Food Away from Home Consumption and Obesity: Is 'Average Consumer' a Myth or Reality?

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Abstract

The epidemic proportions of overweight and obesity prevalence have made it not only a public health threat, but also an economic problem. The high caloric density and increased consumption of food-away-from-home endorse the possibility of significant effects of it on obesity. The objective of this study is to model meals consumed away from home consumption by accounting for consumer heterogeneity in making food consumption decisions. We use random coefficient modeling to estimate a negative binomial model to reveal consumer heterogeneity effects on food away from home.

The results reveal significant associations between BMI_Status categories and food consumption both at home, but no significant associations with food away from home. We also established positive significant effects of caloric intake on meal consumption both at and away from home, with the latter being significantly larger than the former. The effects of the nutrient intake on meal consumption both at home and away from home have almost identical magnitude but opposite signs. The results of this research have significant policy implications as information on demographic profiles of people with overabundant but nutritionally poor food consumption habits would help to create more efficient and well targeted policy choices.

Introduction

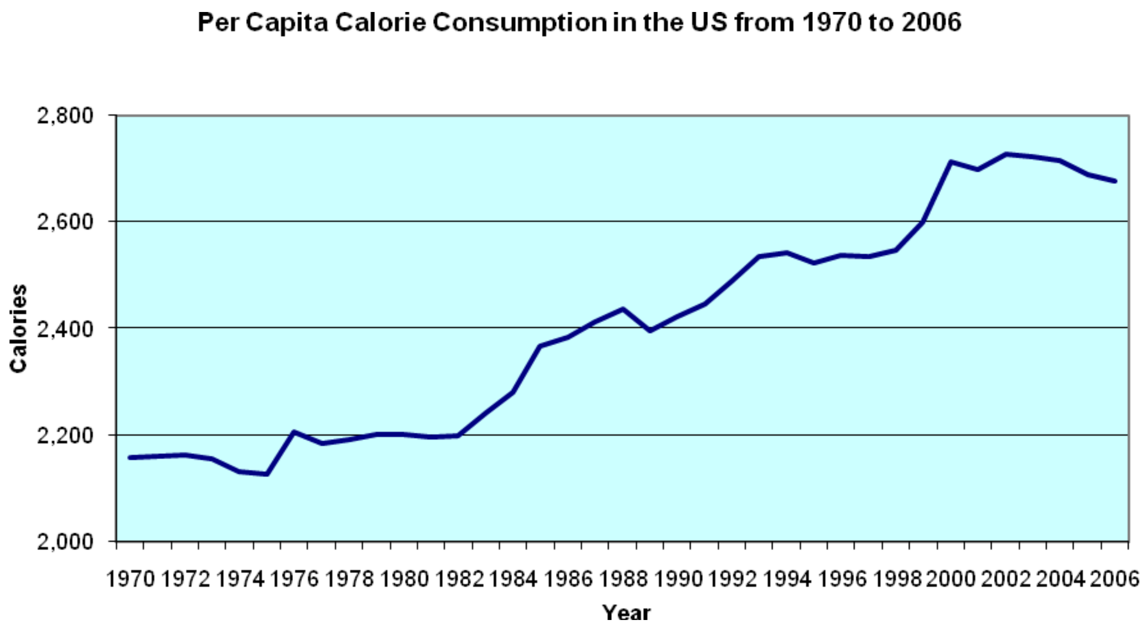
Obesity is a rapidly growing public health threat reaching epidemic proportions worldwide. It is prevalent in both developing and developed countries and affects both adults and children alike. The United States (US), being in forefront of this issue, has overweight rates of 75.6% and 72.6% and obesity rates of 36.5% and 41.8% among males and females, respectively. Health consequences associated with obesity have been extensively researched and are well documented, indicating rising premature death toll and decreasing life expectancy (Peeters et al, 2003; Pi-Sunyer, 1993, 2002). Various estimates of the economic cost of obesity reach up to one hundred billion U.S. dollars and comprise a sizable portion of public health expenditure (Wolf and Colditz, 1994, 1998).

While it is believed that genetic factors may predetermine the rate of metabolism, the relative briefness of obesity prevalence motivates inclination towards environmental and lifestyle factors as the ones tipping the balance between energy intake and energy expenditure. In the context of increased caloric intake, the rise in overweight and obesity rates could be explained by either an absolute increase in the amount of foods consumed or relative increase in the consumption of foods with high caloric density, or both. As demonstrated in the graph below, USDA data show that caloric consumption has indeed increased in the US from 2158 in 1970 to 2681 in 2005[1].

