U.S. Consumers' Intake of Food at Home (FAH) and Food Away from Home (FAFH) As a Complex Economic System

Faith Parum[a] and Senarath Dharmasena[b,Φ]

[a]*Undergraduate Honors Student, Department of Agricultural Economics,*
Texas A&M University,
2124 TAMU, College Station, TX 77843, USA

[b]*Associate Professor, Department of Agricultural Economics,*
Texas A&M University,
2124 TAMU, College Station, TX 77843, USA

Abstract

Americans spend billions of dollars in personal consumption expenditures each year. The percentage of FAH expenditures in the United States has been dwindling, while the percentage of FAFH expenditures has increased. Many factors might be causing this trend. Complex interactions of such factors determining the U.S. consumer's intake of FAH and FAFH expenditures were studied using machine learning and Directed Acyclic Graphical approaches. Employment and education status are common causes of both FAH and FAFH expenditures. Body mass index, marital status, race and sex have mixed effects. Findings will be useful for policy makers to implement social support programs.

Keywords: food at home, food away from home, TETRAD, directed acyclic graphs, machine learning

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[Φ]Corresponding author: Tel: (979) 862-2894
                           Email: sdharmasena@tamu.edu

Introduction

Americans spend 9.7% of their disposable income on food each year, and food expenditures are the third largest in the U.S. economy (Saksena et al., 2018; USDA, 2019). In 2018, Americans spent on average $7,923 on food (Bureau of Labor Statistics, 2019). These expenditures are commonly separated into two categories—food at home (FAH) and food away from home (FAFH). Over the last three decades, consumers' food expenditure patterns have shifted, as food away from home expenditures increased. surpassing food at home in 2009 for the first time. Many possible factors could be influencing this shift, including market shifts, micro and macroeconomic variables, socioeconomic status, and consumer tastes and preferences.

As of 2018, less than 50% of food expenditures were used to purchase FAH. According to the Economic Research Service (ERS) of the U.S. Department of Agriculture, food at home is all food purchased from supermarkets, retailers, smaller grocery stores, or supercenters (Saksena et al., 2018). It can include prepared or semiprepared items that are consumed off premise or at home (Saksena et al., 2018). Most of consumers' food expenditures were used for food at home until 2009. In fact, before the twentieth century, most FAFH meals were only for special events or celebrations, and these meals were normally brought from someone else's home (Saksena et al., 2018). FAFH did not begin to rise until the industrialization period at the end of the nineteenth century. The changing times, urbanization, and the creation of automobiles can be credited for changing the food market and the increasing FAFH expenditures (Saksena et al., 2018). Food away from home is defined as food obtained from restaurants (full service and fast food), school lunches, and an "other" category (vending machines, someone else) (Saksena et al., 2018). The rise of FAFH began at the end of the nineteenth century but did not become dominant until the end of the twentieth century. The creation of the automobile resulted in more workers traveling, thus increasing demand for taverns and cafeterias. However, the eating establishments were visited only if necessary, and most preferred food cooked at home (Saksena et al., 2018). As disposable income increased, more women entered the workforce, and restaurants began to increase in quality and quantity, food-away-from-home expenditures started to climb. However, most of these restaurants still catered to workers looking for a quick meal. It was not until the 1930s that restaurants began to focus on family dining (Saksena et al., 2018). This time also brought an increase in chain restaurants. In the 1960s, the number of restaurants began to increase, and by the 1980s the number had grown by 100% (Saksena et al., 2018). The changing food and work environments have caused more and more food expenditures to be spent on convenience food. Currently, FAFH expenditures account for over 50% of food expenditures (Saksena et al., 2018).

The growing complexity of the food environment and the variables that impact consumers' food expenditures have created complex interactions and have made it difficult to single out variables, specifically in assessing or creating various government policies. Factors that are causing Americans to consume food at home or away from home might be causing some other factors that are determining such consumption patterns. This interaction among variables makes the food purchase patterns a complex economic system. This study uses novel approaches in causality modeling developed using artificial intelligence and machine learning (such as directed acyclic graphs [DAGs]) to study U.S. consumers' intake of FAH and FAFH expenditures. Mapping these

complex interactions of variables creating the intake of FAH and FAFH expenditures can create useful information for policy makers to create viable support programs. In light of this, the main objective of this study is to discover factors that influence consumption of food at home and food away from home and, subsequently, to discover possible interactions among them.

