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Demand for Healthful and Unhealthful Foods: Do Prices Matter on Obesity?

Haobo Luo and Chung L. Huang

This study employs an error correction model (ECM) version of the dynamic AIDS model to test a hypothesis that relatively cheaper unhealthful food price is an important factor contributing to the overweight and obesity problems in the United States. We find that substitution effects between unhealthful and healthful foods are negligible and statistically insignificant. However, the fact that demands for unhealthful food being more responsive to changes in its own price and more habit persistence than healthful food provides the economic perspective that may explain and account for the prevalence of the overweight and obesity epidemic in the United States.

Key words: AIDS-ECM model, healthy food, obesity, overweight, unhealthy food

With the improvement of living standards over the last several decades, there is a growing prevalence of obesity in the United States and many developed countries. In 1997, the World Health Organization (WHO) announced that obesity is a "global epidemic," meaning obesity has become a worldwide challenge (WHO, 1998). In fact, weights in the United States have been inflating at an alarming rate and reached epidemic proportions since 1980. It is estimated that more than 68% of the U.S adult population (Flegal et al., 2010) and about 32% of the nation's youth (Ogden et al., 2010) are considered to be overweight or obese. It has been shown that being overweight or obese increases the risk of developing a number of diseases, including cardiovascular disease, type 2 diabetes, hypertension, osteoarthritis cancer, varicose veins, liver and gallbladder disease, and sleep and respiratory problems (Bray, Bouchard, and James, 1998).

Although obesity is considered as a problem of public health, it is more an economic phenomenon. Previous studies have shown that the obesity-related medical expenditure accounts for 6% to 10% of national health care expenditure in the United States (Allison, Zannolli, and Narayan, 1999; Wolf and Colditz, 1998) and 2% to 3.5% in other developed countries (Levy et al., 1995; Kuriyama et al., 2002). Finkelstein et al. (2009)

Haobo Luo is former graduate research assistant and Chung L. Huang is professor, Department of Agricultural & Applied Economics, The University of Georgia. We gratefully acknowledge the helpful comments and suggestions provided by the anonymous reviewers. Any remaining errors are the sole responsibility of the authors.

found that the increased prevalence of obesity is responsible for as high as $78.5 billion per year in medical spending in 1998 and estimated that the medical costs of obesity could have risen to $147 billion by 2008, or an annual growth rate of 5% during the 11-year period.

There is no doubt that advanced technology and technical innovations have made agricultural production more efficient. Consequently, producers are able to expand food supply and lower the price of calories. Technological change has also affected the life style and working habits of the population as more individuals engage in more sedentary occupations and reduced physical activities. Lakdawalla and Philipson (2002) reported that about 40% of the recent growth in body weight was due to agricultural innovation that has lowered food prices, and 60% may be due to demand factors such as declining physical activity. Technological change on both supply and demand sides also lead to weight growth, falling relative food prices, but ambiguous food consumption trends because both food supply and demand fall (Lakdawalla, Philipson, and Bhattacharya, 2005). Cutler, Glaeser, and Shapiro (2003) suggest that technological changes likely had a large effect on the price of mass produced food which leads individuals to change the composition of their diet toward favoring high calorie foods. The results of Finkelstein, Ruhm, and Kosa (2005) have also shown that technology may be primarily responsible for the obesity epidemic because technological advancements have allowed people to reduce physical activities while expending fewer calories and have also reduced food prices, especially prices for high calorie foods.

If a consumer behaves rationally as prescribed by demand theory, then a change in relative food prices will cause the individual to increase consumption of foods relative to other goods and potentially lead to unwanted weight gain and the incidence of obesity. Gelbach, Klick, and Stratmann (2007) examined the role of relative food prices in determining an individual's body mass index (BMI). They argue that individuals tend to substitute a less healthful diet for a healthful one as healthy foods becomes relatively more expensive. Their results show that individual BMI measures exhibit a statistically significant positive correlation with the prices of healthful relative to unhealthful foods. Using food price and expenditure data from the United States and Japan, Zheng and Zhen (2008) estimated the NTLOG (nonstationary translog) demand system proposed by Lewbel and Ng (2005) for three goods that include the unhealthy food, the healthy food and the other good. The classification of food products into healthy and unhealthy categories was similar and resemble to that of Gelbach, Klick, and Stratmann (2007) adopted in their study. Zheng and Zhen (2008) showed that own-price elasticities are all negative and mostly large in magnitude, suggesting that consumers do respond to price changes. They concluded that falling food price is likely to cause the prevalence of overweight and obesity as hypothesized by Lakdawalla and Philipson (2002). However, Zheng and Zhen (2008) found little support to the proposition that substitution of unhealthful for healthful foods induced by relative price changes is an important cause of the obesity epidemic (Gelbach, Klick, and Stratmann, 2007).

