ARE THE TOTAL DAILY COST OF FOOD AND DIET QUALITY RELATED: A RANDOM EFFECTS PANEL DATA ANALYSIS

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Abstract: There is a common perception that healthy food costs more than less healthy food. In this study we use a demand model for diet quality, rather than the quantity of food. Since in our data, total daily cost and diet quality are both calculated from the foods chosen, we account for the fact that cost is endogenous. We find that while total daily food cost is statistically significant in relation to diet quality, the degree of association is very small. Hence, it does not appear that cost alone prevents individuals in the United States from purchasing a healthy diet. Other factors such as food culture and environment, health behaviours, and demographics are more important. Our findings suggest that the choice to consume a healthy diet is very complicated.

Keywords: diet cost, cost of food, food culture, diet quality, HEI-2005, random effects model, demand model, NHANES, MPED, CNPP Food Prices Database

JEL codes: (D12: Consumer Economics: Empirical Analysis; C3: Multiple or Simultaneous Equation Models)

1. Introduction

During this world-wide economic downturn, the cost of a healthy diet is of particular concern to policy makers and consumers, particularly consumers who are experiencing a loss in income or were already low-income. The 2010 United States Dietary Guidelines Advisory Committee, which makes recommendations on dietary guidance for the US, has expressed concern over the affordability of a healthy diet (Dietary Guidelines Advisory Committee, 2010, 2010) .

Cost was the third most important influence on food choice, after taste and convenience in a survey in which Americans were asked why they ate certain foods (Glanz, et al., 1998). Another study concluded that although food costs are perceived to be a barrier to the adoption of a low-fat diet there was no difference in total food costs among children adhering to such a diet versus other diets (Mitchell, et al., 2000). Since cost is raised as a barrier to healthy eating, income has also been investigated. The non-poor spend more on fruits and vegetables than the poor (Stewart, et al., 2003).

Researchers have also addressed the question of how households and individuals could make healthier food choices without spending more on food. A costing of diets that complied with nutrition recommendations showed that healthful eating could reduce the total cost of food for most people (McAllister, et al., 1994). In a one-year, family-based treatment of children at risk of obesity, researchers found that as the household shifted to healthier options, the household actually spent less on food (Raynor, et al., 2002). The US Department of Agriculture (USDA) estimates the cost of food at home at four expenditure levels, assuming that individuals meet the Dietary Guidelines for Americans (Carlson, et al., 2007, 2007). Comparing these food plans to corresponding food expenditure levels, consumers can eat a healthy diet for the same as they are presently spending or less. Finally, a recent analysis by USDA suggests that cost comparisons should be made based on how much it costs to meet key dietary recommendations. Using this method, many fruits and vegetables are quite competitive in price to the cost of common portions of energy-dense foods such as many processed salty snack foods (Golan, et al., 2008). Following this reasoning, Stewart et al (forthcoming) finds that an individual can meet dietary reccomendations with a variety of fruits and vegetables within the budget of the Supplemental Nutrition Assistance Program (SNAP, formerly known as food stamps).

From an economic perspective, one way to examine the affordability question is to understand how consumers choose what foods to buy and eat. One could assume that consumers are maximizing utility subject to a budget constraint. Utility of food is a function of several attributes such as taste, the contribution the food will make to current and future health, and the environment where the food is consumed. In this paper, we estimate a model which can test the relationship between food cost and diet quality using two-day individual survey data. Future applications of the model are also discussed.

2. Model

Following utility maximization theory an individual *i*'s food demand can be expressed as:

(1) $$Dq_{it} = \alpha X_{it} + \beta P_{it} + u_i + \varepsilon_{it}$$

where Dq_{it} is the amount of food consumed by individual *i* at time *t* (t= 1 or 2 for 2 days of data), X_{it} is a vector of explanatory variables influencing food choices of individual *i* at time *t*. P_{it} is cost of food consumed by individual *i* at time *t*. α and β are conformable parameters to be estimated. Since, in this study we are more interested in the demand for a healthy diet than quantity of food, we convert consumed food quantity to the level of healthfulness of the daily diet. The detail of the conversion is given in the data section. In this model, a random effects term, u_i, is used to capture unobserved factors that influence individual *i*'s food choices, including food preferences or taste. The random effects are randomly distributed among individuals and constant over time for each individual. ε_{it} is used to account for data measurement and other errors.

In this study, the unit food cost P_{it} in (1) is calculated based on the quantity and type of food consumed by the individual, rather than independently measured. According to Theil (1952), Deaton (1988), and Dong, Shonkwiler, and Capps (1998), this quantity derived cost is endogenous. Following Dong, Shonkwiler, and Capps (1998), we define the endogenous food cost to have the following form:

(2) $$P_{it} = \gamma Z_{it} + e_{it}$$

Where Z_{it} is a vector of exogenous variables that influence an individual *i*'s food costs. Z_{it}, like X_{it}, can be individual characteristic variables that influence food choices and the quantity consumed, and in turn, influence food costs. That is, all variables that influence food choices will also influence the estimated food cost.