Literature Review

Literature suggests that factors such as income, time constraints, the relative price of food and non-food items, and household demographic composition are important factors determining the U.S. consumer's food expenditures.

Income plays a large role in the demand for food products. Kamakura and Du (2012) found that the Engel curve (relationship between household income and expenditure on food) for FAFH is upward sloping or a normal good. In contrast, FAH was found to be downward sloping or an inferior good. This relationship was found by an empirical study of expenditures of 30 major commodities over two decades in which the United States faced three recessions. However, during recessionary times FAH expenditures increase and FAFH expenditures decrease (Kamakura and Du, 2012; Saksena et al., 2018).

Time constraints, according to Rahkovsky and Young (2018), can lead to changes in consumers' intakes. This study used the Exact Affine Stone Index (EASI) implicit Marshallian demand model with data from the National Household Food Acquisition and Purchase Survey (FoodAPS) to determine how time constraints influence food demands. As income increases, a higher percentage of expenditures move to more full-service restaurants or more convenient food options. This move can be a costly choice, both in dollars and in nutrition. Food away from home tends to be higher in both categories (Young and Rahkovsky, 2018). Employment can affect consumption patterns as well. Households in which all adults were employed spent more at restaurants. However, if the primary shopper was unemployed, they spent only 36% of their food budget on FAFH (Young and Rahkovsky, 2018). Household demographics, such as age, household size, and structure of the household, could play a large role in food purchases due to stricter time constraints.

Data and Methodology

Data from the USDA Food Acquisition and Purchase Survey (FoodAPS) was used in this study. This survey is a national panel of 4,826 U.S. households and contains information about individual's purchases (USDA-ERS, 2017). Included in this data were FAH and FAFH purchases among a host of other variables. The group sample varies, from those who participate in nutrition assistance programs, low-income households not participating in these programs, and households with higher incomes. FoodAPS participants collected data in seven-day periods between April 2012 and January 2013. They collected all information about purchases at and away from home. These households were instructed to save receipts, scan barcodes, and record other information in food journals (Senia, 2017). The information includes "the quantities, prices, and expenditures for all at home and away from home foods and beverages purchased or acquired by all household members, eating occasions by household members" (Senia, 2017). Other factors were collected

such as income, program participation, food security, health status, and distance to local supermarkets. Data from this survey were also broken down into individual results of the 14,317 members of the household. This analysis allowed us to use the individual level variables, such as Body mass index (BMI), in this study. Because BMI is only available for individuals older than 2 years old, we removed all children under 2 years from this study. This is due to the inaccuracy of BMI for children under 2 as stated by the committee on childhood obesity (Senia, 2017). We also restricted the dataset for those over the age of 21. The exclusion of individuals under the age of 21 was due to a lack of data, which can be explained by the participant receiving meals from outside sources, such as schools. Another possible reason would be the lack of these individuals' purchasing power. If they did make food purchases, they were most likely recorded in their guardian's purchases. In the end, data from 9,152 individuals were used in the study.

Table 1 gives description and summary statistics for all variables used in this study. The average age is around 46 years, and 54% of the sample is female. The racial breakdown is as follows: 69% White, 14% Black, 5% Asian, 1% American Indian, and the remainder identify as another race or multiple races. Around 22% of the sample claim Hispanic ethnicity, 46% are married, 6% are widowed, 14% are divorced, 4% are separated, 30% have never been married, and 51% are employed. This study investigates how socioeconomic and individuals' characteristics affect and interact in consumer expenditure patterns in the United States. Patterns are developed using causality structures identified through cutting-edge machine learning algorithms. Some variables are set to be exogenous (such as race, age, sex) in this study. These causality structures are developed using Directed Acyclic Graphs (Pearl, 2009).

