responding to this criticism, the 2010 Patient Protection and Affordable Care Act required all food vendors with more than 20 locations to display calorie counts on their menus (Bleich *et al*. 2015).

With negative publicity adversely affecting sales, FAFH retailers have responded by improving the nutritional quality of their menu offerings (Jeffrey *et al*. 2006; Binkley 2006). Improvements include the addition of healthy menu lines, healthier children's meals, healthy indicator labels, fortified menu items and the discontinuation of "super-sized" portions (Bleich *et al*. 2015; Bauer *et al*. 2012; Harris *et al*. 2010). FAFH retailers have actively marketed these improvements, with nearly 50% of quick-service restaurants' commercials focusing on healthy menu items (Kirkpatrick *et al*. 2014; Harris *et al*. 2010).

Criticism of the nutritional quality of FAFH has renewed interest in the determinants of FAFH expenditures in the literature. Stewart *et al*. (2005) explore the effect of preferences for a healthy diet and nutritional knowledge on FAFH demand, while Binkley (2006) considers how nutritional concerns and attitudes affect expenditures on FAFH. Liu *et al*. (2013a-b) analyze determinants of expenditures on FAFH by retailer, meal and household type in order to obtain a renewed understanding of the FAFH market. Further, Richards and Mancino (2013) obtain FAFH price elasticities in order to inform FAFH tax policies aimed at curbing obesity.

While rising nutrition concerns have motivated recent studies to rexamine FAFH expenditures, no study has considered determinants of household expenditures on healthy FAFH. Thus, despite FAFH retailers' extensive efforts to improve the nutritional quality of their menu offerings, little is known about the factors affecting consumers' decision to purchase healthy items. Determining which demographic and economic factors affect expenditures on healthy FAFH can help inform future food and nutrition policy and help guide FAFH retailers' product development and marketing efforts. The objective of this study is to analyze households' expenditures in the growing healthy FAFH segment. Specifically, this study seeks to analyze determinants of: (1) households' decision to purchase healthy FAFH given that they are dining away from home and (2) the share of households' FAFH expenditures allocated to healthy FAFH.

1.2 Data

This analysis of healthy FAFH expenditures is conducted using data from the National Household Food Acquisition and Purchase Survey (FoodAPS). Sponsored by the United States Department of Agriculture's Economic Research Service and Food and Nutrition Service, FoodAPS is a nationally representative data set of household food purchases and acquisitions. Administered by Mathematica Policy Research between April 2012 and January 2013, FoodAPS consists of one-week food acquisition diaries for 4,826 participating households, which document all food at home (FAH) and FAFH purchases and acquisitions. Entry and exit surveys were conducted for each household and provide demographic and socioeconomic data.

The FoodAPS data set is ideally suited for analyzing expenditures on healthy FAFH. Unlike the *Consumer Expenditure Survey (CES)* used in several past studies on FAFH, FoodAPS does not limit FAFH to items purchased from restaurants, work or school (Todd & Scharadin 2016; Liu et al. 2013a; Liu et al. 2013b; Jensen & Yen 1996). In addition to these retailers, FoodAPS includes FAFH purchases from supermarkets, grocery stores, convenience stores and gas stations. FoodAPS also improves upon the CES by oversampling low-income households and households receiving SNAP food assistance benefits, allowing for the analysis of food insecure household expenditures on healthy FAFH. Further, FoodAPS is ideal in that it provides detailed nutritional information for each FAFH purchase, including nutrient content and food group servings. This nutritional information is critical for the classification of healthy FAFH items in this study.

Of the 4,826 households participating in FoodAPS, 165 do not report a food purchase or acquisition and are removed from the sample. Because we are interested in the share of FAFH expenditures households allocate to healthy FAFH, households who do not purchase FAFH are also excluded from the sample. Following Drewnowski and Fulgoni (2008), food items with limited nutritional content are removed, including condiments, sweeteners, creamers and alcohol. Further, free items not associated with coupon use are removed. This results in a sample of 3,894 households purchasing 57,779 FAFH items.

The healthfulness of each of the 57,779 FAFH items is evaluated using the UK Food Standards Agency's Nutrient Profiling Model. Developed in 2005 to provide

Table 1.1 Top 10 Healthy FAFH Items by Retailer Type (N=22,617)

Supermarkets	Convenience	QSR	FSR	Others
Baked chips	Baked chips	Baked fries	Baked fries	Baked fries
Baked chicken	Baked fries	Burritos/tacos	Lettuce/salads	Milk, lowfat
Other vegetables	Coffee	Baked chicken	Mixed poultry dish	Lettuce/salads
Yeast breads	Nuts/seeds	Poultry sandwich	Mixed meat dish	Other fruit
Vegetable dish	Burritos/tacos	Baked chips	Dumplings/sushi	Milk, lowfat
Mashed potatoes	Yeast breads	Mixed poultry dish	Vegetable dish	Rolls/buns
Mixed meat dish	Bananas	Coffee	Beef	Milk, reduced fat
Bananas	Fish	Other sandwich	Rice/chow mein	Apples
Poultry dish	Citrus juice	Vegetable dish	Baked chicken	White potatoes
Legumes	Mixed meat dish	Mashed potatoes	Mashed potatoes	Baked chips

regulation on the advertising of unhealthy foods to children, the model identifies healthier food items using a point scoring system ranging from [-15, 40], with lower values associated with healthier items (Food 2011). Under the scoring system, 'A Points' are allocated based on the energy, saturated fat, total sugar and sodium content of each item. Similarly, 'C Points' are allocated based on each item's fruit, vegetable, nut, fiber and protein content.[1] An overall score is then calculated by subtracting the 'C Points' from the 'A Points'. Foods scoring less than 4 points and drinks scoring less than 1 point are classified as healthy options (Food 2011). Applying the Nutrient Profiling Model to the FoodAPS dataset results in the classification of 22,617 FAFH items as healthy. Examples of common healthy FAFH items by retailer type are presented in Table 1.1.

1.3 Theoretical Framework

Following past studies on FAFH demand, Household Production Theory (HPT) is used to model FAFH expenditures (Liu *et al*. 2013a; Liu *et al*. 2013b; Jensen and Yen 1996; Hiemstra and Kim 1996). Developed by Becker (1965), HPT defines households as both

[1] Tables A.1 and A.2 in Appendix A detail the allocation of A and C Points based on specific nutritional component levels.

consumers and producers. In the context of FAFH, households have the option of producing their own home-cooked meals (*i.e.* FAH) or purchasing ready-to-eat meals (*i.e.* FAFH). Faced with a time constraint, a budget constraint and a production function, households maximize their utility by selecting optimal quantities of FAFH and time allocation. Following Binkley (2006), households' utility maximization yields:

(1) $$E_i = f(\boldsymbol{P}, I, T, \boldsymbol{H}, \boldsymbol{D}),$$

where E_i is a measure of household i's FAFH purchases, $\boldsymbol{P}$ is vector of prices, I is household income, T is a household's time cost, $\boldsymbol{H}$ is a vector of household health preferences and $\boldsymbol{D}$ is a vector of demographics and food acquisition characteristics. In this study, E_i represents the share of households' FAFH expenditures allocated to healthy FAFH, which we refer to as healthy FAFH share in the remainder of the article. Given the cross-sectional nature of the FoodAPS data set, market prices are not available. Following Liu *et al.* (2013a) and Liu *et al.* (2013b) regional indicator variables are included to account for market price variation.

1.4 Methodology

1.4.1 The Zero Expenditure Problem

A common issue when analyzing household expenditure data is the presence of a large number of zero expenditures. This problem is known as the censored dependent variable problem, or more commonly as the zero expenditure problem (Wooldridge 2010). There are three potential reasons households' healthy FAFH expenditure shares may equal zero: (1) corner solutions, (2) abstention and (3) infrequency of purchase (Pudney 1989). A corner solution implies that when eating out, households choose not to purchase healthy

Table 1.2 Vuong Model Selection Test: Censored Tobit vs Cragg's Double Hurdle

Vuong Test Statistic	T	P>|t|	Model Selection
3,877.96	18.48	0	Cragg's Double Hurdle

FAFH given the economic environment, while abstention implies that households purchasing FAFH choose not to purchase healthy items independent of economic factors. Under infrequency of purchase, a households' purchase cycle for healthy FAFH is longer than the survey period. However, since we are analyzing the share of FAFH expenditures allocated to healthy FAFH, infrequency of purchase is not a logical explanation for zero expenditure shares in this study.

Two types of models are commonly used to correct for zero expenditure problems: (1) censored tobit models and (2) double-hurdle models. Censored tobit models imply that zero expenditure shares are the result of a corner solution (Wooldridge 2010). However, the censored tobit model is restrictive in that the same mechanism governs both the participation and expenditure decisions. The double-hurdle model overcomes this restriction by modeling a two-step decision process. In the first step, or the participation decision, a household dining away from home decides whether to purchase healthy FAFH. In the second step, or the expenditure decision, the household decides the share of its FAFH expenditures to allocate to healthy FAFH. This approach allows for zero expenditure shares to be the result of both economic factors and abstention.

In this study, a Vuong test for non-nested models is used to determine whether the censored tobit or Cragg's double-hurdle model best fits the FoodAPS data. Shown in Table 1.2, results from the Vuong test strongly reject the null hypothesis that the two models fit the data equally well in favor of the double-hurdle model. Thus, Cragg's double-hurdle model is applied in this analysis.

1.4.2 Cragg's Double-Hurdle Model

In Cragg's double-hurdle model, household participation and expenditure decisions are modeled as follows:

(2) $$y_i = \begin{cases} y_i^* \ if y_i^* > 0 \ and \ s_i = 1 \\ 0 \ otherwise \end{cases}$$

where

(3) $$s_i = z_i \alpha + u_i \ \ u \sim N(0,1)$$

(4) $$y_i^* = x_i \beta + \varepsilon_i \ \ \varepsilon \sim N(0, \sigma^2)$$

where y_i is the observed healthy FAFH expenditure share for household i, y_i^* is the latent healthy FAFH expenditure share, s_i is a binary indicator of healthy FAFH participation among households purchasing FAFH, z_i is a set of explanatory variables for the participation decision, x_i is a set of explanatory variables for the expenditure decision and u_i and ε_i are error terms (Wooldridge 2010). While the set of explanatory variables included in the participation decision (x_i) and expenditure decision (z_i) are allowed to vary, it is common practice to include the same variables in both equations (Wooldridge 2010).

Estimation of Cragg's double-hurdle model is broken into two steps. In the first step, Equation 3 is estimated via a probit regression to model the participation decision. In the second step, Equation 4 is estimated using a truncated regression with a lower limit of zero to model the expenditure decision. The first stage's inverse mills ratio is included in the second stage to correct for potential sample selection bias. Marginal effects and elasticities of the participation probability, conditional level and unconditional level are calculated for continuous and binary explanatory variables respectively. The participation probability $P(y > 0|z)$ represents the probability that households dining away from home purchase healthy FAFH, the unconditional level $E(y|x)$ is the expected value of healthy FAFH expenditure shares for all households purchasing FAFH and the conditional level $E(y|x, y > 0)$ is the expected value of healthy FAFH expenditure shares for only households purchasing healthy FAFH.

1.4.3 Description of Explanatory Variables

Table 1.3 details the explanatory variables comprising z_i and x_i in this study. Based on Equation 1 from Household Production Theory, the explanatory variables are grouped into five categories: (1) income, (2) acquisition characteristics, (3) demographics, (4) health preferences and (5) times costs.

The income category consists of three indicator variables that classify households based on income, Supplemental Nutrition Assistance Program (SNAP) participation and food access. Income is expected to positively affect healthy FAFH participation and expenditure shares, given that low-income households have lower availability of healthy FAFH and healthy eating index (HEI) scores (Hiza *et al*. 2013; Chau *et al*. 2013). A binary indicator variable is also included to indicate whether households receive SNAP benefits. SNAP benefits can be used to purchase select, non-heated FAFH items at retailers other than restaurants, such as supermarkets and convenience stores. Unlike

Table 1.3 Variable Definitions

Variable	Definition	Unit	Base
Dependent Variables			
Healthy FAFH Share	Share of FAFH expenditures allocated to healthy FAFH	%	---
Income			
Low-Income/SNAP	Household has income below the poverty threshold and receives SNAP	DV[a]	High Income
Low-Income/Non-SNAP	Household income below the poverty threshold, but does not receive SNAP	DV	High Income
Low-Access	Household located in low-access tract	DV	High Access
Food Acquisition			
Healthy FAH Share	Share of FAH purchases allocated to healthy FAH	%	---
Supermarket Share	Share of FAFH bought at supermarkets	%	---
Convenience Share	Share of FAFH bought at conv. retailers	%	---
QSR Share	Share of FAFH bought at QSR	%	---
FSR Share	Share of FAFH bought at FSR	%	---
Other Share	Share of FAFH bought at other retailers	%	---
FAFH Visits	Number of visits to FAFH retailers	#	---
Demographics			
Age	Age of primary respondent	Years	---
College	Primary respondent is college educated	DV	No College
African-American	Primary respondent is African-American	DV	White
Asian	Primary respondent is Asian	DV	White
Hispanic	Primary respondent is Hispanic	DV	White
Rural	Household is located in a rural tract	DV	Urban
Midwest	Household is located in the Midwest	DV	Northeast
South	Household is located in the South	DV	Northeast
West	Household is located in the West	DV	Northeast
Health Preferences			
Nutrition Search	Primary respondent searched for nutrition information online in the last 2	DV	No Search
Dieting	A member of the household is dieting	DV	No Diet
Time Cost			
Helathy Time	Primary respondent is too busy to prepare healthy meals	DV	Has Time

[a]DV: Discrete Variable

earned income, SNAP benefits are expected to inversely affect households' healthy FAFH participation and expenditure shares. Nguyen *et al*. (2014) find that SNAP households have lower HEIs than both low-income and high-income, non-SNAP households. Similarly, households with low-access to supermarkets are expected to have lower healthy FAFH expenditure shares and participation, with past research finding low-access is associated with lower HEI scores (Larson *et al*. 2008)[2].

Acquisition characteristics are also expected to affect healthy FAFH participation and expenditure shares. The share of households' FAH expenditures allocated to healthy food is included to test the hypothesis that households purchasing a greater share of healthy FAH, will purchase a greater share of healthy FAFH. In order to account for differences in the availability, FAFH expenditure shares at supermarkets, convenience stores, sit-down restaurants and other retailers are included. The base variable is the share of FAFH expenditures at quick-service restaurants. Creel *et al*. (2005) and Binkley (2008) find that quick-service restaurants tend to have healthier FAFH options than supermarkets and convenience retailers, but less healthy options than sit-down restaurants. Thus, relative to quick-service restaurants, increasing FAFH expenditure shares at supermarkets and convenience retailers (sit-down restaurants and other retailers) is expected to decrease (increase) households' healthy FAFH participation and expenditure shares. Given Frank *et al*. 2009's finding that increased FAFH consumption lowers diet quality, FAFH visits are also included and expected to inversely affect healthy FAFH expenditure shares.