To estimate (1) and (2), we assume ε_{it} and e_{it} are jointly distributed normal with mean zero and variance-covariance matrix as:

$$(3) \qquad \Sigma = \begin{bmatrix} \sigma_\varepsilon^2 & \sigma_{\varepsilon e} \\ \sigma_{\varepsilon e} & \sigma_e^2 \end{bmatrix}.$$

We further assume the random effect u_i in (1) is also distributed normal with mean zero and variance σ_u^2, and u_i is not correlated with both ε_{it} and e_{it}. The reduced form of (1) by replacing P_{it} using (2) is:

$$(4) \qquad Dq_{it} = \alpha X_{it} + \beta(\gamma Z_{it}) + \omega_{it}$$

where $\omega_{it} = \beta e_{it} + u_i + \varepsilon_{it}$. If both ε_{it} and e_{it} are temporally independent in the two time periods, the variance-covariance matrix of ω_{it} and e_{it} for the two time periods can be written as:

$$(5) \quad \Omega = \begin{bmatrix} \sigma_\varepsilon^2 + \sigma_u^2 + \beta^2\sigma_e^2 + 2\beta\sigma_{\varepsilon e} & \sigma_u^2 & \beta\sigma_e^2 + \sigma_{\varepsilon e} & 0 \\ \sigma_u^2 & \sigma_\varepsilon^2 + \sigma_u^2 + \beta^2\sigma_e^2 + 2\beta\sigma_{\varepsilon e} & 0 & \beta\sigma_e^2 + \sigma_{\varepsilon e} \\ \beta\sigma_e^2 + \sigma_{\varepsilon e} & 0 & \sigma_e^2 & 0 \\ 0 & \beta\sigma_e^2 + \sigma_{\varepsilon e} & 0 & \sigma_e^2 \end{bmatrix}$$

Putting equations (1) and (4) together, we consider two time periods. We thus have four equations, which are jointly distributed normally. The log-likelihood function of equations (1) and (4) is thus:

$$(6) \qquad LL_i = -T\ln(2\pi) - \frac{1}{2}\ln|\Omega| - \frac{1}{2}(\omega_i' \; e_i')\Omega^{-1}\begin{pmatrix} \omega_i \\ e_i \end{pmatrix}$$

Where $\omega_i = \begin{pmatrix} Dq_{i1} - \alpha X_{i1} - \beta(\gamma Z_{i1}) \\ Dq_{i2} - \alpha X_{i2} - \beta(\gamma Z_{i2}) \end{pmatrix}$, $e_i = \begin{pmatrix} P_{i1} - \gamma Z_{i1} \\ P_{i2} - \gamma Z_{i2} \end{pmatrix}$ and $T = 2$.

Model estimates can be obtained from maximizing the sum of (6) over all individuals.

Elasticities for individual *i* are evaluated based on the expected values of the two endogenous variables given by equations (1) and (4). The two expected values can be written as:

(7) $$E(P_i) = \gamma \bar{Z}_i$$

(8) $$E(Dq_i) = \alpha \bar{X}_i + \beta(\gamma \bar{Z}_i)$$

In order to obtain the effect of cost on individual *i*'s diet quality, we derive the expected value of diet quality on a given cost as:

(9) $$E(Dq_i \mid P_i) = \alpha \bar{X}_i - \frac{\sigma_{æ}}{\sigma_e^2} \gamma \bar{Z}_i + (\beta + \frac{\sigma_{æ}}{\sigma_e^2})\bar{P}_i$$

Where the variable with a bar over it indicates the mean value of the variable over the two time periods.

The cost elasticity with respect to *Z* from (7) is:

(10) $$\frac{\partial E(P_i)}{\partial Z} \frac{\bar{Z}_i}{\bar{P}_i} = \gamma \frac{\bar{Z}_i}{\bar{P}_i}$$

The diet quality elasticity with respect to food cost from (9) is:

(11) $$\frac{\partial E(Dq_i \mid P_i)}{\partial P} \frac{\bar{P}_i}{D\bar{q}_i} = (\beta + \frac{\sigma_{æ}}{\sigma_e^2}) \frac{\bar{P}_i}{D\bar{q}_i}$$

The diet quality elasticities with respect to X and Z from (8) are:

(12) $$\frac{\partial E(Dq_i)}{\partial X} \frac{\bar{X}_i}{D\bar{q}_i} = \alpha \frac{\bar{X}_i}{D\bar{q}_i} \text{ and } \frac{\partial E(Dq_i)}{\partial Z} \frac{\bar{Z}_i}{D\bar{q}_i} = \beta\gamma \frac{\bar{Z}_i}{D\bar{q}_i}$$

For a common variable *W* in both *X* and *Z*, the diet quality elasticity can be derived from (8) as:

(13) $$\frac{\partial E(Dq_i)}{\partial W} \frac{\bar{W}_i}{D\bar{q}_i} = (\alpha + \beta\gamma) \frac{\bar{W}_i}{D\bar{q}_i}$$

For binary variables, we estimate the marginal impact of changing from one condition to another, where the other variables are held at their respective means. For example, if *W* is binary, equation (13) can be adjusted to calculate the percentage change in the marginal effect as:

$$(14)\quad \frac{\partial E(Dq_i)}{\partial W}\frac{1}{D\overline{q}_i} = (\alpha + \beta\gamma)\frac{1}{D\overline{q}_i}$$

3. Data and Variables

Data from the National Health and Nutrition Examination Survey (NHANES) 2003-04 were used for this study. NHANES collects information about participants' food consumption (in this paper food consumption refers to food that is actually eaten, not food that is purchased and potentially thrown out), demographic and socioeconomic characteristics, and health information obtained during a four-hour medical examination in a mobile examination center. As part of this exam, an in-person interviewer collects a 24-hour dietary recall, and a second day of dietary recall is collected within ten days of the first by telephone. Information about dietary intake for individuals 12 years and older is self-reported. The dietary recall data includes information on where the food was purchased and cosumed, and the day of the week of the recall. USDA later calculates the nutrient content of foods NHANES participants reported consuming. The My Pyramid Equivalent Database (Bowman, et al., 2008) allows us to calculate the MyPyramid equivalent amounts contained in each food; that is, the cups and ounces of fruits, vegetables, milk products, grains, and meat and beans. The two time periods in our model are represented by the first and second day of dietary intake. Most individuals eat different foods on the two days, and some change their food purchase habits (e.g., go out to eat one day, and eat food purchased at a grocery store another day). These differences will allow us to examine the impact of total daily food cost on diet quality.