[1] Data available from Economic Research Service, USDA, at http://www.ers.usda.gov/Data/foodconsumption/FoodGuideIndex.htm

[2] Data available from Economic Research Service, USDA, at http://www.ers.usda.gov/Data/foodconsumption/FoodGuideIndex.htm

[3] This is a geocoded dataset, meaning dates of interviews and regions of survey participant residence are not



The relative increase in the consumption of foods with high caloric density has also increased. This trend is demonstrated by consumption levels of foods in USDA recommended food pyramid's seven groups, for the same time period. The graph below demonstrates this trend[2].

Lin, Guthrie and Frazão (1999) demonstrate that food-away-from-home (FAFH) has higher caloric density compared to food-at-home (FAH). This fact, coupled with the indication that FAFH expenditure share has in fact been increasing from about a third of total food expenditures in 1970 to almost a half in 2006, seems to endorse the possibility of significant effects of relative increase of FAFH consumption on overweight and obesity.

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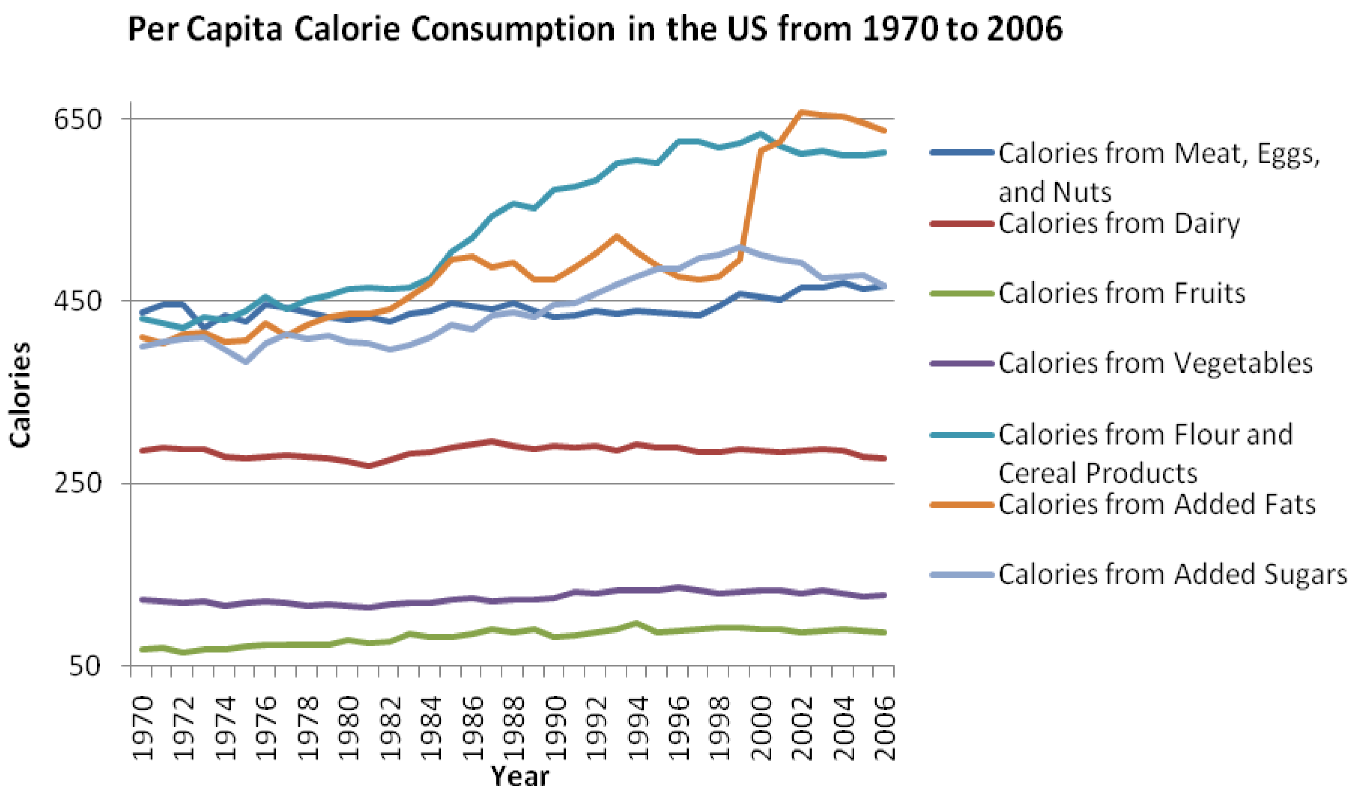
[2] Data available from Economic Research Service, USDA, at http://www.ers.usda.gov/Data/foodconsumption/FoodGuideIndex.htm