Using the Greedy Equivalence Search (GES) machine-learning algorithm, a graphical causal structure among variables was developed by searching over Markov equivalence classes (Meek, 1997; Chickering, 2002; Senia, 2017). Dharmasena et al. (2016) used these techniques to develop causality models on U.S. food environment factors. GES is run using the TETRAD statistical program. This algorithm finds the optimal causal structures that minimize Bayesian Information Criteria (BIC). The BIC approximation is explained in Chickering (2002) from the Schwarz Loss Function, and it underlines the assumptions of GES. The assumptions are causal sufficiency condition, causal faithfulness condition, and causal Markov condition (Dharmasena et al., 2016). Causal sufficiency condition assumes that the variables identified are sufficient to be in the model to develop the DAG of food expenditure patterns. Causal faithfulness condition shows that the edge removal is solely dependent on the correlation and conditional correlations between variables and not due to deep parameter cancellations between the nodes. Causal Markov condition assumes that the joint probability distribution of the variables under consideration is determined by the product of marginal probabilities of each variable and the conditional probability of a given variable, only conditioned on the preceding parent variable. More discussion on these is found in Dharmasena et al. (2016).

Table 1. Descriptions of Variables and Descriptive Statistics

Variable Name	Variable Description	Mean	Std. Dev	Min	Max
FAH	Money spent on Food at Home ($/person/week)	52.06	84.67	0	1,810.05
FAFH	Money spent on Food Away from Home ($/person/week)	17.87	35.42	0	646.78
BMI	Individual's calculated Body Mass Index	28.28	6.93	0.81	160.15

Variable Name	Variable Description	Percentage			
Sex	Female	54			
	Male	46			
Hispanic	Hispanic	22			
	Non-Hispanic	78			
Race	White	69			
	Black	14			
	American Indian	1			
	Asian	5			
	Other	9			
	Multiple race	13			
Education	Less than 10th grade	13			
	High school, no diploma	6			
	High school, diploma	32			
	Some college	29			
	Bachelor's degree	13			
	Master's degree or doctorate	6			
	No education	< 1			
Marital	Married	46			
	Widowed	6			

Table 1. (continued)

Variable Name	Variable Description	Percentage
Marital (continued)	Divorced	14
	Separated	4
	Never married	30
Employment	Employed	51
	Unemployed	49

Results

Figure 1 shows the Directed Acyclic Graph (causality structures) developed for consumer expenditures and various variables. The edges with direction dictate the predictor and the predicted variables in the regression model (Kim and Dharmasena, 2018). "Each number on an edge is the estimated slope coefficient of the predictor variable when the arrow-received variable (dependent variable) is regressed on every causing variable (independent variable)" (Kim and Dharmasena, 2018). Table 2 provides the estimated coefficients for all edges (marginal effects), as well as the *p*-values. All the variables are significant at a 1% level or lower.
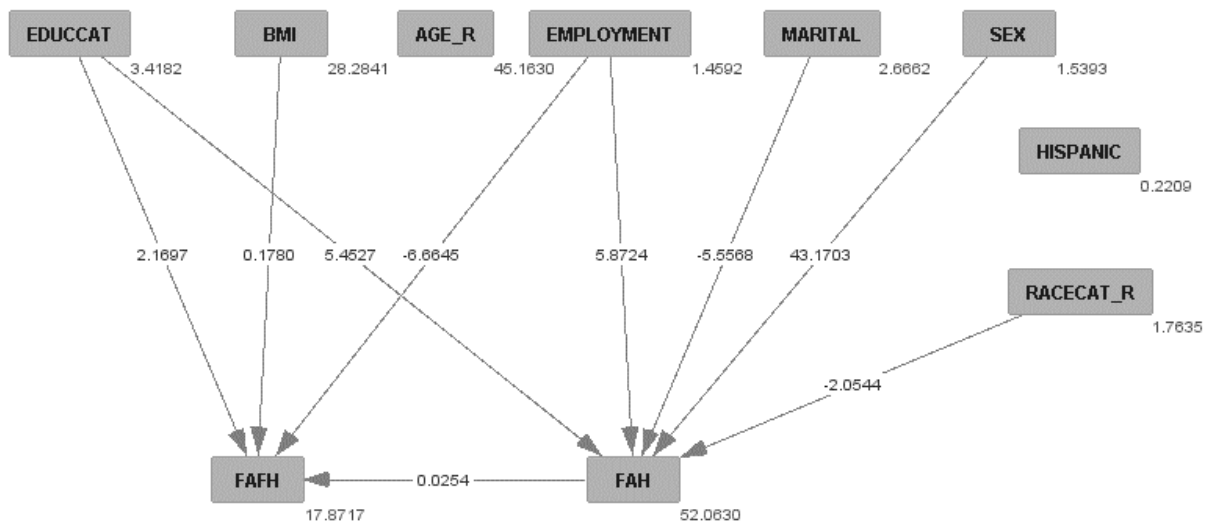

Figure 1. Directed Acyclic Graph (DAG) of Consumer Expenditures on FAH and FAFH

Note: Marginal effects are the numbers shown on arrows. The numbers by the boxes are means for each variable.