Following Binkley (2006), two variables representing households' health preferences are included: (1) nutrition search and (2) dieting. Nutrition search indicates that a household searched for nutrition information online prior to the survey period.

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[2] A census tract is classified as low-access if at least 33% of the population is located more than 1 mile (urban) or 20 miles (rural) from the nearest supermarket (US 2016b).

While past studies find that nutrition information is inversely related to FAFH expenditures, we hypothesize it is positively related to healthy FAFH participation and expenditure shares (Stewart et al. 2005; Binkley 2006). Similarly, we expect that households indicating that one or more household member is dieting will be more likely to purchase and spend a greater share of their expenditures on healthy FAFH items.

The literature further suggests that household characteristics impact healthy FAFH expenditure shares. Hiza et al. (2013) and Ervin (2011) find that dietary quality increases with age and education, suggesting that older households with college-educated heads will have greater healthy FAFH participation and expenditure shares. Findings by Hiza et al. (2013) and Ervin (2011) also suggest healthy FAFH participation and expenditures will vary by race, with Hispanics and Asians having higher HEI scores than Whites. In contrast, rural households are expected to have lower healthy FAFH participation and expenditure shares, with Sharkey *et al*. (2011) and Morton and Blanchard (2007) finding that rural households have lower HEI scores and lower access to healthy food in the US.

The final category of explanatory variables, time costs, accounts for households' opportunity cost of time. Serving as a proxy, *healthy time* is a dummy variable that indicates whether time constraints prevent households from preparing healthy meals at home. Binkley (2006) and McCracken and Brandt (1987) find that the importance households place on convenience is positively associated with FAFH expenditures. Similarly, households' time constraints in healthy meal preparation are expected to have greater healthy FAFH participation and expenditure shares.

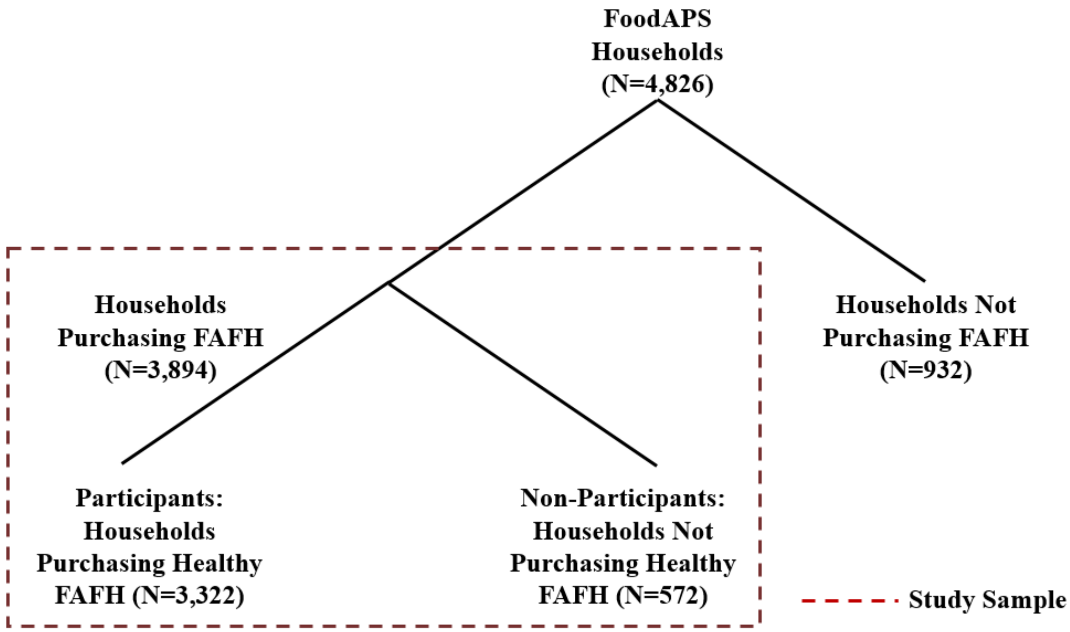

Figure 1.1 FoodAPS Households Included in Study Sample by Participation Level

1.5 Results

1.5.1 Descriptive Statistics

Descriptive statistics are presented in Table 1.4 for all households in the sample. Mean comparison tests are conducted to compare the acquisition characteristics, income, demographics, health preferences and time costs of households purchasing healthy FAFH (participants) and households purchasing only unhealthy FAFH (non-participants). For clarification, Figure 1.1 provides a visual representation of the households in this study's sample by participation level.

Of the 3,894 households purchasing FAFH, 85% purchase healthy FAFH. On average, those purchasing healthy FAFH allocate 42% of their FAFH expenditures to healthy items. This finding mirrors FAH, where participants (non-participants) allocate an average of 45% (44%) of their FAH expenditures to healthy items. Households purchasing healthy FAFH made significantly more visits per week to FAFH retailers on

Table 1.4 Descriptive Statistics for Participating and Non-Participating Households

Variable	Mean Participating (N=3,322)	Mean Non-Participating (N=572)
Dependent Variables		
Healthy FAFH Share	0.42	---
Income		
Low-Income/SNAP***	0.27	0.42
Low-Income/Non-SNAP	0.24	0.26
Low-Access	0.31	0.3
Food Acquisition		
Healthy FAH Share	0.45	0.44
Supermarket Share***	0.04	0.07
Convenience Share***	0.06	0.13
QSR Share*	0.43	0.46
FSR Share***	0.35	0.20
Other Share**	0.12	0.14
FAFH Visits***	5.81	2.04
Demographics		
Age	44.48	45.49
College***	0.23	0.17
African-American*	0.15	0.17
Asian	0.05	0.03
Hispanic*	0.21	0.18
Rural **	0.26	0.30
Midwest	0.25	0.27
South	0.37	0.39
West	0.22	0.20
Health Preferences		
Nutrition Search***	0.30	0.22
Dieting*	0.32	0.28
Time Cost		
Helathy Time***	0.23	0.17

Means differ at the * 0.10 level, ** 0.05 level and *** 0.01 level

average, 5.81, than non-participating households, 2.04. The distribution of FAFH expenditures across retailer types also differs significantly between participating and non-participating households. Participating households purchase a greater share of FAFH from full-service restaurants at 35% versus 20% for non-participating households.

Further, participating households purchase a lower share of FAFH from supermarkets, convenience retailers, other retailers and quick-service restaurants at 4%, 6%, 12% and 43% versus 7%, 13%, 14% and 46% for non-participating households respectively.

Mean comparison tests also highlight the stark differences in the economic status of participating and non-participating households. Differing at the 1% level, 27% of participating households are low-income and receive SNAP benefits versus 42% of non-participating households. However, the share of low-income households, not receiving SNAP does not significantly differ by participation level. Unlike SNAP, participating and non-participating households' access to supermarkets does not significantly differ. Demographics, health preferences and time costs further vary by participation level. Relative to non-participants, a greater share of participating households are college-educated, Hispanic, White and live in an urban census tract. A greater share of participating households also reported searching for nutrition information online and indicated that a household member was dieting. This finding suggests that health preferences may positively affect healthy FAFH participation. In addition to health preferences, times constraints also appear to positively affect healthy FAFH participation. The share of households reporting that time constraints prevent them from cooking healthy meals is greater among participants at 32%, than among non-participants at 28%.

1.5.2 Double-Hurdle Model Estimates

Cragg's double-hurdle model estimates are presented in Table A.3 in Appendix A. The inverse mills ratio is significant in the second stage, indicating that sample selection bias was present, but has been corrected. Further, variance inflation factors indicate no presence of multicollinearity. The resulting estimates explain a significant amount of the variation in households' healthy FAFH expenditure shares, with a pseudo-R^2 of 0.45. In order to facilitate interpretation of the double-hurdle model estimates, marginal effects and elasticities of the participation probability, unconditional expenditure level and conditional expenditure level are also calculated and presented in Table 1.5.

The double-hurdle model estimates indicate that SNAP participation affects households' healthy FAFH expenditure share. Marginal effects imply that, relative to high-income households, households receiving SNAP benefits are 3% less likely to purchase healthy FAFH and, given participation, allocate 5% less of their FAFH expenditures to healthy FAFH items. In contrast, healthy FAFH participation and expenditure shares do not differ between high-income households and low-income households that, despite eligibility, do not receive SNAP benefits. These findings coincide with the nutrition literature, in which Nguyen *et al*. (2014) find that SNAP households have lower HEIs than both low-income and high-income, non-SNAP households. Results further indicate that food access does not affect healthy FAFH participation or expenditure shares.

Acquisition characteristics also significantly affect household healthy FAFH participation and expenditure shares. Conditional elasticities indicate that a 1% increase in participating household's healthy FAH share leads to an 8% increase in their healthy FAFH share. This finding supports the hypothesis that households purchasing a greater share of healthy FAH will purchase a greater share of healthy FAFH. The frequency of visits to FAFH retailers is also positively related to healthy FAFH participation. Elasticity estimates indicate that a 1% increase in FAFH visits leads to a 17% increase in the

Table 1.5 Double-Hurdle Model Elasticities and Marginal Effects (N=3,894)

Variable	Participation Probability[ab]	Unconditional Level	Conditional Level
Income			
Low-Income/SNAP	-0.03***	-0.05***	-0.05***
Low-Income/Non-SNAP	-3.03E-03	-0.01	-0.01
Low-Access	-3.08E-03	-0.02	-0.02
Food Acquisition Characteristics			
FAH Healthy Share	-2.58E-03	0.07***	0.08***
Share of FAFH Purchases at Supermarke	-1.64E-03**	0.01***	0.01***
Share of FAFH Purchases at Convenienc	-4.70E-03***	-0.02***	-0.01**
Share of FAFH Purchases at FSR	0.01***	0.16***	0.15***
Share of FAFH Purchases at Other Retail	-4.36E-03***	0.02***	0.02***
FAFH Visits	0.17***	0.19***	0.02
Household Characteristics			
Age	0.01	0.20***	0.19***
College	-0.01	0.01	0.01
African-American	1.63E-03	0.01	0.01
Asian	0.02	0.12***	0.12***
Hispanic	0.02**	0.01	0.01
Rural	-0.01	-0.04***	-0.03***
Midwest	-0.03***	-0.05***	-0.04***
South	-0.02**	-0.03**	-0.02
West	-0.02	-0.02	-0.01
Health Preferences			
Nutrition Search	0.01*	0.04***	0.03***
Dieting	0.01	0.03**	0.02***
Time Cost			
Healthy Time	3.20E-03	0.03***	0.03**
Inverse Mills Ratio	---	---	---
Constant	---	---	---

[a]Probability/unconditional/conditional level elasticities calculated for continuous variables
[b]Probability/unconditional/conditional level marginal effects calculated for discrete variables
Significant at the * 0.10 level, ** 0.05 level and *** 0.01 level

probability of healthy FAFH participation. This finding suggests that frequent consumption of FAFH may result in variety-seeking behavior in FAFH purchases.

Relative to quick-service restaurants, the share of FAFH expenditures at supermarkets, full-service restaurants and other retailers (convenience retailers) positively (inversely) affects healthy FAFH participation. While the magnitude of the effect is small for supermarkets, convenience and other retailers, a 1% increase in the share of FAFH expenditures at full-service restaurants is associated with a 1% increase in the probability of purchasing healthy FAFH. Conditional elasticities further indicate that, relative to quick-service restaurants, 1% increases in the share of FAFH expenditures at supermarkets, full-service restaurants and other retailers (convenience retailers) lead to 1%, 15% and 2% (1%) increases (decreases) in the share of FAFH expenditures allocated to healthy items respectively. Paralleling the findings of Binkley (2008) and Creel *et al.* (2005), these findings suggest that supermarkets, full-service restaurants and other retailers may have greater availability of healthy FAFH items than quick-service restaurants and convenience retailers.

Largely mirroring the nutrition literature, several demographic factors affect households' healthy FAFH participation and expenditure shares. Age has a large, significant effect on healthy FAFH expenditure shares, with a 1% increase in age leading to a 19% increase in the allocation of FAFH expenditures to healthy FAFH. Healthy FAFH participation and expenditure shares are further found to vary among Hispanic, Asian and White households. Marginal effects indicate that Hispanic households are 2% more likely to purchase healthy FAFH, while Asian households allocate 12% more of their FAFH expenditures to healthy items. However, healthy FAFH participation and expenditure shares do not significantly differ between African-American and White households. Unlike age and race, results indicate that college education does not significantly affect healthy FAFH participation or expenditure shares.

Relative to urban households, participating households located in rural census tracts allocate 3% less of their FAFH expenditures to healthy FAFH items. Compared to the Northeast region of the US, households located in the Midwest and Southern regions are 3% and 2% less likely to purchase healthy FAFH respectively. Further, participating Midwestern households allocated 4% less of their FAFH expenditures to healthy FAFH. These findings likely capture regional differences in FAFH prices, tastes and preferences.

Estimates for the final two categories of explanatory variables, health preferences and time costs, are as expected *a priori*. Households who search for nutrition information online are 1% more likely to purchase, and given participation, allocate 3% more of their expenditures to healthy FAFH. Similarly, participating households with a member dieting allocate 2% more of their FAFH expenditures to healthy FAFH than non-dieting households. As expected, these findings indicate that preferences for a healthy diet and nutrition information positively affect healthy FAFH participation and expenditures. Further, participating households that indicate time constraints prevent them from preparing healthy meals at home allocate 3% more of their expenditure to healthy FAFH.

1.6 Discussion

Given FAFH retailers' recent efforts to improve the nutritional quality of their menu offerings, this study analyzes determinants of households' expenditures on healthy food away from home (FAFH) using the National Household Food Acquisition and Purchase Survey. For households purchasing FAFH, Cragg's double-hurdle model is used to analyze determinants of their decision to purchase healthy FAFH and the share of total FAFH expenditures to allocate to healthy FAFH. Results indicate that healthy FAFH participation and expenditure shares vary with SNAP participation, the healthiness of households' food at home purchases, nutrition information, FAFH retailer type and time constraints, as well as other basic demographic factors.

Results from this study provide further insight into the food purchases of households receiving SNAP food assistance benefits. Relative to high-income households, SNAP households dining away from home are 3% less likely to purchase and allocate 5% less of their FAFH dollars to healthy FAFH. In contrast, the healthy FAFH participation and expenditure shares of low-income households not receiving SNAP do not significantly differ from those of high-income households. As with FAH, these results suggest that receiving SNAP benefits does not lead to improved dietary quality of FAFH purchases. Instead, it appears SNAP's income effect leads low-income households to purchase a greater share of unhealthy FAFH items. This suggests that SNAP households' decisions to purchase healthy FAFH are driven by factors other than income, such as tastes, preferences, cultural values and habits.