A number of studies have examined this issue in the past. For example, Rashad, Grossman and Chou (2005), Rashad (2006) and Binkley (2006), Binkley, Eales, Jekanowski (2000) have modeled the relationship between BMI and restaurant availability and the number of restaurant visits, respectively. A line of research has addressed this problem from the point of view of analyzing the effects (or elasticities) of different foods on weight, some estimated effects on a more aggregate level – by separable food groups. We find two problems with this approach – 1) these are all single-product models and do not allow for substitution, 2) given the diversity of food products in modern society, this approach can either lead to high dimensionality or less applicability in many cases.

Some researchers have studied foods as combinations of characteristics (macronutrients, for example) rather than even well-separable groups of foods (Richards, Patterson, Tegene, 2007). Reducing much more diverse product space to strictly finite characteristic space helps with keeping the curse of dimensionality under control, but is less intuitive. We find that dichotomizing the food space into two groups by food source is more appealing to the consumer consciousness than mere nutrient content information of foods. This approach would also help explain consumers' decision making in terms of meal choices rather than nutrient choices. This combined with health knowledge of consumers and moderated by the demographic profile of consumers help to explain the economic behavior of consumers from yet another point of view.

The objective of this study is to model consumer behavior by allowing heterogeneity in consumer types while still limiting the food choice to only two types of foods – Food At Home (FAH) and Food Away From Home (FAFH). The contribution this study seeks to make is

(1) Allow consumers to react differently to energy intake, depending whether their weight status is obese, overweight, normal weight or underweight;

(2) In the light that there are two aspects to each food intake – calories and nutrients, we are going to assume that consumers can react differently to energy intake depending whether they are calorie optimizers or nutrient optimizers;

In the light of the problem as described above, to better understand and interpret consumer behavior we advocate the use of the Random Coefficient Model (RCM) as a more appropriate tool to highlight consumer behavior differences and similarities.

Empirical Model

The implication of RCM approach on food consumption choices, in contrast to standard linear demand approach, is the significant fact that consumer heterogeneity is taken into account. Formally, we are going to assume that for our purposes there are only two kinds of foods consumers can choose – FAH and FAFH. Correspondingly, the demand as a result of some implicit utility maximization process, depends on personal heterogeneous factors such as health-consciousness and weight status captured by Body Mass Index (BMI), and demographic profile comprised of age, sex, marital status, race, etc.

$$Q_{ij} = \eta_i + \sum_{m=1}^{M} \gamma_{im} + \varepsilon_{ij}$$

Where Q_{ij} is the number of meals *j* consumed by person i, s.t. $j \in \{FAH, FAFH\}$, η_i is the vector of two health-consciousness – Calorie- and Nutrient- metric, and BMI variables for person *i,* and γ_{im} is a vector of *m* demographic variables for person *i*.

We are going to allow heterogeneous preferences on consumers' part, concerning their attitudes toward 1) caloric intake, 2) nutrient intake and by their 3) health condition expressed by BMI:

$$\eta_i = \sum_{l=1}^{3} \beta_{il} \eta_{il}$$

So that unobserved consumer heterogeneity is reflected in each of these characteristic factor's marginal effect:

$$\beta_{il} = \beta_l + \mu_{il}, \qquad \mu_{il} \sim N(0, \sigma^2)$$

We use non-linear random coefficient modeling to estimate consumer heterogeneity effects on FAH and FAFH consumption (numbers of meal occasions consumed at home and away from home, respectively), Q_{ij} , that follow negative binomial distribution. This approach reveals differences in partial effects of Nutrient_Metric and Calorie_Metric on the two foods: FAH and FAFH, distinguished by heterogeneous consumer clusters.

Data

The data in this study come from the National Health and Nutrition Examination Survey (NHANES). NHANES is a program of studies designed to assess the health and nutritional status of adults and children in the United States. NHANES is a major program of the National Center for Health Statistics, which is a part of the Centers for Disease

Control and Prevention (CDC). Although this is a continuous survey, the results are reported biennially. The particular survey used in this study is NHANES 2001-2002.