NHANES 2003-04 is a complex, multistage probability sample of the civilian non-institutionalized population of the United States, and consists of a sampling of individuals of all ages. We included adults ages 20 and over with a reliable dietary recall for both of the two days. Once observations with missing information were removed, the final sample size is 3069 individuals. More information on the NHANES studies can be found elsewhere (Centers for Disease Control and Prevention (CDC), 2003-04).

We use the Healthy Eating Index-2005 (HEI-2005), developed by the USDA (Guenther, et al., 2006, 2008) to measure diet quality from the consumed quantities. This one hundred point scale measures how well a diet complies with The Dietary Guidelines for Americans 2005 (U. S. Department of Health and Human Services and U. S. Department of Agriculture, 2005), and includes component scores for fruits (total and whole), vegetables (total and legumes, orange and dark green), grains (total and whole grains), milk or soy beverage, meat and beans, oils, saturated fat, sodium, and discretionary calories (measured as Solid Fat, Alcohol, and Added Sugars or SoFAAS). For all components a higher score indicates closer adherance to dietary guidance. Thus, a higher score for the food groups and oils indicates a higher level of consumption, while a higher score for the saturated fat, sodium and discretionary calorie components indicates a lower level of consumption.

The NHANES does not collect information on food prices or expenditures for foods consumed. We use the 2003-04 CNPP Food Prices Database (Carlson, et al., 2008, Center for Nutrition Policy and Promotion USDA, 2009) to calculate the prices of food in the consumed form. The database price estimates account for the food purchased but lost in either preparation (peels, seeds, shells, bones and skins) or through cooking (moisture loss) and gives the cost of the food in its consumed form. Because the price only reflects the cost of preparing the food at home, we adjusted the cost upward for foods that were reported purchased at away from home sources. We can then calcualte the estimated total dietary cost for each individual on each day.

The other variables used as demand shifters include demographic variables, indicators of the individual's food culture, food behaviors on each day of intake, and health behaviors and indicators. Demographic variables include income, household size, age, education and gender. Based on our review of the literature (Arnade and Gopinath, 2006, Beydoun and Wang, 2008, Stewart and Blisard, 2008, Variyam, et al., 1998) we expect income, age, education, and being female to be positively associated with higher HEIscores. We introduce the food culture construct to identify variables that might indicate tastes, lifestyle, and familiarity of foods; these include marital status, race and ethnicity, and acculturation. We include marrital status because we hypothesize that singles and individuals in a domestic partnership or married may have different food behavior—singles are more likely to need to make arrangements to eat with others. Married couples include couples who are living as married. Hispanics and immigrants tend to have healthier diets than whites and native born individuals, but this drops off as the individual becomes more aculturated to mainstream US dietary habits (Aldrich and Variyam, 2000).

Food behaviors are factors that could change between the two dietary recall days and include the percent of total energy consumed at each meal and snacks; and the percent of energy that was purchased from counter-service restaurants, table- service restaurants, and other away from home food venues such as cafeterias, recreation facilities, or movie theaters. Studies have found that away from home sources tend to lower diet quality on that day (Beydoun, et al., 2008, Mancino, et al., 2009, Todd, et al., 2010)**.** Spreading calories out throughout the day may also improve diet quality, particularly by eating breakfast (Morgan, et al., 1986). For Americans, spreading calories out generally means increasing calories at breakfast and lunch, and decreasing calories consumed at the evening meal and snacks. We anticipate that food habits will be different between the week day and the weekends. However, we believe Friday may be different since individuals may be more or less inclined to go out for dinner on Friday night, or even Friday lunch may be different from other days of the week.

Finally, we consider health behaviors as indicators of how much the individual may value a healthy diet. The health behaviors include smoking status, exercise level, and whether a doctor has informed the individual that he or she has at least three of the five symptoms of metabolic syndrome, an indicator of elevated risk for cardio-vascular disease. The five symptoms are: hypertension (high blood pressure), diabetes, elevated cholesterol levels (LDL), low levels of HDL, and a waist size larger than 102 cm for men and 88cm for women (Expert Panel on Detection, 2001). NHANES asks about all of these factors, but only asks wheter a doctor has told the participant if he or she has a high level of cholesterol; we assume this generally means high LDL, coupled with low levels of HDL. We anticipate that individuals who have been told by a doctor that they have a diet-related health condition may be making an effort to eat a healthy diet. Individuals who smoke general have significantly lower quality diets (Ma, et al., 2000) though this may be an indicator of how much the individual values long-term health (Huston and Finke, 2003). Those who exercise more may also value health more and eat a healthier diet.

4. Results

Figure 1 shows the plot of Total Daily Food Expenditure versus HEI-2005 scores without controlling for any other explanatory variables. Note that there does not appear to be a very strong relationship. One might conclude from this plot that it is possible to get a healthy diet (high HEI-2005) by either spending a large amount of money or a small amount of money. Observations are very tightly clustered with a total spending of between $0.50 and $7 per day in 2004 dollars.