This study also finds that the healthiness of participating households' food purchases is similar across FAFH and FAH, with 42% and 45% of FAFH and FAH shares allocated to healthy items respectively. A 1% increase in the share of FAH expenditures allocated to healthy items is also associated with an 8% increase in healthy FAFH expenditure shares. Given the conscious decision to purchase healthy FAFH, these results indicate that FAFH purchases are not inherently less healthy than FAH purchases. Thus, encouraging healthy decision-making may prove more effective in improving the nutritional quality of households' FAFH purchases than discouraging the consumption of FAFH altogether.

Further, results also indicate that obtaining nutrition information alters both households' healthy FAFH participation and expenditure shares. Households who make nutrition searches online are 1% more likely to purchase and allocate 3% more of their FAFH expenditures to healthy items. However, only 28% of households reported searching for nutritional information. This finding suggests that increasing households' use of nutrition information can help improve the nutritional quality of their FAFH purchases. Potential methods of increasing use of nutrition information include nutrition education programs with a focus on collecting and interpreting nutrition information, as well as increasing the transparency of nutritional information at FAFH retailers.

In addition to implications for food and nutrition policy, findings from this study also have direct implications for FAFH retailers carrying healthy FAFH products. Estimates obtained from the double-hurdle model identify key consumer segments that allocate a greater share of their FAFH expenditures to healthy FAFH items. Results suggest that high-income, non-SNAP, urban, health-conscious and older households' are key consumer segments in the healthy FAFH industry. Identification of key consumer segments is essential for FAFH retailers to effectively market healthy FAFH products.

This study presents a first look at the determinants of households' expenditures on healthy FAFH. Based on the findings from this study, further research on healthy FAFH expenditures is needed to obtain a clearer picture of the role of healthy FAFH in households' diets. In future studies, analysis of healthy FAFH expenditures by household type would provide a better understanding of the effects of income and SNAP benefits on healthy FAFH expenditures. Analysis of healthy FAFH expenditures segmented by retailer type and meal type would also provide insight on the types of healthy FAFH households purchase and where households' choose to purchase healthy FAFH. Further, future research employing a systems demand approach would give valuable insight on households' substitution among healthy FAFH, unhealthy FAFH, healthy FAH and unhealthy FAH.

CHAPTER 2 A SEGMENTED HEDONIC ANALYSIS OF THE NUTRITIONAL COMPOSITION OF FRUIT BEVERAGES

2.1 Introduction

With the average American consuming nearly 40 liters of fruit beverages every year, the United States is one of the world's largest fruit beverage consumers (Euromonitor 2015; Singh et al. 2015). Fruit beverages can be grouped into two categories: fruit juice and fruit drinks. Fruit juice is defined as pure, 100% juice with no added ingredients, while fruit drinks are fruit beverages containing ingredients other than fruit juice, such as sugar, and often have minimal nutritional value (Mintel Report 2015). On average, fruit drinks contain only 10% fruit juice (Harris et al. 2011).

Currently, a significant shift in fruit beverage consumption is occurring in the US, due largely to concerns over its sugar content. Wang et al. (2008) explain that fruit beverages' sugar content is similar to that of soft drinks and other sugar sweetened beverages. Studies have further found evidence that fruit beverage consumption is associated with an increased risk for obesity, heart disease and diabetes (Dennison et al. 1997; Wojcicki and Heyman 2012; Imamura et al. 2015; Eshak et al. 2013). Reflecting these concerns, the Dietary Guidelines for Americans have been revised and now recommend abstaining from fruit drink consumption and limiting fruit juice consumption (US 2015). As a result, the United States Department of Agriculture has cut back on fruit beverage provisions in food assistance programs such as Women, Infants, and Children (WIC), and has begun regulating fruit beverage sales in schools. Consumers' reactions to these concerns and changing federal guidelines/programs are reflected in the sales declines for fruit juice and non-diet fruit drinks from 2010 to 2015 (Mintel Report 2015;

Okrent and MacEwan 2014).

Despite its high sugar content, many nutritionists view fruit beverages as an important source of vitamins and minerals and as a cost effective way for consumers to meet their daily fruit intake recommendations (O'Neil et al. 2012; Clemens et al. 2015). Among its consumers, fruit beverages are increasingly purchased for their functional attributes i.e. the nutrients they contain (Mintel 2014). According to Mintel, over 40% of Americans depend on fruit juice as a source of added nutrients in their diets (2015). Manufacturers have responded to the demand for functional fruit beverages by emphasizing the naturally occurring nutrients in their products and introducing fruit beverages fortified with vitamins and minerals (Siro et al 2008; Bishai and Nalubola 2002).

Given the increased importance consumers and manufacturers have placed on the functional nutrients found in fruit beverages, as well as the changing federal guidelines on fruit beverage consumption, this study seeks to determine whether specific nutrients garner price premiums in fruit beverages sold in the US. Specifically, this study seeks to answer the following questions: (1) which nutrients found in fruit beverages garner price premiums, (2) do the specific nutrients that garner price premiums vary by fruit beverage type and (3) what other attributes of fruit beverages garner a price premium. This study adds to the literature in that it is the first to consider whether specific nutrients garner price premiums in fruit beverages sold in the US. Further, this study is the first to estimate separate hedonic models for fruit juice and fruit drinks, thus allowing price premiums for nutrients to differ between the two fruit beverage types.

2.2 Background

2.2.1 US Fruit Beverage Industry

The US is one of the largest consumers of fruit beverages, with 8.4 and 4.2 billion liters of fruit juice and fruit drinks purchased in 2014 (Euromonitor 2015; Singh et al. 2015). According to Mintel, approximately 75% (49%) of US consumers reported drinking fruit juice (drinks) in 2015. Orange (mixed fruit) is the most popular flavor of fruit juice (fruit drink), with a 60% (29%) market share (Euromonitor 2015). Other leading fruit juice (drink) varieties in order of market share include apple, mixed fruit, tomato, grape, cranberry, grapefruit, prune and lemon (citrus, berry, lemonade, grape and apple) (Euromonitor 2015).

The fruit beverage industry in the US is relatively concentrated, with ten major companies accounting for 70% of fruit beverage sales. These companies and their respective market shares are as follows: Coca-Cola Co. (18.2%), PepsiCo Inc (13.4%), Campbell Soup (7.7%), Kraft Foods Group Inc. (6.6%) Ocean Spray Cranberries Inc. (6.5%), Dr. Pepper Snapple Group (5.3%), National Grape Cooperative Association Inc. (3.7%), Citrus World (3.3%), Beverage Holdings (2.4%) and Nestle (2.2%) (Euromonitor 2015).

2.2.2 Nutritional Composition of Fruit Beverages

In the US, sugar-sweetened beverages are the single greatest source of added sugars in the American diet, with fruit drinks alone accounting for 10% of the added sugar consumed every year (Krebs-Smith 2001; US 2015). On average, an eight ounce fruit drink serving contains thirty-two grams of sugar or approximately 100% of one’s recommended daily sugar intake (Harris et al. 2011). A 2014 report by Yale's Rudd Center for Food Policy and Obesity further explains that the average fruit drink sold in the US contains only 10% fruit juice, with the remaining 90% of the drink comprised of water and sugar (Harris et al. 2011). Correspondingly, fruit drinks are described as providing empty calories, in that they are high in energy from added sugars, but low in nutrients such as vitamins, minerals and fiber (Reedy & Krebs-Smith 2010).

Unlike fruit drinks, fruit juice has historically been viewed as an important source of nutrients in the American diet. A detailed summary of the nutritional composition of seven common varieties of fruit juice is provided in Table B.1 in Appendix B. In general, fruit juice is a significant source of Vitamin C, Potassium, Magnesium, Iron and Phosphorus (O'Neil and Nicklas 2008). However, despite being a natural source of vitamins and minerals, all fruit juice varieties have high sugar contents, ranging from 49% of the recommended daily sugar intake for an 8oz serving of grapefruit juice to 119% for grape juice (O'Neil and Nicklas 2008; US 2013c).

2.2.3 Federal Programs, Policies and Guidelines Concerning Fruit Beverages

Over the past decade, federal programs, policies and guidelines have been altered or enacted in response to concerns over the high sugar content of fruit beverages in the US. Issued every five years, the Dietary Guidelines for Americans (DGA) provide consumers with guidance on maintaining a healthy diet and serve to inform food, health and nutrition policy (US 2015). The DGA recommendations on fruit beverage consumption have evolved considerably over the past decade. In 2005, the DGA recommended choosing fruit beverages with little added sugar (US 2005). By 2010, the DGA specifically stated to abstain from consuming fruit drinks and suggested limiting children's intake of fruit juice, especially if children are overweight or obese (US 2010). In the 2015 DGA, specific limits were placed on added sugar consumption, with no more than 10% of one's calories to be derived from added sugar (US 2015).

In 2007, the USDA's nutrition program for Women, Infants and Children (WIC) was revised in response to the 2005 DGA's recommendation to choose beverages with little added sugar (Cole et al. 2011). Established in 1966, the goal of WIC is to provide supplemental foods containing nutrients known to be lacking in the diets of at-risk women and children (Oliveira et al. 2002). Since its inception, fruit juice has been among the items provided by WIC due to its vitamin content. To be deemed WIC eligible, a product must contain only 100% unsweetened, pasteurized juice and contain a minimum of 20 mg of Vitamin C per 100ml of juice (US 2016c). In compliance with the 2005 DGA, revisions made to WIC in 2007 include the removal of fruit juice from all infant packages and a nearly 50% reduction in the maximum fruit juice prescription for women and children (Cole et al. 2011).

The USDA has also taken steps to regulate beverages sold in US schools. In July of 2014, the USDA implemented the Smart Snacks in School Standards which defined nutritional standards that all foods and beverage items sold in schools must satisfy (US 2013a). The standards effectively banned the sales of SSBs in schools, including fruit drinks. Among fruit beverages, only 100% fruit juice or 100% fruit juice diluted with water and with no added sugar can be sold in schools. The standards also limit the portion size of fruit juice that can be sold to 8oz and 12oz in elementary and middle/high schools respectively (US 2013a).

2.2.4 Changing Consumer Demand for Fruit Beverages

Consumers have reacted to the concerns over the sugar content in fruit beverages, as well as the changing federal guidelines and programs, by altering their fruit beverage consumption (Okrent and MacEwan 2014). Fruit juice expenditures in the US declined by 5% from 2010 to 2015, with approximately 34% of consumers who stopped drinking fruit juice doing so because of its high sugar content (Mintel 2015; Mintel 2014). During the same time period, fruit drink expenditures increased by 6%, driven primarily by the development of products containing fewer calories and less sugar (Mintel 2015; Taylor 2014; Okrent and MacEwan 2014).

Among consumers, fruit beverages are increasingly viewed as functional foods (Mintel 2014). The Functional Food Center defines functional foods as "natural or processed foods that contain known or unknown biologically-active compounds; which, in defined, effective non-toxic amounts, provide a clinically proven and documented health benefit for the prevention, management, or treatment of chronic disease" (Martirosyan and Singh 2015). According to Mintel, 40% (24%) of US consumers who purchase fruit juice (fruit drinks) look for vitamin or mineral enhanced formulas (Mintel 2014). Leading functional ingredients consumers seek in fruit beverages include Vitamin C, Vitamin D and Calcium (Euromonitor 2016). In addition to added nutrients, approximately 43% of fruit juice and fruit drink consumers are interested in no sugar added or low sugar varieties. (Mintel 2014).

In response to consumer demand for functional fruit beverages, manufacturers are emphasizing the naturally occurring nutrients in its products and introducing new fruit beverages fortified with vitamins and minerals (Siro et al 2008; Bishai and Nalubola

Table 2.1 Top Fruit Beverage Front-of-Package Nutrition Labels

	100% Fruit Juice	Fruit Drinks
Vitamin C	● % Daily Value Vitamin C ● An Excellent Source of Vitamin C ● With Vitamin C	● With Vitamin C ● % Vitamin C Per Serving ● Excellent/Good Source of Vitamin C
Vitamin D	● An Excellent Source of Vitamin D ● Plus Calcium & Vitamin D	● Plus Vitamin D
Vitamin E	● % Daily Value of Vitamin E	● Great Source of Vitamin E
Antioxidants	● Antioxidant Advantage ● Packed with Antioxidants A & C ● Essential Antioxidants ● Natural Source of Antioxidants	● Antioxidants Vitamin C & E ● 100% Daily Value of the Antioxidant Vitamin C
Multiple Vitamins	●With Vitamins A,B,C,D,E ● Packed with Vitamins ● Excellent Source of Vitamins	● Good Source of Vitamins A, C, E
Calcium	● % Daily Value of Calcium ● An Excellent/Good Source of Calcium ● Plus Calcium & Vitamin D	● None
Sugar	● 1/2 the Sugar ● No Sugar Added ● Less Sugar ● No High Fructose Corn Syrup	● % less sugar ● reduced sugar ● No High Fructose Corn Syrup
Fiber	●High Fiber ● Good Source of Fiber ● With Fiber	● None

2002). Key nutrients manufacturers are fortifying their fruit juice (drink) products with include Calcium, Vitamin D and Vitamin C (Vitamin C and Vitamin E) (Euromonitor 2016). In addition to functional attributes, a main area of focus for fruit beverage manufacturers is sugar reduction in its products (Mintel 2015). Manufacturers are conveying the nutritional benefits of their fruit beverages to consumers through the use of front-of-package labels. Detailed in Table 2.1, common front-of-package nutrition labels on fruit beverages include: good source of vitamins/antioxidants, % daily value of vitamins/minerals, natural source of antioxidants and no added/reduced/less sugar.

2.2.5 Uniqueness of this Study

Given the increased importance consumers and manufacturers place on the functional nutrients found in fruit beverages, as well as changing federal guidelines on fruit beverage consumption, this study seeks to determine whether key nutrients garner price premiums in fruit beverages. Several past studies have considered price premiums for nutrients in foods other than fruit beverages. Looking at breakfast cereal, Morgan et al. (1979) and Stanley et al. (1991) collectively find that protein, minerals, vitamins and sugar garner a premium price, while fiber and calories are associated with a price discount. Similarly, Angulo et al. (2006) and Harris (1997) conclude that meat with greater fat, protein and fiber content commands a premium price. Gulseven and Wohlgenant (2014) further find a price premium for lactose and cholesterol free milk.

Two past studies have analyzed whether nutrients garner price premiums in fruit beverages. Weemaes and Riethmuller (2001) considered the price premium associated with quality attributes, including nutrients, in Australian fruit beverages. Findings include that sugar is associated with a negative price premium and fruit beverages labeled with the Australian Heart Foundation seal garner a price premium. In 2014, Szathvary and Trestini analyzed the effects of nutrition and health claims on the prices of fruit beverages in Northeast Italy. Results suggest that fruit beverages containing a nutrition and/or health claim are associated with a price premium.

This study adds to the literature in that it is the first to consider whether specific nutrients garner price premiums in fruit beverages sold in the US. Building off of Weemaes and Riethmuller (2001) and Szathvary and Trestini's (2014) analysis of select nutrition claims, this analysis seeks to determine the price premiums associated with all key nutrients found in fruit beverages, including Vitamin C, Vitamin D, Antioxidants, Calcium, and sugar. This study is also the first to perform a segmented hedonic analysis of fruit beverages, with separate models estimated for fruit juice and fruit drinks.