This is a 24-hour dietary intake recall dataset comprised of 143,004 food consumption observations for 11,039 individuals for the period of January 1, 2001 to December 31, 2002[3]. Since this study is concerned about adult choice behavior only, observations for individuals 19 years old and younger and observations with missing values were eliminated from the sample, leaving us with 4209 individuals/observations.

The first of the consumer specific variables mentioned above – Nutrient_Metric, is constructed by summing up nutrient intake data about 10 vitamins (vitamins A, C, B2, B12, etc.), 9 elements (calcium, magnesium, etc.), and 3 macronutrients (protein, carbohydrates, fat), for each occasion of food consumption for each meal occasion distinguished by food source (at-home or away-from-home).

These aggregated variables are then compared to daily requirements/allowances (by age and by sex) and the ratios of distances (absolute distance, in nutrient case) and recommended levels are formed:

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[3] This is a geocoded dataset, meaning dates of interviews and regions of survey participant residence are not revealed for confidentiality purposes.

$$Nutrient\_Metric = Average\begin{pmatrix} \dfrac{|Calcium\_recommended - Calcium\_actual|}{Calcium\_recommended} \\ \vdots \\ \dfrac{|Fiber\_recommended - Fiber\_actual|}{Fiber\_recommended} \end{pmatrix}$$

The daily requirements are differentiated by respondent's gender and age group: four age groups (i) less than 30 years old, (ii) 31-50 years old, (iii) 51-70 years old, and (iv) 71 or more years old, therefore comprising eight categories altogether.

The complete list of nutrients, along with their daily requirements is presented in Table 1 below.

Based on the nutrient intake as defined in Table 1 below, a binary variable measuring the consumer nutrient-consciousness, *nutrient*, was created that essentially indicates the over or under consumption of nutrients based on the Euclidian distance between each consumer's nutrient consumption (differentiated by gender and by age) and the 'ideal' point (where the person should be based on gender and age) in the 22-dimensional nutrient space.

The second of the consumer specific variables mentioned above – Calorie_Metric, is constructed by summing up caloric intake data per person:

$$Calorie\_Metric = \frac{Calories\_recommended - Calories\_actual}{Calories\_recommended}$$

Table 1. Vitamins, Minerals and Macronutrients and Their Daily Requirements[4,5] Used in the Nutrient_Metric.

	Males				Females			
Age Group	< 30	31 - 50	51 - 70	> 71	< 30	31 - 50	51 - 70	> 71
Vitamins:								
Vitamin_A	900	900	900	900	700	700	700	700
Vitamin_C	90	90	90	90	75	75	75	75
Vitamin_E	15	15	15	15	15	15	15	15
Vitamin_K	120	120	120	120	90	90	90	90
Vitamin_B1	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1
Vitamin_B2	1.3	1.3	1.3	1.3	1.1	1.1	1.1	1.1
Niacin	16	16	16	16	14	14	14	14
Vitamin_B6	1.3	1.3	1.7	1.7	1.3	1.3	1.5	1.5
Folate	400	400	400	400	400	400	400	400
Vitamin_B12	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Minerals								
Calcium	1000	1000	1200	1200	1000	1000	1200	1200
Magnesium	400	420	420	420	310	320	320	320
Phosphorus	700	700	700	700	700	700	700	700
Iron	8	8	8	8	18	18	8	8
Zinc	11	11	11	11	8	8	8	8
Copper	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Sodium	2880	2640	2400	2400	2400	2160	1920	1920
Potassium	4200	3850	3500	3500	3500	3150	2800	2800
Selenium	55	55	55	55	55	55	55	55
Macronutrients								
Protein	56	55	50	50	50	45	40	40
Carbohydrate	130	130	130	130	130	130	130	130
Fat	78	72	65	65	65	59	52	52
Dietary_fiber	30	28	25	25	25	23	20	20

[4] Since the metric is a proportion value, it is unitless. Therefore we are skipping the measurement units for the saving space.
[5] The nutrient daily recommended values are acquired from the Center for Nutrition Promotion and Policy, USDA, and U.S. Food and Drug Administration, U.S Department of Health & Human Services.

The data, again, are differentiated by gender and by age. The specific sex-age requirements are presented in Table 2 below.