Table 1 shows the sample statistics for all the variables used in the analysis. Note that for variables that change between the two days, these statistics reflect both days. For adults over age 20, the mean HEI-2005 score is 53 with a standard deviation of only 14.3, indicating that there is plenty of room for improvement in many adult's diet. The mean total daily food cost is $5.17, though there is considerable variation in the cost. Note that the mean age is high because this sample only includes adults age 20 and above. The household income and level of college education is slightly lower than the population, reflective of the fact that NHANES over-samples low-income households. We do not present weighted results because we do not use weights or control for complex sample design in the model estimation. Thus, our results are reflective of this particular sample, and not necessarily representative of the United States. Note that we have controlled for most factors commonly used to estimate sample weights in our model.

Table 2 shows the β and γ coefficient estimates in addition to the estimates of variances in all the error terms from maximizing the sum of equation 6 using GAUSS Windows version 9.0. The standard errors of the estimated coefficients are calculated from the inverse of the negative Hessian matrix of the likelihood function. The R-squared values are 0.31 for the cost equation and 0.26 for the diet quality equation. This is one of the highest R-squared values we have seen for predicting diet quality, using what is essentially cross-sectional data. Note that the variable immigrant is omitted in the HEI-2005 equation to obtain identification. Since these coefficients are difficult to interpret, we convert the continuous variables to elasticities, following equation 13. For the binary indicator variables, we calculate the marginal impact as the variable changes from a value of 1 to 0, as described by equation 14. We then use the elasticity and marginal effects to estimate the change in total daily cost and HEI for a given change in the X and Z. The estimated changes to cost are shown in Figure 2, while the changes in HEI-2005 are depicted in Figure 3. The largest impact on total daily cost is gender-- females spend about a dollar less on food than males; this is not surprising since females tend to eat less than males and have lower nutrient and energy requirements. We also note that Hispanics and Blacks spend about $0.6 to $0.7 less than Whites, while immigrants, and those who speak Spanish at home spend $0.3 to $0.5 more than native born and English speakers. It is plausible that immigrants and those who speak primarily Spanish at home are more likely to shop at smaller, ethnic grocery stores than non-immigrants; these establishments are often higher priced than larger grocery stores. Those who exercise or have been told that they have a diet related health condition spend $0.1 to $0.45 more than sedentary individuals or those without a health condition. Individuals who exercise, meaning that they make time for exercise, place a higher value on health than those who do not. Similarly, those with a metabolic syndrome appear more willing to spend more on food. The result that purchasing food at locations other than grocery stores costs more is a result of the way we constructed the price data, and is not a surprising result. The results in figure 2 only show the characteristics of individuals who spend more or less on food; this does not reflect diet quality.

In figure 3, we note that while cost is significant in the diet quality model, the impact is rather small. For every $1 increase in total daily cost-- an approximate 20% increase in average cost-- we estimate the HEI score will go up about 2 points. Other factors have much larger impacts: non-smokers score nearly 6.25 points higher than smokers, immigrants score 6.1 points higher than native-born, Hispanics score 9.4 points higher than whites who are not Hispanic, but those who speak Spanish in the home score 4.6 points lower. Since the variable for immigrant was left out of the quality equation, we calculated the marginal impact using equation 12 as 0.114 (translating to 6.1 point increase at the mean) and a T-ratio of 7.8. Females score just over 2.5 points higher than males, while a college degree and household size is not significantly related to obtaining a healthy diet. Consuming food purchased at sources other than stores lowers the score, while food consumed Monday through Thursday is healthier than foods consumed on the weekend. Food consumed on Friday is not significantly different in quality from the weekend. Those who exercise a moderate amount have healthier diets than either those who are very active or are sedentary. While the very active individuals value health, they may not place as high a priority on eating healthy. Income has a rather modest impact; for every $10,000 increase, the HEI scores go up 0.16 points.

5. Discussion

In this paper we develop a model that measures the impact of total daily diet cost on diet quality. This model accounts for random and unobserved differences between individuals as well as other factors which are known to impact diet quality. We also account for the fact that we derive cost and diet quality from food consumption, and thus cost is endogenous. The relatively high R-squared values indicate that this model does make a contribution (Carlson and Gerrior, 2006, Mancino, et al., 2009)**.** Since the cost of edible food is readily available in a data set that also included behavioural and health indicator variables, using NHANES data along with the CNPP Food Prices Database to test this model is a good choice. Our findings on demographic and food culture variables agree with others, as discussed in the data section. In a recent careful implementation of a first difference model also using NHANES 2003-04, Mancino, Todd and Lin (2009) find that away from home food sources lowers HEI-2005 scores. They treat food-away-from home as endogenous and find that by treating it as an exogenous variable, we may be overstating the impact. The impact of health behaviours is also what we expected.