2.3 Hedonic Pricing Model

2.3.1 Hedonic Price Theory

In their formative works, Lancaster (1966) and Rosen (1974) questioned the traditional notion that consumers obtain utility from goods themselves. Instead, they explain that goods are made up of a set of attributes and it is these attributes that provide utility to the consumer. This concept serves as the basis for hedonic price theory. Under this theory, the observed prices and quantity of attributes for a specific good define a set of hedonic prices (Rosen 1974). There are three key assumptions made by hedonic theory: (1) consumers are aware of all available versions of a product, (2) there is significant variation within a product segment and (3) it is costless to switch between products (Costanigro et al. 2011).

2.3.2 Hedonic Price Model

Following Rosen (1974), the hedonic price function for a good is defined as follows:

(1) $p(z) = p_i(z_1, \ldots, z_k)$

(2) $z_i = (z_1, \ldots, z_k)$

where z is the product and z_i is a row vector of the attributes for the i_{th} product. Given this price function, consumers choose a bundle of attributes to maximize the following utility function (3) subject to their budget constraint (4):

(3) $U = U(x, z_1, \ldots, z_k)$

(4) $y = x + p(z)$

where *y* is income and *x* represents all other goods and has a unit price. Maximization of the utility function subject to the budget constraint results in the following first order condition:

$$(5)\ p_{z_k} = \frac{U_{z_k}}{U_x}.$$

This first order condition yields the implicit price for a specific attribute, p_{z_k}, and implies that consumers are indifferent between paying the implicit price for an additional unit of an attribute and using the money to purchase all other goods *x* (Costanigro et al. 2011).

Analogously, producers choose a bundle of attributes and the number of goods to produce containing a particular attribute, $M(z)$, to maximize the following profit function:

$$(6)\ \ \pi = Mp(z) - C(M, z; \beta),$$

where $C(M, z; \beta)$ is the producer's cost function and β is a parameter representing the producer's factor prices and production technologies. Maximization of this profit function results in the following first order condition:

$$(7)\ p_{z_k} = \frac{C_{z_k}}{M}.$$

This first order condition implies that the marginal cost of adding an additional unit of an attribute to a product equals the implicit price of the attribute (Costanigro et al. 2011). Thus, at equilibrium, the market clearing implicit price for a particular attribute represents both producers' costs of providing the attribute and consumers' willingness-to-pay for the attribute.

There are several common issues associated with hedonic models, the most important of which of which is model misspecification. Economic theory provides no guidance on choosing the appropriate functional form for the hedonic price function

(Chau and Chin 2003; Halvorsen and Pollakowski 1981). Following Yim et al. (2014) and Teuber and Hermann (2012), the Box-Cox Test was used to determine the appropriate functional form for the hedonic price functions in this study (Box and Cox 1964). Three functional forms were considered: linear, log-linear and inverse square root. Results from the Box-Cox Test suggest that the log-linear functional form outperforms the other specifications and was thus used in this study. Other common issues present in hedonic analyses include heteroscedasticity and multicollinearity (Constanigro et al. 2011). In this analysis, the Breusch-Pagan-Godfrey test and variance inflation factors are used to detect the presence of heteroscedasticity and multicollinearity respectively.

2.3.3 Application of Hedonic Price Model to Fruit Beverages

In this analysis, we estimate hedonic models for 100% fruit juice and fruit drinks. The following hedonic price functions are estimated:

$$(8)\ \ln(JuicePrice) = \beta_0 + \sum_{j=1}^{4} \alpha_j Nutr + \sum_{k=1}^{14} \beta_k Prod + \sum_{l=1}^{3} \gamma_l Pack + \sum_{m=1}^{15} \delta_m Acq + \varepsilon$$

$$(9)\ \ln(DrinkPrice) = \beta_0 + \sum_{j=1}^{8} \alpha_j Nutr + \sum_{k=1}^{15} \beta_k Prod + \sum_{l=1}^{3} \gamma_l Pack + \sum_{m=1}^{14} \delta_m Acq + \varepsilon$$

where *JuicePrice and DrinkPrice* are the price per ounce for fruit juice and fruit drink purchases respectively. Attributes of fruit beverages included in the hedonic price function are classified into four categories: (1) nutrients (*nutr*), (2) product attributes (*prod*), (3) packaging (*pack*) and (4) acquisition attributes (*acq*). The variables included in these categories are detailed in Table 2.2.

The first category of attributes, nutrients, is comprised of the key nutrients found

Table 2.2 Variable Definitions

Variable	Definition	Unit	Base Variable
Dependent Variables			
Per Unit Price	Fruit juice/drink price per oz	$/oz	---
Nutrients			
Antioxidants	Antioxidant content	mg/100g	---
Calcium and Vitamin D	Calcium and Vitamin D content	mg/100g	---
Vitamin C	Vitamin C Content	mg/100g	---
Total Sugar	Sugar Content	g/100g	---
Product Attributes			
Brand	10 top brand name dummies	DV	Other Brands
Private Label	Private label product	DV	Non-Private Label
Diet	Diet/low-calorie product	DV	Non-Diet
Flavor	Flavor of fruit beverage:other citrus, berry, lemonade, apple, mixed fruit, vegetable, grape, other flavors	DVs	Orange
Organic	Organic product	DV	Non-Organic
Packaging			
Package Size	Set of 3 package size dummies: oversized (≥ 89oz), standard (59-64oz) and single serve (≤ 24 oz)	DVs	Other Sizes
Acquisition Attributes			
Low-Access Tract	Acquisition in low-access census tract at 1/10 mi urban/rural	DV	Non-Low-Access
Low-Income Tract	Acquisition in low-income census tract	DV	Non-Low-Income
Region	Item purchsed in the West, South or Midwest	DVs	Northeast
Season	Item purchased in fall, winter or spring	DVs	Summer
Store Type	Set of 4 dummies for store type: convenience, club store, discount store and supermarket	DVs	Grocery Store
WIC	WIC payment used	DV	Non-WIC
Coupon Used	Amount of coupon(s) applied	$	---
Store Savings	Amount of store savings applied	$	---

in fruit beverages that are sought by consumers and advertised by manufacturers. These include: antioxidants, Vitamin C, Vitamin D, Calcium and sugar[3]. Calcium and Vitamin D are combined into a single variable as fruit beverage manufacturers tend to fortify fruit beverage products with Vitamin D in conjunction with Calcium (Biancuzzo et al. 2010; De Lourdes et al. 2012; Table 2.1). With the exception of sugar, a price premium is expected for each of these nutrients due to the health benefits they provide consumers, as well as the added costs manufacturers incur when fortifying fruit beverages. Conversely, we hypothesize that sugar will garner a negative price premium as consumers and manufacturers seek to limit its content in fruit beverages. Interaction terms between the nutrients and a diet (zero or low-calorie) fruit drink dummy variable, are also included in the nutrients category. These interaction terms are included to distinguish between the price premium for nutrients in diet and non-diet fruit drinks.

The second category, product attributes, consists of five variables representative of the products' characteristics: flavor, brand name, private label, diet and organic. In their studies on fruit beverages, Szathvary and Trestini (2014) and Weemaes and Riethmuller (2001) found that price premiums for fruit beverages varied by flavor. In this study we include the following top-selling fruit beverage flavors: orange, other citrus, berry, apple, lemonade[4], mixed fruit, vegetable[5], grape and other flavors (Euromonitor 2015); orange is the reference flavor. In addition to flavor, dummy variables for brands with a market share greater than 5% in the fruit juice and drink markets are included in the model. Depending on the brands's reputation, prior hedonic analyses have found that

[3] For brevity, sugar is included in the nutrients variable category despite it classification as a carbohydrate.
[4]A lemonade dummy variable is not included in the fruit juice price functions as no lemonade is 100% juice.
[5] A vegetable dummy variable is included only in the juice price functions as all vegetable beverages are 100% juice

brand names garner both positive and negative price premiums (Morgan et al. 1979; Szathvary and Trestini 2014). A dummy variable is also included for private label products, with the expectation that these products are associated with negative price premiums (Sethuraman & Cole 1999). Two additional product attributes are included in the analysis: organic and diet[6]. Past studies have found that organic beverages garner significant price premiums (Szathvary and Trestini 2014; Gulseven and Wohlgenant 2014). Diet fruit beverages are also expected to garner a price premium given their value-added attribute of having fewer calories.

In the third category of variables, packaging, three variables are included to characterize each fruit beverage's package size: standard, single serve and oversized. In their analysis of soda prices, Fox and Melser (2014) found that the relationship between package size and price is non-linear. In general, single-serving containers of soft drinks cost more per ounce. than standard sized containers (two liters). The authors further find that oversized packages (24 packs) cost less per ounce than standard sized packages. Analogous to the findings of Fox and Mesler (2014), we expect that single-serving fruit beverages will garner a positive price premium and that standard and oversized fruit beverage containers will garner a negative price premium relative to other sizes.

The final category of variables describes the attributes of the acquisition, including where, when and how the fruit beverages were purchased. Store type, region and census tract characteristics are included to characterize where the fruit beverages were purchased. Szathvary and Trestini (2014) found that fruit beverages sold at supermarkets garner a price premium over other retailer types. Past studies have also

[6] Note that only fruit drinks can be classified as "diet"

found significant heterogeneity in the regional consumption of food products (Morgan et al. 1979; Drescher et al. 2008; Singh et al. 2015). Dummy variables for acquisitions made in low-income and low-access census tracts are also included in the model. Due to a lack of competition from other retailers, food price tend to be higher in low-access census tracts (Ver Ploeg 2010). Low-income census tracts are also expected to charge higher prices in that they have fewer chain retailers and supermarkets (Ver Ploeg 2007, Powell et al. 2007). Seasonal dummy variables are included in the price functions to account for price variation due to the seasonality of fruit production and demand. We also account for whether WIC was used as payment for fruit juice. Because the size, flavor and brand that WIC participants can purchase is predetermined, these consumers likely do no not consider price when purchasing fruit juice**.** Finally, the dollar amount of coupons and store savings applied to fruit beverages are included, with the intuitive hypothesis that coupon usage and store savings are associated with lower prices.

2.4 Data

2.4.1 Data Set

The National Household Food Acquisition and Purchase Survey (FoodAPS) data set was used for the analysis in this study (2016b). Funded by the United States Department of Agriculture (USDA) Economic Research Service (ERS) and the Food and Nutrition Service (FNS), FoodAPS is a national survey of 4,826 households. Collected between April 2012 and January 2013, the FoodAPS dataset contains a record of each household's food at home (FAH) and food away from home (FAFH) acquisitions over a one-week period. Entry and exit surveys were administered to households in order to collect demographic and socioeconomic data. The FoodAPS dataset also contains supplemental data on the nutritional composition of all food items purchased, food acquisition characteristics, payment methods and product attributes.

During the one-week acquisition period, 1,852 households in the FoodAPS dataset purchased fruit beverages for at home consumption. These households made a total of 4,166 fruit beverage purchases, of which 42% were fruit juice and 58% were fruit drink purchases. Fruit beverage items that had a price of zero and were not associated with coupons or store discounts were removed from the dataset. Each fruit beverage item purchased was then classified as either 100% fruit juice or as a fruit drink based on the percentage of juice it contained and its sugar content. This resulted in a final sample size of 1,362 fruit juice and 1,832 fruit drink purchases.

2.4.2 Descriptive Statistics

Descriptive statistics for the fruit beverage prices and attributes are presented in Table 2.3. Comparing fruit juice to fruit drinks, we find that fruit juice is slightly more expensive, with an average price of $0.07 per ounce versus $0.06 per ounce for fruit drinks. Of particular interest to this study are the differences in nutritional composition of fruit juice and fruit drinks. The descriptive statistics reveal that fruit juice has significantly higher levels of all key nutrients in comparison to fruit drinks. In particular, fruit juice contains approximately 500% more antioxidants, 400% more Calcium and Vitamin D, and 225% more Vitamin C than fruit drinks. Despite having different vitamin and mineral contents, fruit juice and fruit drinks contain similar amounts of sugar. On average, fruit juice and fruit drinks contain 10.24 and 11.63 grams of sugar per 100g

Table 2.3 Descriptive Statistics By Fruit Beverage Type

Variable	Mean (Juice)	Mean (Drinks)
Dependent Variables		
Per Unit Price**	0.07	0.06
Nutrients		
Antioxidants***	0.83	0.16
Calcium and Vitamin D***	31.28	7.4
Vitamin C***	30.08	13.08
Total Sugar***	10.24	11.63
Product Attributes		
Brand***	0.05-0.08	0.05-0.10
Private Label***	0.21	0.05
Diet	---	0.05
Flavor***	0.06, 0.05, ---, 0.17, 0.12, 0.07, 0.06, 0.07	0.02, 0.10, 0.13, 0.02, 0.44, ---, 0.04, 0.14
Organic	0.05	0.06
Packaging		
Package Size*, ***, ***	0.11, 0.13, 0.45	0.13, 0.22, 0.33
Acquisition Attributes		
Low-Access Tract***	0.35	0.29
Low-Income Tract***	0.48	0.59
Region***	0.26, 0.31, 0.25	0.26, 0.38, 0.19
Season***	0.37, 0.04, 0.13	0.33, 0.06, 0.16
Store Type***	0.02, 0.04, 0.02, 0.86	0.03, 0.02, 0.05, 0.84
WIC	0.08	---
Coupon Used	0.02	0.01
Store Savings**	0.17	0.14

*Means for fruit juice and drinks differ at the 0.10 level, ** 0.05 level and *** 0.01 level serving respectively.

Putting these numbers into perspective, Figure 2.1 presents the percentage recommended daily value (%DV) of key nutrients provided by the fruit beverages in the data set (US 2013c). On average, an 8oz serving of fruit juice provides 115%, 7% and 6% of the %DV of Vitamin C, Calcium and Vitamin D, and antioxidants, while fruit drinks provide 50%, 2% and 1% of the %DV respectively. Comparing sugar content, an 8oz serving of fruit juice contains 73% of the %DV, compared to 83% for fruit drinks.

In addition to nutrients, the descriptive statistics reveal key differences in the product attributes of fruit juice and drinks. The distribution of flavors varies significantly between fruit juice and fruit drink purchases. For fruit juice, orange is the top-selling flavor, followed by apple, mixed fruit, vegetable/other flavors, grape/other citrus and berry. Mixed fruit is the top selling fruit drink flavor, followed by lemonade/other flavors, orange, berry, grape and apple/other citrus. These distributions are similar to those reported by Euromonitor (2015), suggesting that the fruit beverage purchases in the FoodAPS dataset are representative of all US fruit beverage acquisitions.