Table 2. Caloric Intake Daily Requirements[6] Used in the Calorie_Metric.

	Males				**Females**			
Age Group	< 30	31 - 50	51 - 70	> 71	< 30	31 - 50	51 - 70	> 71
Caloric intake	2400	2200	2000	2000	2000	1800	1600	1600

Based on the caloric intake allowances or requirements above, a binary variable measuring the consumer calorie-consciousness, *over_calorie*, was created that essentially indicates the over or under consumption of calories, that takes the value of 1 if the Calorie_Metric is positive (in case of calorie over-consumption) or 0 if the Calorie_Metric is negative (in case of calorie under-consumption).

The third consumer specific variable – BMI, is calculated using measured (not self reported) weight and standing height using the following formula:

$$BMI = \frac{Weight\_in\_kgs}{(Height\_in\_meters)^2}$$

[6] The nutrient daily recommended values are acquired from the Center for Nutrition Promotion and Policy, USDA.

BMIs were categorized according to the international standards of

Weight Category	BMI Range
Underweight	BMI < 20
Normal Weight	$20 \leq$ BMI < 25
Overweight	$25 \leq$ BMI < 30
Obese	$30 \leq$ BMI

The set of demographic variables includes age, education level, employment status, marital status and region of residence[7].

The variables' titles, their descriptions and summary statistics are provided in Table 3 below.

[7] Region will be included subject to the condition in the footnote above.

Table 3. Variable Summary Statistics and Descriptions[8]

Variable	Description	Mean	Median	Minimum	Maximum	Std Dev
FAFH	Number of meals consumed away from home	1.2	1.0	0.0	7.0	1.18
FAH	Number of meals consumed at home	2.63	3.0	0.0	7.0	1.21
BMI	Body Mass Index = Weight (in kilograms)/Height (in meters)	28.24	27.3	15.41	65.41	6.20
BMI_Status	Equals to 1 if BMI < 20 Equals to 2 if 20 ≤ BMI < 25 Equals to 3 if 25 ≤ BMI < 30 Equals to 2 if 30 ≤ BMI	2.94	3.0	1.0	4.0	0.88
Calorie_Metric	Measures calorie intake as a ratio of recommended calories by age and sex	0.09	0.03	-0.96	6.80	0.48
Nutrient_Metric	Measures nutrient intake as a ratio of recommended nutrient by age and sex	0.71	0.57	0.22	12.37	0.53
Over_Calorie	Equals 1 if Calorie_Metric is positive, 0 otherwise	0.52	1.0	0.0	1.0	0.50
Nutrient	Equals 1 if Nutrient_Metric is >1, 0 otherwise	0.15	0.0	0.0	1.0	0.35
PIR	Poverty-Income ratio	2.73	2.48	0.0	5.0	1.63
Male	Dichotomous variable equal to 1 if the respondent is male, 0 otherwise	0.47	0.0	0.0	1.0	0.50
Age	Respondent’s age in years	48.15	46	20	85	18.38
Married	Dichotomous variable equal to 1 if the respondent is married or living with a partner, 0 otherwise	0.64	1.0	0.0	1.0	0.48
Education	Dichotomous variable equal to 1 if the respondent has high school or higher education, 0 otherwise	0.47	0	0	1	0.50

[8] Summary statistics of some variables are not presented in this table for two reasons; Either the variable has got to be constructed using NHANES geocoded data (which is not publicly available), or due to last minute data file corruption the author could not make all the expected changes.

Results

The RCM results, consistent with the OLS results, indicate that associations between the number of meals away from home and BMI_Categories are not significantly different between obese and any other BMI_status categories. In other words, as far as trips to restaurants are concerned, consumers decisions are not affected by their BMI_status. Meals at home decisions for underweight and normal weight consumers, on the other hand, are positively and significantly different from obese consumers, indicating underweight and normal weight consumers consume more meals at home compared to obese consumers. For FAH decisions there is no significant difference between overweight and obese consumers.

The results indicate that males are significantly more likely to eat away from home than females consistent across RCM and OLS models. Age seems to have a positive significant effect on FAFH and no effect on FAH whatsoever. Income, consistent with the finding in literature, has positive significant effect on FAFH and negative significant effect on FAH. The quadratic effects of income on FAFH have been supported by both models, while the OLS method failed to capture the quadratic effect of income on FAH. The interaction term between age and income is uniformly insignificant. While consistent in signs, the OLS method fails to demonstrate the significance associations between education and both FAFH and FAH. Both RCM and OLS results indicate that married consumers eat significantly fewer meals away from home, and significantly more meals at home. This result makes a lot of intuitive sense and demonstrates the economies of scale of home food production.