First, there is a contemporaneous causality relationship between food at home and food away from home expenditures, meaning more food at home purchased leads to an increase in food away from home purchases. However, this is a weak effect and can be explained by other factors. Sex was found to have the largest impact on FAH, with women purchasing more than their male counterparts. Marital status and race have a negative impact on FAH. Employment effects both FAH and FAFH but has differing signs as it negatively impacts food away from home and positively impacts food at home. Education has a positive effect on both FAFH and FAH. BMI has a positive effect on FAFH. This model found that age and ethnicity are not determining factors of FAH and FAFH expenditures.

Table 2. Parameter Estimates for Each Edge

From	To	Edge Coefficient*	*p*-Value
FAH	FAFH	0.0254	<0.0000
BMI	FAFH	0.1780	0.0008
Education	FAFH	2.1697	<0.0000
Employment	FAFH	-6.6645	<0.0000
Race	FAH	-2.0544	0.0008
Employment	FAH	5.8724	0.0007
Marital	FAH	-5.5568	<0.0000
Sex	FAH	43.1703	<0.0000
Education	FAH	5.4527	<0.0000

Note: Significance level considered is *p*-value 0.01; *Edge Coefficient is the partial effect of the variables.

Conclusions

Factors affecting FAFH expenditures are an individual's education status, body mass index, and employment status. Food-at-home expenditures are determined by the individual's education status, employment status, marital status, gender, and race. The resulting knowledge of direct and indirect causal relationships among consumer expenditures and other factors will be useful in food marketing, as well as for government policy makers to design appropriate food assistance programs.

Acknowledgements

References

Bureau of Labor Statistics, Department of Labor. 2019. *Consumer Expenditures—2019*. Available online: https://www.bls.gov/news.release/pdf/cesan.pdf

Chickering, D.M. 2002. "Optimal Structure Identification with Greedy Search." *Journal of Machine Learning Research* 3:507–554.

Dharmasena, S., D.A. Bessler., and O. Capps Jr. 2016. "Food Environment in the United States as a Complex Economic System." *Food Policy* 61:163–175.

Kamakura, W.A., and R. Yuxing Du. 2012. "How Economic Contractions and Expansions Affect Expenditure Patterns." *Journal of Consumer Research* 39(2):229–247.

Kim, Y., and S. Dharmasena. 2018. "Price Discovery and Integration in U.S. Pecan Markets." *Journal of Food Distribution Research* 49(1):39–47.

Okrent, A., and A. Kumcu. *U.S. Households' Demand for Convenience Foods*. Washington, DC: U.S. Department of Agriculture, Economic Research Service.

Pearl, J. 2009. *Causality: Models, Reasoning, and Inference*. New York, NY: Cambridge University Press.

Rahkovsky, I., and Y. Jo. 2018. *Higher Incomes and Greater Time Constraints Lead to Purchasing More Convenience Foods.* Washington, DC: U.S. Department of Agriculture, Economic Research Service.

Saksena, M., A. Okrent, T.D. Anekwe, C, Cho, C. Dicken, A. Effland, H. Elitzak, J. Guthrie, K. Hamrick, Jeffrey Hyman, Y. Jo, B-H. Lin, L. Mancino, P.W. McLaughlin, I. Rahkovsky, K. Ralston, T.A. Smith, H. Stewart, J.E. Todd, and C. Tuttle. 2018. *America's Eating Habits: Food Away from Home*. Washington, DC: U.S. Department of Agriculture, Economic Research Service.

U.S. Department of Agriculture. 2017. *National Household Food Acquisition and Purchase Survey (FoodAPS)*. Washington, DC: U.S. Department of Agriculture, Economic Research Service.

U.S. Department of Agriculture. 2019. *Americans' Budget Share for Total Food Has Changed Little during the Last 20 Years*. Washington, DC: U.S. Department of Agriculture, Economic Research Service.