We also find that while the market share of the top five fruit juice and drink brands are similar, private label products comprise 21% of fruit juice purchases, but only 5% of fruit drink purchases. According to Abate and Peterson (2005), the narrow price difference between private label and branded juice drinks is a possible explanation for private label products' low market share in the fruit drink segment. Considering packaging, a greater share of fruit drinks are purchased in single serve and oversized packages, 22% and 13%, versus 13% and 11% for fruit juice. Conversely, a greater share of fruit juice purchases are in standard size packages, 45%, versus 33% for fruit drinks.

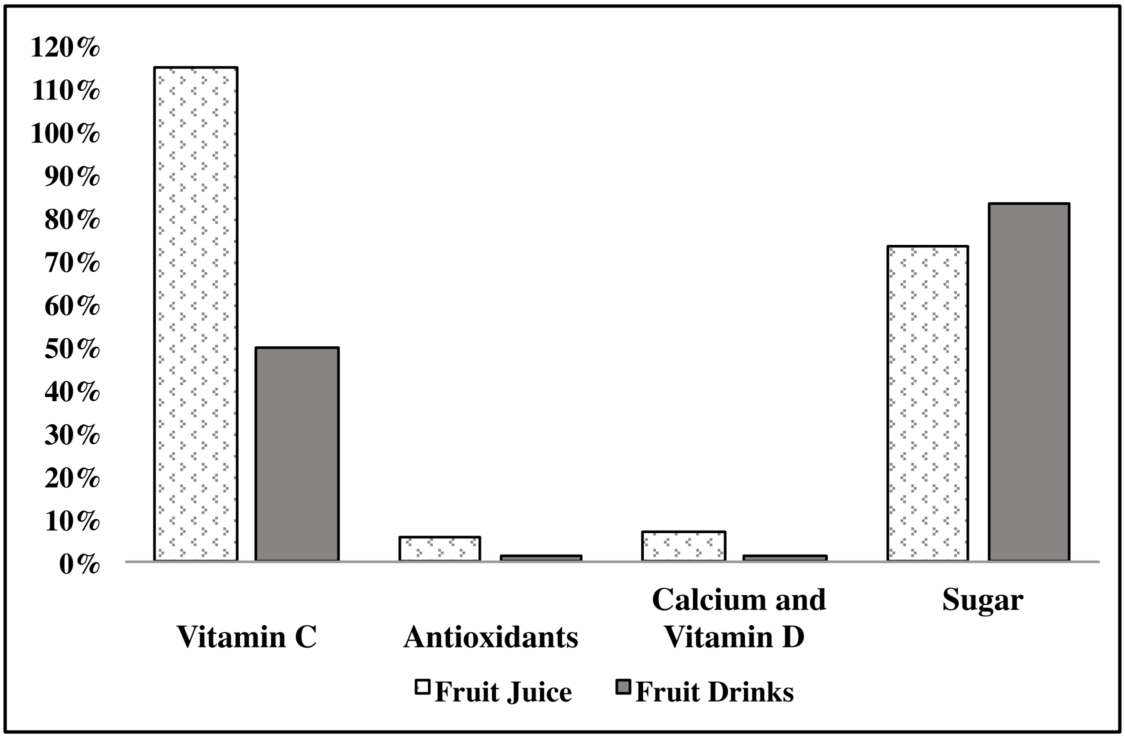

Figure 2.1. Percent Daily Value of Key Nutrients in Fruit Beverages Based on a 2,000 Calorie Diet

The characteristics of fruit beverage acquisitions also differ significantly between fruit juice and fruit drinks, with both regional and seasonal heterogeneity. Fruit drinks purchases are more prevalent in the Southern portion of the United States, while fruit juice purchases are more prominent in the Midwest. Where acquisitions are made also varies significantly by fruit beverage type. While the shares of fruit drinks and juice purchased at supermarkets are similar, a greater share of fruit drink purchases are made at convenience retailers and discount stores, while a greater share of fruit juice purchases are made at club stores. We also find that fruit drink (fruit juice) purchases are more common in low-income (low-access) census tracts. Looking at payment type, 8% of fruit juice purchases were made using WIC benefits. While savings from coupons are comparable, store savings are, on average, 20% greater for fruit juice than fruit drinks.

2.5 Results

Estimates of the log-linear fruit juice and fruit drink hedonic price equations are obtained using ordinary least squares regression techniques and are presented in 2.3. The estimated models explain a significant portion of the variation in fruit juice and fruit drink prices, with r-squared values of 0.64 and 0.62 respectively. Breush-Pagan test results suggest the presence of heteroskedasticity, thus we calculate White-Huber standard errors.

2.5.1 Nutrients

Of particular interest to this study, are the price premiums associated with nutrients and sugar in fruit beverages. The hedonic price estimates in Table 2.4 show that price premiums for nutrients and sugar vary between fruit juice, non-diet fruit drinks and diet fruit drinks.

Looking first at fruit juice, we find that all nutrients garner a price premium. Adding an additional mg of antioxidants (Vitamin C) to fruit juice leads to a 5% (0.01%) increase in the price per ounce. For a standard 60oz container, this corresponds to a $0.21 and $0.01 premium for an additional mg of antioxidants and Vitamin C respectively. While Calcium/Vitamin D also garners a price premium, the premium itself is extremely small. Adding an additional mg of Calcium/Vitamin D increases the per ounce price of fruit juice by just 0.0005%, or a $0.002 premium for the standard 60oz container. These price premiums for nutrients in fruit juice likely reflect both manufacturers' costs and consumers' willingness-to-pay. For manufacturers, fortifying fruit juice with vitamins and minerals leads to increased production costs. On the demand side, consumers may pay a premium for fruit juice containing more nutrients given their positive health

Table 2.4 Fruit Beverage Hedonic Price Function Estimates

	Fruit Juice (N=1,362)		Fruit Drinks (N=1,832)	
Variable	**Coeff.**	**SE**	**Coeff.**	**SE**
Nutrients				
Antioxidants	0.05*	0.03	0.01	0.04
Diet*Antioxidants	---	---	-0.36**	0.17
Vitamin C	2.20E-03***	6.33E-03	0.01***	1.32E-03
Diet*Vitamin C	---	---	-0.02**	0.01
Calcium/Vitamin D	4.95E-04**	2.20E-04	0.02***	0.01
Diet*Calcium/Vitamin D	---	---	-0.06***	0.03
Total Sugar	2.75E-04	6.33E-04	0.01***	3.06E-03
Diet*Total Sugar	---	---	-0.06**	0.03
Product Attributes				
Brand 1	0.07	0.06	-0.31***	0.04
Brand 2	0.25***	0.03	-0.08*	0.05
Brand 3	0.15***	0.03	0.39***	0.05
Brand 4	0.05	0.04	-0.01	0.04
Brand 5	0.29***	0.04	0.05	0.05
Private Label	-0.25***	0.03	-0.22***	0.04
Other Citrus	0.21***	0.05	0.10	0.07
Berry	0.18***	0.05	0.23***	0.05
Apple	-0.02	0.04	0.33***	0.13
Lemonade	---	---	0.24***	0.06
Mixed Fruit	0.04	0.04	0.20***	0.04
Vegetable	-0.42*	0.24	---	---
Grape	0.16***	0.06	0.05	0.09
Other Flavors	0.19***	0.07	0.01	0.05
Diet	---	---	1.43***	0.44
Organic	0.30***	0.07	0.86***	0.06
Packaging				
Oversized Package	-0.38***	0.04	-0.53***	0.04
Single Serve Package	0.67***	0.06	0.66***	0.06
Standard Size Package	-0.30***	0.04	-0.06*	0.04
Acquisition Attributes				
Low-Access Tract	9.03E-03	0.02	0.02	0.03
Low-Income Tract	-0.08***	0.02	-0.12***	0.02
Fall	0.04*	0.02	-0.02	0.03
Spring	0.12***	0.03	-0.06*	0.04
Winter	0.01	0.04	-0.12**	0.06
Midwest	-0.08**	0.03	-0.03	0.04
South	-0.06*	0.04	-0.06*	0.04
West	3.43E-03	0.04	0.02	0.04
WIC	0.12***	0.03	---	---
Convenience	0.26***	0.07	0.18	0.12
Club Store	-0.14	0.10	0.02	0.08
Discount Store	-0.42***	0.12	0.03	0.07
Supermarket	-4.20E-03	0.06	-0.01	0.05
Coupon Used	-0.52*	0.32	-0.10	0.09
Store Savings	-0.18***	0.02	-0.15***	0.04
Constant	-2.87***	0.07	-3.82***	0.07
R-Squared	**0.64**		**0.62**	

*, ** and *** denote significance at the 10%, 5% and 1% level

benefits. Unlike nutrients, sugar is not associated with a price premium in fruit juice. This finding is likely the result of the fact that manufacturers do not incur the cost of adding sugar to fruit juice, as juice naturally contains large amounts of sugar (O'Neil and Nicklas 2008). Consumers may also pay a premium price for fruit juice containing more sugar given the growing public concern over the adverse health effects of sugar consumption.

Unlike fruit juice, an additional gram of sugar is associated with a 1% price premium for non-diet fruit drinks. For the standard 60oz container, this corresponds to $0.04 for each additional gram of sugar. This premium is partly attributable to the added costs manufacturers face when adding sugar to non-diet fruit drinks. On the demand side, consumers that prefer the taste of sweeter drinks may also be pay a premium for non-diet fruit drinks containing additional sugar.

Also differing from fruit juice, only select nutrients garner price premiums in non-diet fruit drinks; Vitamin C and Calcium/Vitamin D are associated with a price premium, while antioxidants are not. Adding an additional mg of Vitamin C (Calcium/Vitamin D) to a non-diet fruit drink leads to a 1% (2%) increase in the price per ounce. For the standard 60oz container, this corresponds to a $0.04 and $0.07 premium for Vitamin C and Calcium/Vitamin D respectively. As with fruit juice, these premiums likely reflect the costs incurred by manufacturers to fortify the fruit drinks with nutrients, as well as consumers' willingness to pay for nutrients given their positive health benefits. However, the price premiums for Vitamin C and Calcium/Vitamin D in non-diet fruit drinks are larger than those for fruit juice. One plausible explanation for this difference is the fact that fruit drinks contain less naturally occurring nutrients than fruit juice. (Harris et al.

2011; Empty 2015). Thus, to achieve the same level of nutrients, non-diet fruit drink manufacturers must incur higher fortification costs than fruit juice manufacturers.

Differing from both non-diet fruit drinks and fruit juice, nutrients and sugar in diet fruit drinks are associated with negative price premiums. An additional mg of antioxidants, Vitamin C and Calcium/Vitamin D leads to a 35%, 1% and 4% decrease in the price per ounce respectively. For the standard 60oz container, this corresponds to a $1.26, $0.04 and $0.14 discount for an additional mg of antioxidants, Vitamin C and Calcium/Vitamin D. Similarly, an additional gram of sugar leads to a 5% decrease in the price per ounce for diet fruit drinks, or a $0.18 discount for the standard 60oz container. Given that manufacturers still incur additional costs when adding nutrients and sugar to diet fruit drinks, these negative price premiums suggest that diet fruit drink consumers pay a premium to reduce nutrients and sugar. Given the nature of diet fruit drinks, consumers intuitively seek to reduce to nutrients and sugar in diet fruit drinks in order to reduce the fruit beverages' caloric content; by reducing the nutrient and sugar content of a diet fruit drink, one also decreases the calories in the drink.

Based on these results, three main generalizations are made about the price premiums for nutrients and sugar in fruit beverages:

1. All nutrients garner premium prices in fruit juice
2. Sugar and select nutrients garner premium prices in non-diet fruit drinks
3. All nutrients and sugar are associated with price discounts in diet fruit drinks

2.5.2 Product Attributes

In addition to nutrients, several product attributes also garner price premiums in fruit beverages. As found by Szathvary and Trestini (2014), nearly all of the top fruit juice and fruit drink brands garner a price premium, ranging from 15% to 39%. However, fruit drink Brands 1 and 2 have negative coefficients, suggesting that these are discount or value brands. Unlike branded products, private label fruit beverages are associated with price discounts. Relative to branded products, private label fruit juice and fruit drink products cost 25% and 22% less per ounce respectively. Results also highlight flavors' effect on fruit beverage prices. Relative to orange juice, berry, grape, other citrus and other flavors garner price premiums ranging from 16% to 21%. Conversely, vegetable flavored juice is shown to cost 42% less per ounce than orange juice. Considering fruit drinks, nearly all flavors are associated with higher prices than orange flavored drinks, with price premiums ranging from 20% for mixed fruit to 33% for apple flavored drinks.

The estimation results also indicate that organic and diet fruit beverages are associated with significant price premiums. Compared to non-organic fruit beverages, organic fruit juice and fruit drinks price is 30% and 86% higher per ounce respectively. This finding is comparable to that of Szathvary and Trestini (2014), who found a 48% price premium for organic fruit beverages sold in Australia. Diet fruit drinks also garner a substantial price premium, with prices 143% higher than those of non-diet fruit drinks.

2.5.3 Packaging

Similar to Fox and Melser's (2014) findings for soft drinks, fruit beverages sold in single serve packages are associated with higher prices, relative to other package types. Single serve packages garner 67% and 60% price premiums for fruit juice and fruit drinks. Also mirroring Fox and Melser (2014), fruit beverages sold in standard sized and oversized packages are associated with lower per ounce prices than other package types. This negative price premium is greater for oversized packages than for standard sized packages, with oversized packages priced 38% (53%) less per ounce for fruit juice (drinks) and standard sized packages priced 30% (6%) less per ounce respectively.

2.5.4 Acquisition Attributes

Several attributes of the acquisition event also affect the price of fruit beverages. The estimation results indicate there is both seasonal and regional variation in fruit juice and fruit drink prices. Further, while fruit drinks prices appear to be similar across retailer types, the type of store fruit juice is purchased at has a significant impact on its price. Relative to grocery stores, fruit juice prices are 26% higher at convenience retailers and 42% less at discount retailers.

Further, the estimation results confirm that store savings and coupon usage are associated with lower prices for fruit beverages. When store savings are applied to an item, prices decrease by 18% and 15% for fruit juice and fruit drinks. Similarly, fruit juice prices decrease by 52% when a coupon is used; for fruit drinks, the coefficient for coupon usage is negative but not significant. The hedonic price equation estimates further indicate a 12% price premium for fruit juice purchased using WIC benefits. This finding supports this studies hypothesis that because the size, flavor and brand that WIC participants can purchase is predetermined, WIC consumers likely do not consider price when purchasing fruit juice.

Dummy variables for acquisitions made in low-income census tracts also significantly affect fruit beverage prices. Low-income census tracts are associated with fruit juice and fruit drink prices 8% and 12% less than those in non-low-income census tracts. This is likely attributable to retailers charging lower prices in low-income areas where households have less disposable income.