Table 4. RCM and OLS Results by Food Source

Effect	BMI_ Status	Male	Random Coefficient Model FAFH Estimate (Pr > |t|)	Random Coefficient Model FAH Estimate (Pr > |t|)	Ordinary Least Squares Model FAFH Estimate (Pr > |t|)	Ordinary Least Squares Model FAH Estimate (Pr > |t|)
Intercept			-0.3625 (0.0091)	0.6111 (<.0001)	0.5270 (0.0006)	2.2101 (<.0001)
Over_Calorie			0.2801 (<.0001)	0.0854 (<.0001)	0.3061 (<.0001)	0.2056 (<.0001)
Nutrient			-0.1317 (0.0012)	0.1117 (<.0001)	-0.1340 (0.0091)	0.2778 (<.0001)
Age			0.01811 (0.0008)	0.0007 (0.7821)	0.0183 (0.0017)	-0.0024 (0.6933)
Age_Sq			-0.00035 (<.0001)	0.0001 (0.0100)	-0.0003 (<.0001)	0.0002 (0.0026)
Married			-0.08815 (0.0049)	0.1295 (<.0001)	-0.1300 (0.0005)	0.2971 (<.0001)
Education			0.07304 (0.0197)	0.0255 (0.0985)	0.0607 (0.1051)	0.0524 (0.1814)
PIR			0.3349 (<.0001)	-0.0773 (0.0006)	0.3724 (<.0001)	-0.1680 (0.0031)
PIR_Sq			-0.03886 (<.0001)	0.0069 (0.0461)	-0.0351 (<.0001)	0.0136 (0.1273)
Interaction			-0.00006 (0.92)	0.0004 (0.1391)	-0.0011 (0.0683)	0.0009 (0.1443)
BMI_Status	1		-0.06061 (0.3834)	0.0656 (0.0462)	-0.0285 (0.7233)	0.1654 (0.0501)
BMI_Status	2		-0.02786 (0.4648)	0.0474 (0.0106)	-0.0431 (0.3412)	0.1152 (0.0151)
BMI_Status	3		0.01616 (0.6430)	0.0064 (0.7070)	0.0338 (0.4164)	0.0192 (0.6588)
BMI_Status	4		0	0	0	0
Male		0	-0.1577 (<.0001)	0.1232 (<.0001)	0.1745 (<.0001)	-0.3002 (<.0001)
Male		1	0	0	0	0

Table 4. RCM and OLS Results by Food Source - Continued

			Random Coefficient Model	Random Coefficient Model	Ordinary Least Squares Model	Ordinary Least Squares Model
			FAFH	FAH	FAFH	FAH
Effect	**BMI_ Status**	**Male**	**Estimate (Pr > |t|)**	**Estimate (Pr > |t|)**	**Estimate (Pr > |t|)**	**Estimate (Pr > |t|)**
Fit Statistics						
AIC			11696.81	14015.82		
BIC			11791.99	14110.99		
Pearson Chi-Square / DF			1.03	0.53		
R-Square					0.1452	0.0959
Adj R-Sq					0.1426	0.0931

While both estimation methods demonstrate significant positive associations between caloric intake and the numbers of meal occasions (both at home and away from home), OLS estimates are larger in magnitude, with the OLS estimate in the FAH model being almost three times as large. In other words, consumers with calorie overconsumption consume three times more meals (0.2056) FAH meals than consumers with calorie under consumption (0.0854). As expected, nutrition-conscious consumers eat significantly fewer meals away from home and significantly more meals at home. Again, while the RCM and OLS estimates in FAFH models are almost identical, OLS estimate in FAH model is almost three times as large as the RCM estimate.

Conclusion

The results of this research are may have significant policy implications as information on demographic profiles of people with overabundant but nutritionally poor food consumption habits would help to create more efficient and well targeted policy choices. The results would also open up possibilities for healthy food marketing and health marketing, such as identifying the appropriate marketing tools to address appropriate market niche. The findings of this study might be accentuated especially that obesity appears to be the disease of the poor, making the reaction of the tails of the distribution more meaningful and revealing than merely explaining the traditional mean behavior.

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