Our most important finding is that the impact of total daily cost of food has a rather small impact on diet quality. These results suggest that spending more on food does not imply that individuals will obtain a much healthier diet. Increasing daily food expenditure by 20% is associated with a 2-point increase in HEI scores: on average, from 53 to 55, a score still far below the 100 point score that indicates a diet that fully meets nutritional recommendations. It is also interesting to note that while individuals with a higher education and a higher income spend more on food, these expenditures do not translate into healthier diets. As the household income rises from the sample mean of $38,786 to $48,786 with other variables being kept the same, the HEI only goes up by 0.16 points, a relatively insignificant amount. Those with college degrees do not obtain healthier diets than everyone else. The results from this study do not fully support the popularly held belief that a healthy diet costs more and the more money a person spends on food, the greater the likelihood he or she will have a healthy diet. To determine whether a healthy diet costs more, cost per calorie comparisons between a food that has few nutrients per calorie, such as potato chips, and a food that has many nutrients per calorie, such as an orange, have been made. Since healthier foods tend to have fewer calories than less healthy foods, it is a basic algebra rather that the actual cost of food that causes healthy foods to be more expensive (Burns, et al., 2010). When these same comparisons are made using cost per pound, the potato chips become more expensive than an orange or a plain potato. More importantly, such comparisons fail to examine the total diet cost as this study has.

Other factors were found to have a significant relationship with diet quality.. Awareness of these factors should assist nutrition educators in developing and targeting their programs. For example, eating breakfast, rather than skipping it improved diet quality. In addition to food-related behaviors, other factors were found to be associated with a higher diet quality. It is not surprising that smoking was associated with lower diet quality. It seems that smokers engage in other less than healthful lifestyles, particularly with regards to food consumption. Economic theory suggests that smokers are unwilling to forgo smoking for long-term health, an indication of a shorter time horizon (Huston and Finke, 2003). Nutritionists should be aware that clients who smoke may need more immediate satisfaction from efforts to improve diet quality than the benefits of long-term health .

This study's main strength is the use of an economic demand model where the individual is assumed to demand a certain level of healthfulness in his or her diet as measured by the HEI-2005. We also control for the endogeniety of the diet cost, and make use of the two days of dietary recall data by using a random effects model. This is an appropriate model to use when evaluating the impact that cost has on a consumer's decision to eat a healthy diet. We also evaluate the total diet and total expenditure over an entire day; this approach correctly measures what consumers spend on food. Since many previous studies have made use of the cost of energy, future research will use this model to evaluate the importance of energy cost on diet quality.

Table 1: Summary Statistics

Variable	Definition	Mean	Std Dev
HEI-2005	Healthy Eating Index	53.3419366	14.352103
total daily cost ($)	Cost for 1 day ($)	5.1756564	3.0152239
Demographic Variables			
female	Female	0.5096123	0.4999483
male	Male (omitted)	0.4903877	0.4999483
income ($)	Household income	38786.25	26719.83
college	College education	0.1981101	0.3986081
ltcol	Has not received a 4 year college degree (omitted)	0.8018899	0.3986081
age	Age in years	49.7240143	19.2165031
hhsize	Household size	2.9687195	1.5786374
Food Culture			
English	Speak English at home (omitted)	0.8527207	0.365443123
Spanish	Speak Spanish at home	0.1117628	0.3151001
olang	Speak other Language at home	0.0355165	0.1850962
white	Non-Hispanic White (omitted)	0.5457804	0.60350162
hispanic	Hispanic Origin	0.2333007	0.4229665
nhisb	Non-Hispanic, Black	0.1854024	0.3886553
other	Mixed or Other race or ethnicity	0.0355165	0.1850962
singl	Not married or living as married, including divorced	0.3848159	0.4865914
partnered	Married or living as married	0.6151841	0.4865914
immigrant	Immigrant	0.1994135	0.399592
native	Native-born (omitted)	0.8018899	0.3986081

Food Behaviours			
% store	% of energy purchased from store (omitted)	0.7525185	0.2885724
% other source	% of energy from other sources such as school cafeteria, soup kitchen etc. (omitted)	0.0207293	0.422985431
% fastfood	% of energy purchased at counter-service restaurants	0.1230785	0.2194761
% table rest	% of energy purchased at table-service restaurants	0.0813399	0.1905558
% other rest	% of energy purchased at other restaurants	0.0223338	0.1056474
% breakfast	% of energy consumed at breakfast	0.2065768	0.1574574
% lunch	% of energy consumed at mid-day meal	0.2508058	0.1998572
% dinner	% of energy consumed at evening meal	0.3538888	0.1997587
% snack	% of energy consumed as snacks	0.1887016	0.176713
Mon-Thur	Dietary recall on Monday-Thursday	0.5246008	0.4994351
Friday	Dietary recall on Friday	0.1632454	0.3696195
weekend	dietary recall on Saturday-Sunday (omitted)	0.3121538	0.621332434
Health Behaviors			
sedentary	Exercise less than 30 minutes most days (omitted)	0.4822418	0.4997253
active	Exercise 30-60 minutes most days	0.1671554	0.373145
v_active	Exercise more than 60 minutes most days	0.3506028	0.4771976
not smoking	Not currently smoking	0.7816878	0.4131341

smoker	Currently smoking (omitted)	0.2183122	0.4131341
metabolic syndrome	Doctor told individual has at least 3 of the following: hypertension, diabetes, elevated cholesterol, and large waist	0.3398501	0.4736967
Not metabolic syndrome	Doctor has not told individual has at least 3 conditions (omitted)	0.6601499	0.4736967