2.6 Conclusions

Given the increased importance consumers and manufacturers have placed on the functional nutrients found in fruit beverages, as well as the changing federal guidelines on fruit beverage consumption, this study sought to determine whether specific nutrients garner price premiums in fruit beverages sold in the US. Using the National Household Food Acquisition and Purchase Survey, hedonic price models for fruit juice and fruit drinks are estimated to determine whether specific nutrients, product characteristics, packaging type and acquisition characteristics are associated with price premiums. Based on the results from the hedonic price models, three generalizations are made about the price premiums for nutrients and sugar in fruit beverages: (1) all nutrients garner premium prices in fruit juice, (2) sugar and select nutrients garner price premiums in non-diet fruit drinks and (3) all nutrients and sugar are associated with negative price premiums in diet fruit drinks. Findings further suggest that product attributes such as brand, flavor, organic labels, diet labels and package type, and acquisition characteristics such as store type, region, season and payment type are associated with price premiums in fruit beverages.

This study's price premium estimates for nutrients can provide valuable insight to fruit beverage manufacturers, particularly in their design of future marketing initiatives and new product development. Given the growing concern over the healthfulness of fruit beverages in recent years, manufacturers are employing marketing tools such as front-of-package labels and advertisements to emphasize the nutrients found in fruit beverages. Estimates of price premiums for these nutrients can help fruit beverage manufacturers determine which specific nutrients to emphasize in these marketing initiatives. Assuming that the marginal costs of different nutrients are similar, fruit beverage manufacturers should emphasize the nutrients that garner the largest price premium. Results from this study suggest that fruit juice marketing initiatives should focus on antioxidants, while non-diet drink marketing efforts should emphasize Vitamin C and Calcium/Vitamin D. For diet fruit drinks, all nutrients are associated with a negative price premium, suggesting that marketing efforts should focus on calorie content instead of nutrient content.

Estimates of nutrient price premiums can also guide fruit beverage manufacturers in product development. In developing a new fruit beverage product, manufacturers must determine whether or not to fortify the product with nutrients and, in the case of fortification, which specific nutrients should be used. Price discounts suggest that fortification will not lead to increased returns for diet fruit drink manufacturers. However, positive price premium estimates from this study suggest that fruit beverage manufacturers should consider fortifying fruit juice and non-diet fruit drinks with certain nutrients. Fruit juice and non-diet fruit drink manufacturers can compare the price premiums for specific nutrients estimated in this study to their marginal costs of fortification to determine which specific nutrients to use in fortifying their product.

CHAPTER 3 RETHINKING HOUSEHOLD DEMAND FOR FOOD DIVERSITY

3.1 Introduction

According to the *2015 Dietary Guidelines for Americans (DGA)*, food variety is an essential component of a healthy diet (US 2015). The *DGA* encourages variety across food subgroups, which respectively contain different micronutrients and macronutrients (US 2015). Murphy *et al* (2006) and Foote *et al* (2004) find evidence that diversity across food subgroups is positively associated with nutritional adequacy. Further, food diversity is credited with helping maintain a healthy body weight and reducing the risk of diet-related diseases, including heart disease and diabetes (British 2007).

The link between food diversity and health, has served as motivation for several economic studies on the diversity of household food expenditures (Thiele and Weiss, 2003; Lee and Brown 1989; Shonkwiler *et al* 1987; Lee 1987). In these studies, food diversity is measured using indices of household expenditures across food categories designated based on product codes (*i.e.* food classification systems created by market intelligence agencies, retailers and government). Under a product code approach, convenience foods (*i.e.* foods which have processing added by a manufacturer/distributor to provide time-savings to consumers) are classified based on their processed form and subgroup (Lee and Lin 2013). This approach conflicts with the *DGA*'s definition of food diversity as variety across food subgroups, irrespective of processed form (US 2015).

Relative to studies conducted in the 1980's, classification of convenience foods is of particular importance in contemporary analyses of food diversity demand. Convenience foods have gone from an emerging trend in the 1980's, to a staple in household diets, with Okrent and Kumcu (2016) finding that convenience foods comprise nearly 75% of all US food expenditures (Capps *et al* 1985). Given this changing food landscape, product code-based indices are increasingly capturing diversity in household expenditures across different processed forms as opposed to food subgroups. This raises the question of whether product code-based food diversity indices are still an accurate indicator of nutritional adequacy or whether product-code indices now better represent diversity in product types and form. With this question in mind, it is necessary to reassess household demand for food diversity using an index that classifies foods based on their subgroup composition.

Recent studies in the nutrition literature by Vadiveloo *et al* (2014) and Drescher *et al* (2007) develop healthy food diversity (HFD) indices based on the *DGA* and the *German Nutrition Society Guidelines*. In these indices, food categories are designated based on food subgroups, irrespective of processed form. However, the indices are representative of diversity across the volume of foods individuals consume, not household food expenditures as in economic studies on the demand for food diversity.

The purpose of this study is to develop a group-based food diversity index based on the US HFD, which represents diversity in household expenditures across food subgroups. This group-based food diversity index is then applied to examine the relationship between the demand for food diversity, food expenditures and household characteristics. Further, findings using the new group-based food diversity index are compared to those obtained using the product code-based food diversity index.

3.2 Literature Review

Household demand for food diversity has been widely examined in the economic literature. Foundational studies by Theil and Finke (1983) and Jackson (1984) examine whether the demand for diversity varies with income. Both studies consider diversity across broad commodity groups, including food. Jackson (1984) develops a hierarchical demand system in which the consumption set changes with income, while Theil and Finke (1983) measure diversity using the Herfindahl-Hirschman and entropy indices. Both studies find evidence that the demand for consumption diversity increases with income.

Focusing specifically on food, Lee (1987) and Shonkwiler *et al* (1987) examine the relationship between food diversity, expenditures and demographics. Both studies employ count indices, which measure the number of different food categories households purchase. The studies conclude that increased food expenditures are associated with increased demand for food diversity. Lee (1987) further finds a positive relationship between food diversity and household size.

Lee and Brown (1989), Jekanowski and Binkley (2000) and Thiele and Weiss (2003) measure food diversity based on the distribution of expenditure shares across food categories. Types of distributional measures utilized in these studies include the Simpson and entropy[7] indices, which are defined as:

(1) $S = 1 - \sum_{i=1}^{n} w_i^2$

(2) $E = -\sum_{i=1}^{n} w_i log w_i$,

where w_i represents the budget share for food category i. The Simpson and entropy

[7] The entropy index is also commonly referred to as the Shannon Index

indices range from $\left[0,1-\frac{1}{n}\right]$ and $[0, \log(n)]$ respectively. For both indices, zero indicates that households buy from a single food category, while the maximum value refers to households buying equal shares of all n categories.

All three studies find that food expenditures or income are positively related to food diversity demand. Lee and Brown (1989) further find that the food diversity demand is positively related to receiving Supplemental Nutrition Assistance Program (SNAP) benefits, as well as household size, age and gender. Lee (1987) finds evidence of an inverse relationship between racial and food diversity, while Thiele and Weiss (2003) find that the food diversity demand is greater among single, male households and households with children.

3. 3 Theoretical Background

Following Lee and Brown's (1989), household demand for food diversity is derived from the traditional consumer utility maximization problem:

(3) $$\max_{\boldsymbol{q}} U(\boldsymbol{q}, \boldsymbol{z})$$

$$s.t.\ \ \boldsymbol{p} \cdot \boldsymbol{q} \leq m$$

$$\boldsymbol{q} \geq 0,$$

where $\boldsymbol{q}$ is a vector of household quantity demanded of n commodity categories, $\boldsymbol{p}$ is a vector of prices for the n commodities, m represents household expenditures on all commodities and $\boldsymbol{z}$ is a vector of demographic variables. Solving this problem yields a set of commodity demand equations. Assuming weak separability, the quantity demanded for food can be considered separately from that of other commodity categories and is defined as:

(4) $q_{Fi} = g_{Fi}(\boldsymbol{p_F}, m_F, \boldsymbol{z})$

where q_{Fi} denotes household quantity demanded of food category i, $\boldsymbol{p_F}$ is a vector of prices and m_F represents total household food expenditures. Expenditure shares for each food category, W_{Fi}, are then defined as:

(5) $W_{Fi} = \frac{p_{Fi} \cdot q_{Fi}}{m_F} = h_{Fi}(\boldsymbol{p_F}, m_F, \boldsymbol{z})$

Thus, a distributional measure of food diversity is given by:

(6) $D = d(W_{Fi}) = d\big(h_{Fi}(\boldsymbol{p_F}, m_F, \boldsymbol{z})\big) = f(\boldsymbol{p_F}, m_F, \boldsymbol{z})$,

where D is a measure for food diversity, typically the entropy or Simpson index.

3.4 An Alternative Group-Based Food Diversity Index

In calculating the diversity measure defined in Equation 6, all past economic studies on food diversity demand have used product codes to designate the *i* food categories. Product codes refer to classification systems created by market intelligence agencies, food retailers and government. Examples include the National Food Consumption Survey 15-digit code system and the Bureau of Labor Statistics 6-digit code system.

Classification of convenience foods is central to the product code-based approach. Unlike basic foods, which are raw or minimally processed, convenience foods have been processed or prepared to some extent by a manufacturer or food distributor with the express purpose of creating a time savings or an ease of preparation, or elimination of the need for preparation, by the consumer (Lee and Lin 2013). In the literature, foods are typically categorized into four groups based on their processed form: (1) basic foods, (2) complex ingredients, (3) ready-to-cook and (4) ready-to-eat (Okrent & Kumcu 2016).

While basic foods refer to raw or minimally processed foods, the remaining three categories represent different forms of convenience foods. Complex ingredients refer to processed foods used in producing a meal or snack (ex: vegetables, frozen meat), ready-to-cook refers to meals and snacks that require minimal preparation beyond heating or adding hot water (ex: frozen entrees, soup) and ready-to-eat refers to meals and snacks to be consumed as is (ex: refrigerated entrees, food away from home, canned fruit).

Under a product code-based classification scheme, basic and convenience foods are classified into separate categories. For example, instead of a single meat category, raw meat and frozen meat are classified as separate food categories, while frozen dinners are considered a separate category from the meat and vegetables they contain. Because convenience foods are a composition of basic foods in different processed forms, use of a product code approach leads to a diversity measure that not only captures diversity across food subgroups, but also diversity across processed form. This product code-based approach conflicts with the *DGA*'s definition of food diversity, in which diversity refers to variety across food subgroups, irrespective of processed form (US 2015).

Recent studies in the nutrition literature by Vadiveloo *et al* (2014) and Drescher *et al* (2007) develop Healthy Food Diversity (HFD) indices that designate food categories based on subgroups as defined in the *DGA* and *German Nutrition Society Guidelines*. These indices are an improvement over existing nutrition measures of food diversity, such as the Healthy Eating Index, which only measure consumption of select subgroups. Mirroring its German predecessor, the US HFD index developed by Vadiveloo *et al* (2014) is defined as:

(7) $US\ HFD = (1 - \sum_{i=1}^{n} w_i^2) * hv$

$s.t.\ hv = (\sum_{i=1}^{n} hf_i * w_i)$

where w_i is the share of each food subgroup i based on the volume of the total diet, *hv* is the health value of the individual's diet and hf_i is a health factor based on the DGA daily intake recommendations for each food subgroup. The index is calibrated by dividing by the maximum value of $(hf_i * w_i)$, resulting in a range of $[0, 1 - 1/n]$. The US HFD index was validated as a measure of nutritional adequacy through its strong correlation with individual dietary quality indicators (Vadiveloo *et al* 2014).

While the US HFD index uses a group-based food classification scheme and is a validated measure of nutritional adequacy, it is calculated using volume shares as opposed to expenditure shares which economic studies use to understand the demand for food diversity. The US HFD index reflects diversity across the volume of foods individuals consume and uses actual consumption data from dietary recall surveys. In contrast, economic studies on food diversity demand tend to use food acquisition data from scanner datasets and household surveys to analyze diversity in household food expenditures. Complementing analyses conducted using volume shares, use of expenditure shares allows economists to consider another dimension of food diversity and therefore better inform food assistance and nutrition policy.

Thus, in this study, a group-based food diversity index is developed based on the US HFD, which represents diversity in household expenditures across food subgroups. This group-based index is then applied to reassess household demand for food diversity. Following Vadiveloo *et al* (2014), we designate the $i = 1, \ldots, n$ food categories based on the USDA's MyPlate food subgroups (US 2016a). Detailed in Figure 3.1, this group-based approach to classification yields 23 categories. For each basic food item $b =$

IRI Basic Food Categories / MyPlate Food Subgroups (N=23)

Cheese	Meat	Soy
Milk	Poultry	Dark Green Veg.
Yogurt	Seafood (Hi-Fat)	Tomatoes
Citrus, Melon, Berries	Seafood (Low-Fat)	Other Red/Orange Veg.
Other Whole Fruit	Cured Meat	Potatoes
Fruit Juice	Organ Meat	Other Starches
Refined Grains	Eggs	Other Vegetables
Whole Grains	Nuts/Seeds	

IRI Convenience Food Categories (N=91)

Food Away From Home	Frozen Meat	Pies/Cakes
Appetizers - FZ[a]	Fruit - FZ	Pies - FZ
Asian Food	Gelatin/Pudding	Pizza -FZ
Baked Beans	Hot Cereal	Pizza - RFG
Bakery Goods - RFG[b]	Ice Cream Cones/Mix	Pizza Products
Bakery Snacks	Ice Cream/Sherbet	Plain Vegetables - FZ
Baking Mixes	Instant Potatoes	Popcorn
Baking Needs	Jellies/Jams/Honey	Potatoes/Onions - FZ
Bottled Juices - FZ	Juices - FZ	Poultry Substitutes - FZ
Bread/Dough - FZ	Luncheon Meats	Poultry - FZ
Breakfast Food - FZ	Lunches - RFG	Prepared Deli Food - RFG
Cake - SS	Meat - FZ	Prepared Vegetables - FZ
Canned/Bottled Fruit	Meat - SS	Processed Poultry
Cheesecakes	Mexican Foods	Salad Toppings
Chocolate Candy	Mexican Sauce	Salad/Coleslaw - RFG
Cold Cereal	Microwave Dinners	Salty Snacks
Cookies	Non-Fruit Drinks - SS	Seafood - FZ
Crackers	Non-Chocolate Candy	Seafood - SS
Desserts - RFG	Novelties - FZ	Side Dishes - RFG
Desserts/Toppings - FZ	Other Breakfast Food	Snack Bars
Dinners - SS[c]	Other Foods - FZ	Snack Nuts/Seeds
Dinners/Entrees - FZ	Other Snacks	Soup
Dips - SS	Pancake Mixes	Soup/Sides - FZ
Dips - RFG	Pasta	Spaghetti/Italian Sauce
Dough/Biscuit - RFG	Pasta - FZ	Specialty Nut Butter
Dry Dinner - Add Meat	Pasta - RFG	Stuffing Mixes
Dry Dinner Mixes	Pastry Doughnuts	Toaster Pastries/Tarts
English Muffins	Peanut Butter	Tomato Products
Entrees - RFG	Pickles/Relish - RFG	Tortilla/Egg Roll Wraps
Fish/Seafood - FZ	Pickles/Relish/Olives	Vegetables - SS
Fresh Bread/Rolls		

[a]Frozen [b]Refrigerated [c]Shelf-stable

Product Code Food Categories (N=114) Group Food Categories (N=23)

Figure 3.1 Group and Product Code-Based Food Categories

$1, \ldots, B$, we denote the price and quantity demanded as p_{Fb} and q_{Fb}. Similarly, for each convenience food item $j = 1, \ldots, J$, we denote the price and quantity demanded as p_{Fj} and q_{Fj} Total household food expenditures are denoted by m_F. It is important to note that each food item is comprised of at least one food category i. For example, a macaroni and cheese frozen dinner contains refined grains, cheese and milk. We alter Equation 5 to account for this relationship as follows:

(8) $$W_{Fi}^{G} = \frac{\sum_{b=1}^{B}(p_{Fb}q_{Fb}d_{ib} + \sum_{j=1}^{J}(p_{Fj}q_{Fj})s_{ij}}{m_F}$$

where d_{ib} is a binary variable indicating which food subgroup i corresponds with basic food item *b* and s_{ij} represents the share of convenience food item *j* comprised by food subgroup i. Table 3.1 provides an overview of the share of each food subgroup comprised by basic and convenience foods; for 13 of the subgroups, convenience foods comprise at least 50% of expenditures and thus will have a large impact on the diversity of household expenditures across food subgroups. For example, over 65% of household expenditures on the cheese subgroup are attributable to convenience foods. The expenditure shares in Equation 8 are then used to calculate the group-based entropy index of food diversity as follows:

(9) $$E^{G} = \frac{-\sum_{i=1}^{n}(W_{Fi}^{G})\log(W_{Fi}^{G})}{\log(23)}$$

Deviating from Vadiveloo *et al*'s (2014) US HFD index, a health value is not incorporated into Equation 9 given that it is calculated using expenditure shares. In the US HFD index, the health value is calculated based on subgroup volume shares and the DGA subgroup recommended daily values (RDV). Household food expenditures are not an accurate measure of volume, as they represent food acquisitions and not necessarily

Table 3.1 Share of Food Subgroups Comprised by the Product Code Index's Basic and Convenience Food Categories

Food Subgroup	Basic Food Categories (N=23)	Convenience Food Categories (N=91)
Cheese	34.9%	65.1%
Milk	61.6%	38.4%
Yogurt	90.9%	9.1%
Citrus, Melon, Berries	81.8%	18.2%
Other Whole Fruit	84.2%	15.8%
Fruit Juice	67.9%	32.1%
Refined Grains	29.6%	70.4%
Whole Grains	50.0%	50.0%
Meat	58.2%	41.8%
Poultry	34.6%	65.4%
Seafood (Hi-Fat)	50.0%	50.0%
Seafood (Low-Fat)	36.0%	64.0%
Cured Meat	71.7%	28.3%
Organ Meat	20.0%	80.0%
Eggs	50.0%	50.0%
Nuts/Seeds	58.8%	41.2%
Soy	75.0%	25.0%
Dark Green Vegetables	50.0%	50.0%
Tomatoes	34.1%	65.9%
Other Red/Orange Vegetables	4.5%	95.5%
Potatoes	54.1%	45.9%
Other Starches	9.0%	91.0%
Other Vegetables	51.7%	48.3%

individual food consumption. Further, food expenditures depend not only on quantity, but also on price variation due to quality. Thus, weighting Equation 9 by a health value will not result in a food diversity index that also represents adherence to the DGA's RDVs, as in Vadiveloo *et al* (2014).

In order to compare the group and product code-based food diversity indices, the entropy index in Equation 9 is standardized by dividing by log(23) (Tuomisto 2012). This results in a group-based food diversity index that ranges from $[0, 1]$, where zero refers to households buying from a single food category and one refers to buying equal shares of all 23 food categories.

For comparison, we also calculate a product code-based food diversity index. Under this approach, the *i* food categories are designated based on the Information Resources Inc.'s (IRI) food categories. Detailed in Figure 3.1, this results in 114 food categories, of which 23 are basic food and 91 are convenience food categories. Expenditure shares are calculated for each food category following Equation 5. The product code-based entropy food diversity index is then defined as:

(10) $$E^{PC} = \frac{-\sum_{i=1}^{n}(\frac{p_{Fi}q_{Fi}}{m_F})\log(\frac{p_{Fi}q_{Fi}}{m_F})}{\log(114)}.$$

This product code food diversity index ranges from $[0,1]$, where zero refers to households buying from a single food category and one refers to buying equal shares of all 114 food categories.

3.5 Empirical Model

As shown in Equation 6, the food diversity indices defined in Equations 9 and 10 can be expressed as a function of expenditure and demographic variables; as in past studies, prices are excluded due to multicollinearity issues. Following Thiele and Weiss (2003), both food diversity indices are specified as linear in independent variables, with the exception of household size, which is specified in exponential form. This results in the following equations:

(11) $$E^{G} = \alpha_0 + \sum_{i=1}^{3} \alpha_i EXP_k + \sum_{i=4}^{16} \alpha_i DEM_k + \varepsilon_k$$

(12) $$E^{PC} = \beta_0 + \sum_{i=1}^{3} \beta_i EXP_k + \sum_{i=4}^{16} \beta_i DEM_k + \varepsilon_k,$$

where E^{G} is the group-based index, E^{PC} is the product code-based index and *k=1,…,K* is

Table 3.2 Variable Definitions

Variable	Definition	Unit	Base Variable
Food Diversity Indices			
Group Index	Group based food diversity index	Index	---
Product Code Index	Product code based food diversity index	Index	---
Independent Variables			
Basic Food Expenditures	Household weekly expenditures on basic foods	$	---
Convenience Food Expenditures	Household weekly expenditures on convenience foods	$	---
FAFH Expenditures	Household weekly expenditures on food away from home	$	---
Household Income	Monthly household income	$	---
SNAP	Household receives SNAP	DV	No SNAP
Female	Household head is female	DV	Male
Household Size	Size of household	#	---
College Degree	Household head has college degree	DV	No degree
Age	Age of household head	#	---
Hispanic	Household head is Hispanic	DV	White
African-American	Household head is African-American	DV	White
Asian	Household head is Asian	DV	White
Northeast	Household is in Northeast	DV	West
Midwest	Household is in Midwest	DV	West
South	Household is in South	DV	West

the set of all households. Detailed in Table 3.2, explanatory variables are grouped into two categories: (1) expenditures (*EXP*) and (2) demographics (*DEM*).

The first category of independent variables, is comprised of expenditures on three types of foods: (1) basic foods, (2) convenience foods and (3) food away from home (FAFH). Past studies find a positive relationship between food diversity and household expenditures on food (Lee 1987; Lee and Brown 1989; Jekanowski and Binkley 2000).

Jekanowski and Binkley (2000) explain that as household food expenditures increase, they purchase a greater variety of higher quality foods.

The second category of variables contains the following demographics: income, SNAP, gender, education, household size, age, race and region. Thiele and Finke (2003) find a positive relationship between household income and food diversity, explaining that households purchase a greater variety of non-essential food products as their income increases. Equations 11 and 12 also include a binary variable indicating whether households receive SNAP food assistance benefits. Lee and Brown (1989) find that increases in SNAP benefits are associated with increases in food diversity.

Past studies further find that food diversity increases at a decreasing rate given an increase in household size, suggesting there are economies of scale in the food diversity (Lee 1987; Lee and Brown 1989; Thiele and Weiss 2003). Thiele and Weiss (2003) further find evidence linking education to food diversity demand. Moon *et al* (2002) suggest that education increases knowledge of the nutritional benefits of consuming a varied diet. Similarly, Lee (1987) and Lee and Brown (1989) find that food diversity is greater for female-headed households, and posit that females place greater importance on the nutritional benefits of consuming a varied diet than males. Based on findings by Lee (1987), Lee and Brown (1989), Jekanowski and Binkley (2000) and Thiele and Weiss (2003), a household head's age is expected to have an inverse effect on food diversity.

3.6 Data

Required data on expenditures, food subgroup composition and demographics is obtained from the National Household Food Acquisition and Purchase Survey

(FoodAPS). Collected by the USDA's Economic Research Service and Food and Nutrition Service between 2012-2013, FoodAPS is a nationally representative survey of 4,826 households. Participating, households recorded all food purchases in a one-week food acquisition diary. Surveys were administered to collect demographic characteristics for each household. The dataset contains a total of 259,124 food purchases and provides descriptions, prices and quantity purchased for each item. Linked with IRI Market Research data, the dataset is ideal for calculating both group and product code-based diversity indices in that it provides the food subgroup composition for each item, as well as corresponding IRI product code-based categories.

Of the 4,826 households participating in FoodAPS, 165 do not report a food acquisition event and are removed from the sample. Following Murphy *et al* (2006), we remove food items whose consumption totals less than one-half of a serving of a food subgroup; this includes goods such as alcoholic and zero-calorie beverages. Free acquisitions not associated with coupon use are also removed. This results in a final sample of 4,341 households and 200,173 food items.

3.7 Results

3.7.1 Descriptive Statistics

Descriptive statistics for food diversity indices, expenditures and demographics are detailed in Table 3.3. On average, FoodAPS households spend the most food dollars, \$49.87 per week, on basic food items, followed by FAFH and convenience foods at \$32.92 and \$15.20 per week. Comparatively, households have an average monthly income of \$3,950, household size of three people and household head age of forty-six years. Of the households represented, 31% receive SNAP, 34% have a college degree and

Table 3.3 Descriptive Statistics

Variable	Mean	SD
Food Diversity Indices		
Group Index	0.68	0.12
Product Code Index	0.37	0.17
Independent Variables		
Basic Food Expenditures	49.87	49.38
Convenience Food Expenditures	15.20	19.25
FAFH Expenditures	32.92	39.35
Household Income	3949.80	4283.49
SNAP	0.31	---
Female	0.74	---
Household Size	3.01	1.73
College Degree	0.34	---
Age	45.91	16.30
Hispanic	0.20	---
African-American	0.14	---
Asian	0.04	---
Northeast	0.17	---
Midwest	0.25	---
South	0.36	---

38% are from a minority race. A total of 17%, 25% and 36% of households are located in the Midwest, Northeast and Southern regions of the US respectively.

Descriptive statistics strongly suggest that the two indices are representative of different types of food diversity. Shown in Figure C.1 in Appendix C, the two food diversity indices are only moderately correlated, with a correlation coefficient of 0.54. Using Welch's T-Test, the mean group and product code-based food diversity scores

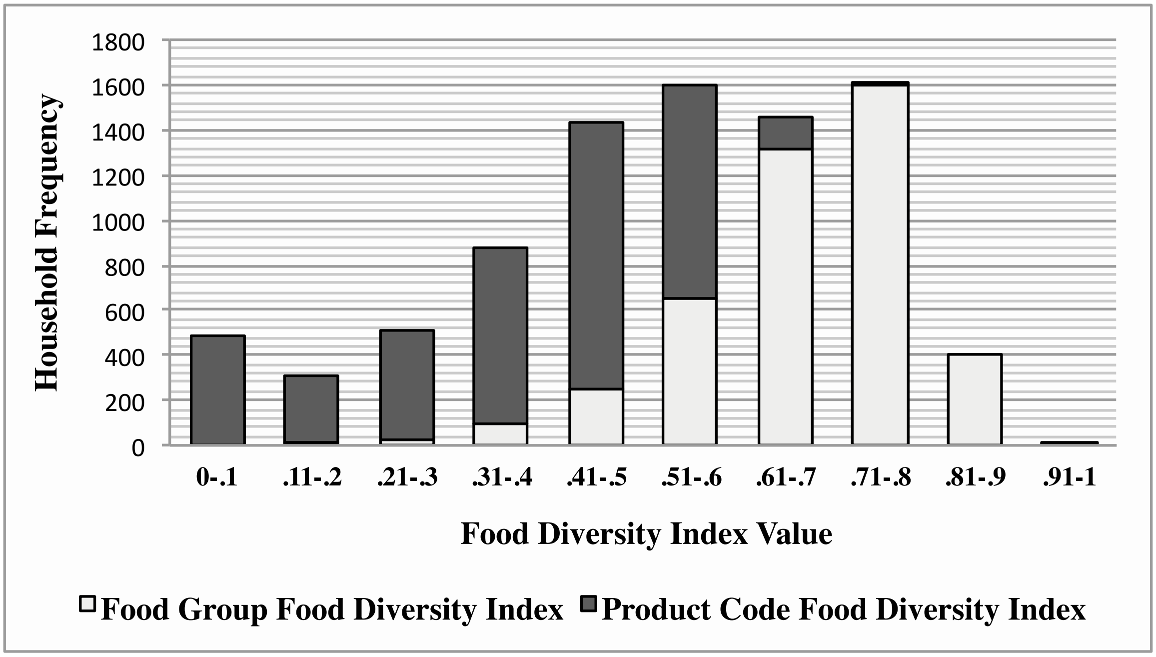

Figure 3.2 Distribution of Group and Product Code Food Diversity Indices

differ at the 1% level. With mean values of 0.68 and 0.37, households' group-based index is nearly double that of their product code-based food diversity score. Figure 3.2 details the distribution of the two food diversity indices. Both indices are left skewed, with the group and product code indices having a skewness of -1.18 and -0.75. This finding suggests that, for both indices, there are few households with low levels of food diversity. However, the group-based food diversity index is more highly left skewed than the product code-based index. This implies that households distribute their food expenditures more evenly across group-based categories than across product code-based categories.

The moderate level of correlation between the two indices, along with differences in means and skewness, supports the notion that the two measures are capturing different forms of food diversity. The group-based index is capturing diversity among food subgroups and thus diversity among the vitamins and minerals needed for a healthy diet. In contrast, the product code-based index is capturing diversity in processed form, as well

Table 3.4 OLS Regressions on Food Diversity Indices (N=4,341)

Variable	Group Diversity Index		Product Code Index	
	Coeff.	SE	Coeff.	SE
Basic Food Expenditures	0.001***	5.10E-05	0.002***	8.48E-05
Convenience Food Expenditures	0.001***	1.11E-04	0.003***	1.76E-04
FAFH Expenditures	0.001***	3.93E-05	-0.001***	4.67E-05
Household Income	5.26E-08	3.81E-07	7.99E-07	4.66E-07
SNAP	-0.015***	0.004	-0.008**	0.004
Female	0.015***	0.004	0.020***	0.004
Household Size	0.006*	0.004	0.015***	0.001
Household Size Squared	-0.001***	4.11E-04	-0.002***	0.001
College Degree	0.013***	0.003	0.008**	0.004
Age	3.26E-04	1.01E-05	0.001***	1.17E-04
Hispanic	0.004	0.004	0.005	0.005
African-American	-0.017***	0.005	-0.034***	0.006
Asian	-0.008	0.008	0.001	0.008
Northeast	-0.002	0.005	-0.002	0.006
Midwest	0.003	0.005	0.005	0.005
South	0.004	0.004	0.006	0.005
Constant	0.558***	0.010	0.211***	0.012
R-Squared	**0.33**		**0.58**	

Note: *, **, *** denote significance at the 10%, 5% and 1% significance level

as diversity in food subgroups. Given that both indices are calculated using the same set of food items, the lower product code food diversity scores suggest that households have less diversity in the processed form than in the types of food subgroups they purchase.