N = 6138

Table 2: Parameter Estimates

Likihood value = -1657.6525070
Sum of gradient = 0.0005677

	Cost equation			Quality equation		
Variable	PARAMTER	STD ERR	T-ratio	PARAMTER	STD ERR	T-ratio
interc	1.5552	0.098	15.8713	1.5351	0.4962	3.0934
Demographic Variables						
INCOME	0.0649	0.0066	9.7826	-0.0661	0.0219	-3.023
HHSIZE	-0.0083	0.004	-2.0865	0.0004	0.0058	0.0728
AGE	-0.2123	0.0158	-13.4272	0.3231	0.0686	4.711
COLLEGE	0.1064	0.0167	6.3773	-0.0512	0.0399	-1.285
FEMALE	-0.2014	0.0111	-18.1297	0.2913	0.0642	4.5346
Food Culture						
SINGLE	-0.0145	0.0121	-1.1963	0.0102	0.0169	0.6048
HISPANIC	-0.1251	0.025	-5.0089	0.1769	0.0295	5.9934
NHISB	-0.1422	0.0144	-9.8554	0.1349	0.0477	2.8253
OTHER RACE/ETHNICITY	0.0292	0.035	0.835	-0.0049	0.049	-0.1008
SPANISH SPOKEN	0.0623	0.0251	2.4784	-0.0869	0.0296	-2.9354
OTHER LANGUAGE	-0.1041	0.0331	-3.1397	0.1417	0.0452	3.1342
IMMIGRANT	0.0953	0.0212	4.4933			
Food Behaviours						
% FASTFOOD	0.6035	0.0272	22.1478	-0.9287	0.186	-4.992
% TABLE REST	0.8172	0.0311	26.2769	-1.1714	0.2536	-4.6199
% OTHER REST	0.6112	0.0633	9.6493	-0.7251	0.206	-3.5206
% BREAKFAST	-0.1225	0.0386	-3.171	0.2108	0.0622	3.3887
% LUNCH	0.0434	0.0286	1.5164	0.0185	0.0395	0.4683
% SNACK	0.2094	0.0332	6.304	-0.2869	0.076	-3.7763
MON-THUR	-0.0316	0.0153	-2.0662	0.0781	0.021	3.7222
FRIDAY	0.0011	0.0192	0.0554	0.01	0.0236	0.4248
Health Behaviours						
NOT SMOKING	0.009	0.0131	0.6869	0.1064	0.0175	6.0634
ACTIVE	0.0819	0.0162	5.0562	-0.0711	0.0337	-2.1096
V_ACTIVE	0.0856	0.0123	6.9846	-0.0581	0.0304	-1.9133
METABOLIC SYNDROME	0.0316	0.0131	2.419	-0.0167	0.0195	-0.8587
COST(delta)				1.1976	0.307	3.9007

R-squared of cost equation: 0.308613
R-squared of quality equation: 0.264081

sig11(quality)	0.5913	0.1394	4.2406
sig22(cost)	0.4877	0.0033	149.9555
sigqq(random eff)	0.1338	0.0047	28.3195
sig12(cov)	-0.2684	0.0731	-3.6698

Figure 1:

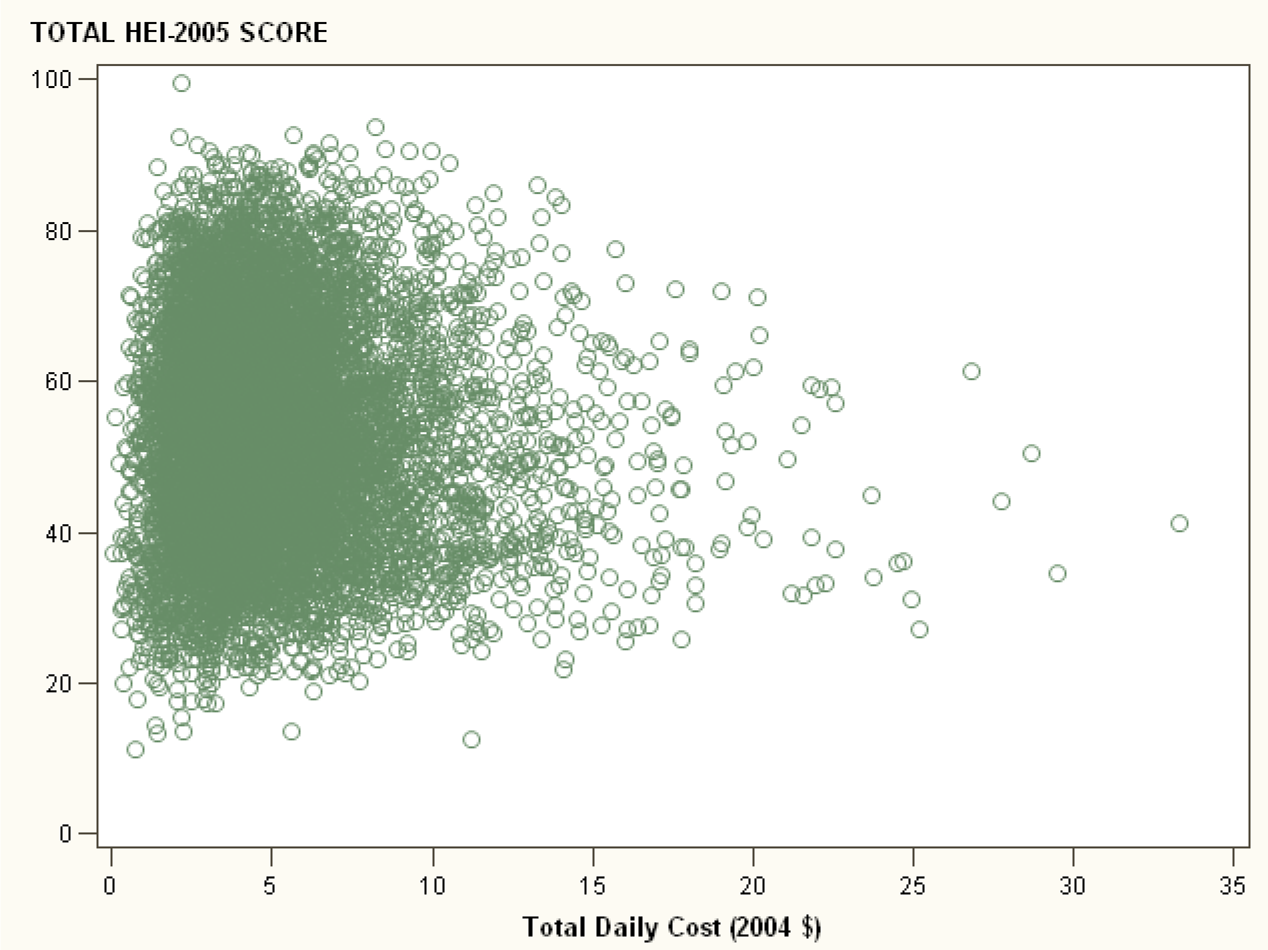
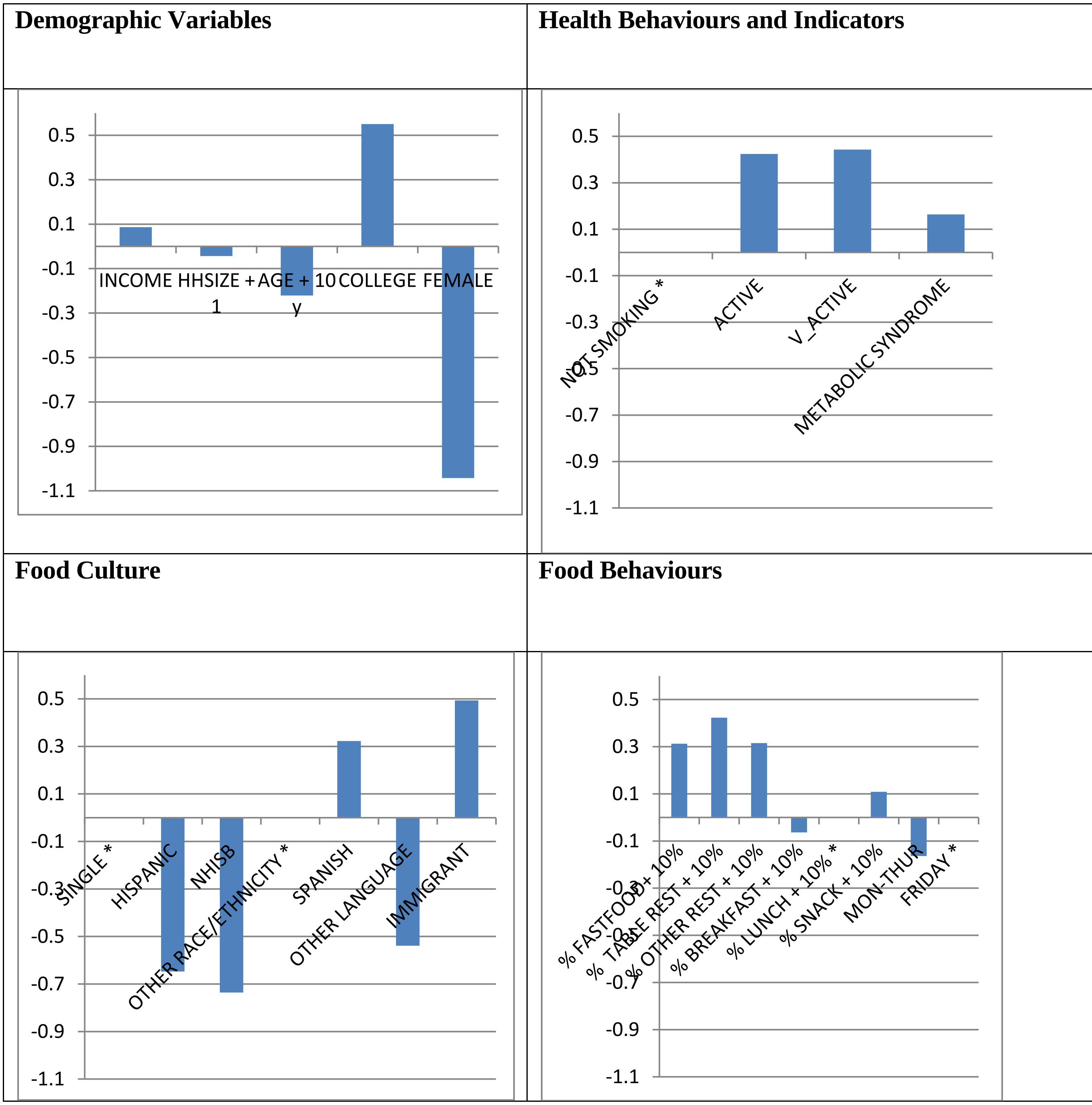

TOTAL HEI-2005 SCORE
100
80
60
40
20
0
0
5
10
15
20
25
30
35
Total Daily Cost (2004 $)