3.7.2 Regression Results

Equations 11 and 12 are estimated using OLS regression techniques, with the resulting estimates presented in Table 3.4. White-Huber standard errors are calculated to correct for heteroscedasticity. With R^2 values of 0.32 and 0.58, the estimated models explain a significant portion of the variation in the group and product code-based diversity indices.

3.7.3 Expenditures

Expenditures on basic foods, convenience foods and FAFH are found to have a significant, positive effect on households' group-based food diversity. For all three types of food expenditures, a \$1 increase results in a 0.001 increase in the group-based food diversity index, suggesting that households purchase a greater variety of foods as their expenditures increase. Putting this into perspective, a \$10 increase in any of the three types of food expenditures will increase the households' group-based food diversity score by 1%. The finding that all three expenditure coefficients are equal implies that, despite different processed forms, similar levels of food subgroup diversity can be obtained from purchasing basic foods, convenience foods and FAFH.

Expenditures on all three types of food also have a significant effect on product code-based food diversity. However, results indicate that expenditures on basic foods, convenience foods and FAFH have varying effects on product code-based food diversity. Increasing FAFH expenditures by \$1 results in a 0.001 decrease in the product code-based diversity index. This finding is the result of FAFH being comprised of only one convenience food category under the product code classification scheme. Thus, despite the fact that FAFH items are composed of a variety of food subgroups, increased expenditures on FAFH more highly concentrates food expenditures in a single food category, thus reducing diversity. Unlike FAFH, a \$1 increase in expenditures on basic (convenience) foods results in a 0.002 (0.003) increase in the product code-based diversity index. Convenience food expenditures have a larger effect than basic food expenditures because the product code-based food diversity index is comprised of 91 convenience food categories versus 23 basic food categories; households must spend a greater share of their food dollars on convenience versus basic foods to achieve the maximum food diversity score.

This rationale also explains why coefficients for basic and convenience food expenditures are larger than their group-based food diversity index counterparts. The product code-based food categories are specifically delineated into basic and convenience categories, making it highly responsive to the distribution of food expenditures across basic and convenience foods. In contrast, the group diversity index does not distinguish between basic and convenience foods, defining all food items in terms of their food subgroup composition. As with the descriptive statistics, these findings further suggest that the group-based index is capturing diversity in food subgroups, while the product code index reflects diversity in both processed form and food subgroups.

3.7.4 Demographics

Results indicate that household income does not significantly affect either food diversity index. This finding mirrors that of Jekanowski and Binkley (2000) who explain that much of the effect of income on food diversity likely operates through food expenditures. Unlike earned income, receiving SNAP has a significant, inverse effect on group and product code-based food diversity, suggesting that SNAP households' food purchases are less diverse than those of non-SNAP households. The magnitude of the coefficient for SNAP in the group-based diversity index equation is double that of the corresponding product code-based coefficient. This difference implies that SNAP households have greater diversity across processed forms than across food subgroups. Because food subgroups are representative of nutritional adequacy, use of a product code-based food diversity index in policy analysis may overstate the nutritional adequacy of food insecure households' food purchases.

Supporting prior findings by Lee (1987) and Lee and Brown (1989), female-headed households are found to have greater group and product code-based food diversity scores than male-headed households. While both coefficients are positive, at 0.020 the product-code coefficient for female-headed households is larger than its group-based food diversity counterpart of 0.015. This larger coefficient for the product score suggests that female-headed households' food purchases are more evenly distributed across processed form than across food subgroups.

Household size is found to have significant positive, but decreasing effect on both food diversity indices, suggesting that there are economies of scale in the diversity of food purchases. Specifically, the addition of a household member increases group (product code)-based food diversity at a decreasing rate until a household size of 3 (3.75) is reached, after which food diversity declines with household size. Also of note, the magnitudes of the household size and household size squared coefficients are double that of the product code-based coefficients. This suggests that larger households have lower food diversity across food subgroups than across processed forms. Thus, because food subgroups are representative of nutritional adequacy, use of a product code food diversity index in policy analysis may overstate the nutritional adequacy of larger households' food purchases.

Results further indicate that households with a college-educated head are associated with a 0.013 and 0.008 increase in group and product code-based food diversity. The larger effect of a college education on the group-based index suggests that college-educated households have greater diversity across food subgroups than across processed forms. Given the link between food subgroup variation and nutritional adequacy, this finding supports Moon *et al*'s (2002) hypothesis that education increases the likelihood of consuming a varied diet due to having greater knowledge of its nutritional benefits. Thus, use of a product code-based food diversity index to inform nutrition education policy may understate the effect education has on households' nutritional adequacy.

While a household head's age does not affect group-based food diversity, a one-year increase in the age increases a household's product code-based food diversity score by 0.001. Thus, relative to younger households, older households are expected to have greater diversity across processed form, but not across food subgroups. This result conflicts with findings by Lee (1987), Lee and Brown (1989) and Jekanowski and Binkley (2000), who find that food diversity decreases with age. However, these studies use datasets collected from 1977-1990. Thus, it is possible that the current generation of older households have greater variety across product code-based food categories.

While no significant effect is found for Hispanic or Asian households, we find that African-American households' group and product code-based food diversity indices are 0.017 and 0.034 lower than that of White households. The larger magnitude of the product code coefficient suggests African-American households have less diversity across processed form than across food subgroups. This corresponds with prior studies' findings that African-Americans are less likely to consume convenience foods (Harris and Shiptsova 2007; Lee and Lin 2013; Capps *et al* 1985).

3.8 Conclusions

In past economic studies on food diversity demand, diversity is defined as a measure of food expenditures across categories designated based on product codes. Under a product code classification scheme, foods are classified based on their processed form. This approach conflicts with the *DGA*, which defines food diversity as variety across food subgroups (US 2015). Given the increasing prevalence of convenience foods in US household diets, this study develops a group-based food diversity index based on the US HFD, which represents diversity in household expenditures across food subgroups, irrespective of processed form. This group-based food diversity index is then applied to reexamine the relationship between food diversity, expenditures and demographics. Further, estimates obtained using the group-based index are compared to those obtained using a traditional product code-based index.

The results from this paper confirm that the group and product code-based food diversity indices are capturing different forms of food diversity. Descriptive statistics indicate that the two indices are only moderately correlated and have varying means and skewness. Regression estimates show that food expenditures, SNAP, gender, age, household size, race and education significantly affect the diversity of household food purchases. However, the magnitude and direction of these effects vary for group and product code-based food diversity indices. In particular, receiving SNAP benefits has a larger inverse effect on group-based food diversity, suggesting that food insecure households have greater diversity across processed form than across subgroups. Further, education has a larger positive effect on group-based food diversity, indicating that educated households have greater diversity across subgroups than processed form. Also of note, expenditures on FAFH positively affect group-based food diversity, but have an inverse effect on product code-based food diversity.

Given the differences between the group and product code-based food diversity indices, it is essential that studies select a food diversity index that directly corresponds to their research question. Results suggest that a group-based food diversity index is appropriate for studies seeking to inform food assistance and nutrition policy, while a product code-based index is ideal for guiding food industry management's marketing strategies.

Past economic studies overwhelmingly cite food diversity's link with nutritional adequacy as their motivation for analysis, explaining that their findings have important implications for policy involving food assistance and nutrition education programs (Thiele and Weiss 2003; Lee and Brown 1989; Shonkwiler *et al* 1987; Lee 1987). While each of these studies use a product code-based food diversity index, the nutritional motivation of their analysis suggests that use of a group-based food diversity index, which reflects variation across food subgroups and thus essential nutrients, would be more appropriate. The results from this article indicate that the use of product code-based food diversity indices in these past studies likely led to estimates which understate the food diversity issues faced by SNAP households, as well as the potential mediating effects of education.

Differing from the majority of economic studies on food diversity, Jekanowski and Binkley (2000) analyze food diversity in order to guide food industry managers in their development of marketing strategies. In particular, understanding how market characteristics affect food diversity can help food industry manufacturers and retailers determine their optimal product mix, in terms of the number, processed form and packaging of the products offered. In this context, use of a product code-based index is ideal in that it captures diversity across both processed form and food subgroups.

APPENDICES

APPENDIX A Supplementary Material For Chapter 1

Table A.1 UK FSA's Nutrient Profiling Model A Points Allocation

Points	Energy (kJ)	Sat Fat (g)	Total Sugar (g)	Sodium (mg)
0	≤ 335	≤ 1	≤ 4.5	≤ 90
1	> 335	> 1	> 4.5	> 90
2	> 670	> 2	> 9	>180
3	>1005	> 3	> 13.5	> 270
4	> 1340	> 4	> 18	> 360
5	>1675	> 5	> 22.5	> 450
6	> 2010	> 6	> 27	> 540
7	> 2345	> 7	> 31	> 630
8	> 2680	> 8	> 36	> 720
9	> 3015	> 9	> 40	> 810
10	> 3350	> 10	> 45	> 900

Table A.2 UK FSA's Nutrient Profiling Model C Points Allocation

Points	Fruit, Veg & Nuts (%)	NSP Fiber (g)	Or AOAC Fiber (g)	Protein (g)
0	≤ 40	≤ 0.7	≤ 0.9	≤ 1.6
1	> 40	> 0.7	> 0.9	> 1.6
2	> 60	> 1.4	> 1.9	> 3.2
3	.	> 2.1	> 2.8	> 4.8
4	.	> 2.8	> 3.7	> 6.4
5	> 80	> 3.5	> 4.7	> 8.0

Table A.3 Double-Hurdle Model Estimates (N=3,894)

Variable	Participation	Expenditure Share
Income		
Low-Income/SNAP	-0.23***	-0.06***
Low-Income/Non-SNAP	-0.03	-0.01
Low-Access	-0.03	-0.03
Food Acquisition Characteristics		
FAH Healthy Share	-0.05	0.10***
Share of FAFH Purchases at Supermarkets	-0.34**	0.14***
Share of FAFH Purchases at Convenience	-0.58***	-0.08**
Share of FAFH Purchases at FSR	0.31***	0.25***
Share of FAFH Purchases at Other Retailers	-0.33***	0.09***
FAFH Visits	0.29***	1.83E-03
Household Characteristics		
Age	2.15E-03	2.36E-03***
College	-0.08	0.02
African-American	1.57E-03	0.01
Asian	0.18	0.14***
Hispanic	0.16*	0.01
Rural	-0.08	-0.04***
Midwest	-0.26***	-0.05***
South	-0.21**	-0.03
West	-0.16*	-0.02
Health Preferences		
Nutrition Search	0.12*	0.04***
Dieting	0.08	0.03***
Time Cost		
Healthy Time	0.03	0.03***
Inverse Mills Ratio	---	0.42***
Constant	0.21	0.05

Significant at the * 0.10 level, ** 0.05 level and *** 0.01 level

APPENDIX B Supplementary Material For Chapter 2

Table B.1 % Daily Value of Nutrients in 8oz of Assorted Fruit Juices Based on a 2,000 Calorie Diet

Nutrient	Apple Juice	Cranberry Juice Cocktail	Grape Juice (Purple)	Grapefruit Juice (White)	Orange Juice	Pineapple Juice	Prune Juice
Energy, kcal	6%	7%	8%	5%	5%	7%	9%
Protein, g	0%	0%	3%	2%	3%	3%	3%
Total sugars, g	76%	94%	119%	49%	63%	109%	109%
Dietary fiber, g	1%	0%	0%	1%	3%	2%	10%
Total fat, g	0%	0%	0%	0%	1%	0%	0%
Vitamin A, RAE	0%	0%	0%	4%	1%	0%	0%
Vitamin E, mg	0%	3%	0%	1%	2%	0%	2%
Vitamin C, mg	4%	100%	0%	156%	143%	42%	18%
Calcium, mg	2%	1%	0%	2%	2%	3%	3%
Phosphorous, mg	2%	0%	3%	4%	4%	2%	6%
Magnesium, mg	2%	1%	6%	8%	7%	8%	9%
Iron, mg	5%	1%	3%	3%	6%	4%	17%
Sodium, mg	0%	0%	0%	0%	0%	0%	0%
Potassium, mg	8%	1%	10%	11%	12%	9%	20%

Sources: O'Neil & Nicklas (2008); FDA (2013b)

APPENDIX C Supplementary Material For Chapter 3

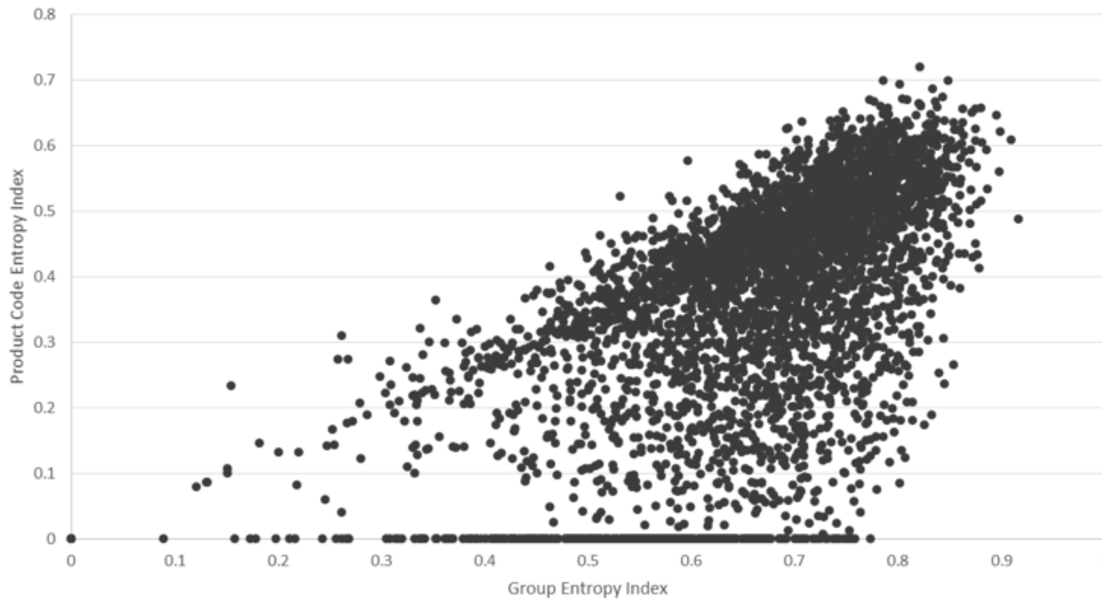

Figure C.1 Correlation of Group and Product Code Food Diversity Indices

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