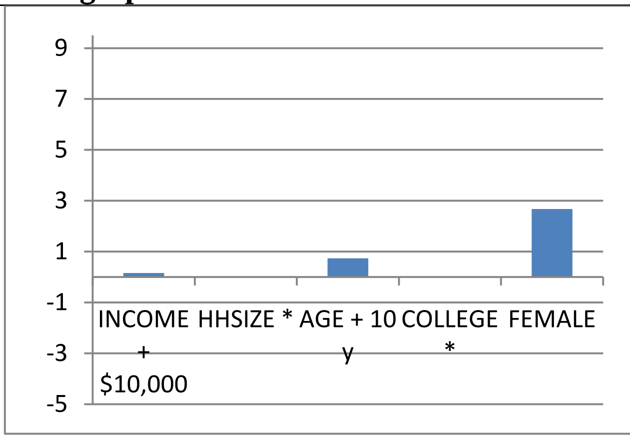
Figure 2: Changes in Cost*



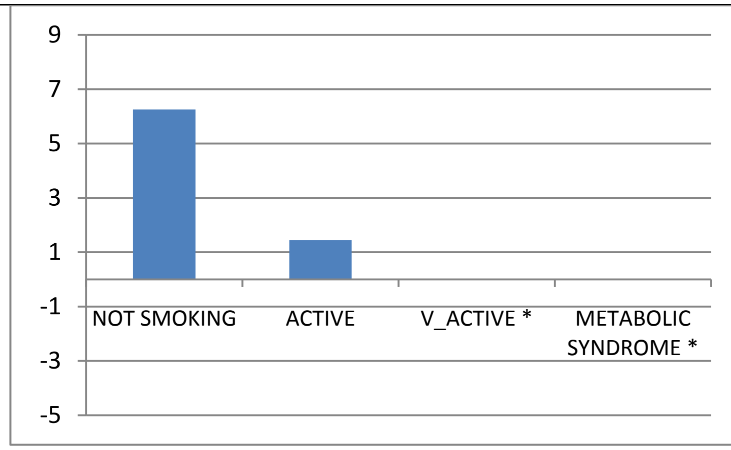
* Variables with an "*" are not significantly related to cost, or not significantly different from omitted category.

Figure 3: Change in Diet Quality for Given Change in Input*

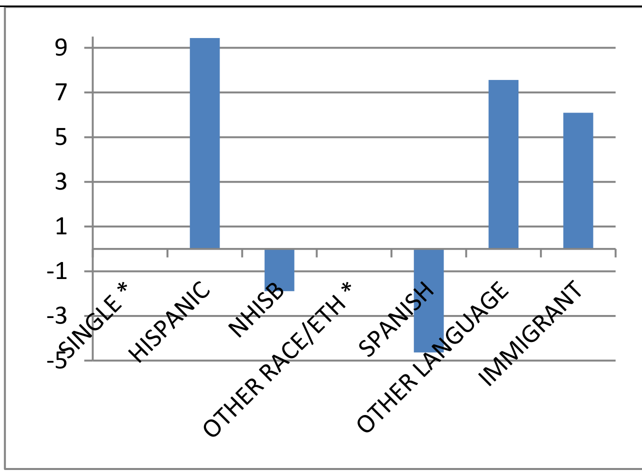
Demographic Variables



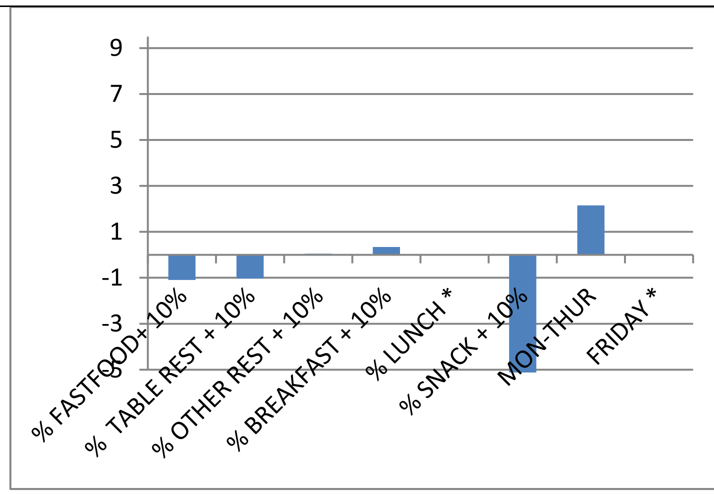
Health Behaviour and Indicators



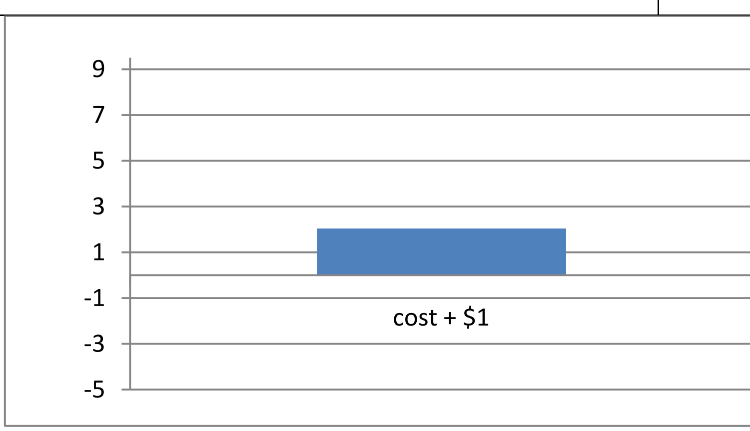
Food Culture



Food Behaviours



Cost



* Variables marked with an "*" are not significantly related to diet quality, or not significantly different from omitted category

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