Schroeter, Lusk, and Tyner (2008) developed a theoretical model to investigate the impact of food price and income on body weight and to identify conditions under which price and income changes are most likely to change weight. Their analysis demonstrates a case where a tax on food away from home could actually lead to increase in body weight instead of reducing weight as might be expected. Binkley, Eales, and Jekanowski (2000) showed the source from which food is obtained is an important factor contributing to changes on individuals' BMI. They found a positive and significant relationship between a respondent's BMI and consumption of food away from home to suggest that the increase in overweight and obesity in the United States can be attributed to the trends in increased restaurant and fast food consumption. Chou, Grossman, and Saffer (2004) investigated the factors that may be responsible for the rapidly increasing rate of adult obesity in the United States using the 1984-1999 Behavioral Risk Factor Surveillance System. Their results indicate that relative price variations determine variations in BMI and explain a substantial amount of its trend in weight outcomes. The set of relative prices includes the price of meal in fast-food and full-service restaurants, the price of food consumed at home, the price of cigarettes, the price of alcohol, and clean indoor air laws. Variyam (2005) contended that even though convenience, fast food, and increased accessibility of restaurant meals have been blamed for contributing to the rise in obesity, they are the quality attributes that are valued by consumers. As income grows, it reinforces the price effects in the sense that consumers will demand additional quality attributes beyond basic nutrients, such as tastiness, convenience, and ease of preparation in foods they consumed at home or away from home.

Nordström and Thunström (2011) analyzed the impact of economic policies for healthier food intake on different household categories. Their results suggest that households without children experience the highest increase in fiber intake from those tax reforms designed to increase consumers' grain consumption. However, those households also experience high intake in unhealthy nutrients, which make the net health effects difficult to evaluate. Miller and Coble (2007) found that direct government payments do not significantly affect the affordability of food, either in the aggregate or across specific food groups. Jetter and Cassady (2006) suggest that public policies should take the food environment into account in order to develop successful strategies to encourage the consumption of healthier foods. Caraher and Cowburn (2005) conducted a policy analysis of food taxes as a way of influencing food consumption and behavior. Their review suggests that food taxes as a stand-alone initiative to counteract obesity are likely to fail. They recommend that taxing food (and subsidies) should be considered within closed systems such as schools, canteens and the workplace.

French (2003) also demonstrated that price reductions are an effective strategy to increase the purchase of more healthful foods in community-based settings such as work sites and schools. Horgen and Brownell (2002) investigated the feasibility and effectiveness of an environmental intervention for improving diet by comparing the impact of health messages, lowered prices, and their combination on the purchase of healthy food items in a restaurant. Their findings suggest that price decreases may be a more powerful means than health messages of increasing consumption of healthful foods.

To improve diets by shifting food prices, many researchers have realized that it is important to understand how price changes affect demands for various foods. In order to assess the impact of food price on consumption, Andreyeva, Long, and Brownell (2010) reviewed all U.S.-based studies on the price elasticity of demand for major food categories to determine mean elasticities by food category and variations in estimates by study design. Kinsey and Bowland (1999) employed a series of calculations involving existing price and income elasticities to analyze the impact of changing the prices of aggregate food groups on number of servings of food that would be eaten in the Food Guide Pyramid (FGP).[1] They found that lowering the price of fruits, meats and dairy products would result in food consumption patterns that more closely conform to FGP serving's recommendations, while lowering the price of meat tended to decrease Healthy Eating Index scores because it increased fat consumption.

In analyzing the quantitative effects of using economic instruments in health policy, Smed, Jensen, and Denver (2007) have shown that the impact of price instruments is stronger for lower social classes than in other groups of the population. Similarly, Powell and Chaloupka (2009) examined the effectiveness of fiscal pricing (tax or subsidy) as potential policy instruments to reduce individuals' weight outcomes. They found that altering the cost of energy-dense (unhealthy) foods relative to less-dense (healthy) foods through small taxes or subsidies are not likely to produce significant changes in BMI or obesity prevalence. However, nontrivial pricing interventions may have some measureable effects on Americans' weight outcomes, particularly for children and adolescents, low-socioeconomic status population, and those most at risk for overweight.

The objective of our study is to further examine the "price-effect" on obesity using an alternative approach by estimating a system of demand equations. Unlike previous studies, we do not relate directly the changes in relative food prices to individual weight status. Instead, we investigate the underlying demand relationships by estimating a complete demand system that includes healthful and unhealthful foods, and a nonfood component. Our approach is similar to Zheng and Zhen's (2008) study except that we

[1] On June 2, 2011, the U.S. Department of Agriculture replaced the FGP with the current nutrition guide, MyPlate (http://www.choosemyplate.gov/).

used a dynamic version of the AIDS (almost ideal demand system) model with our data base extended to cover earlier as well as more recent time periods. Our study is a follow up of Zheng and Zhen's (2008) study in an effort to provide further evidences that may support or refute the "price-effect" hypothesis as proposed by Lakdawalla and Philipson (2002) or Gelbach, Klick, and Stratmann (2007). However, our study is different from Zheng and Zhen (2008) in an important aspect that we provide a means to analyze the demand relationships within the context of short- and long-run equilibriums.

In this study, we find some evidence to substantiate the contention that relatively cheaper food price may cause overweight and obesity. The own-price effects on both healthy and unhealthy food are negative as to be expected. We did not find a sizable own-price demand elasticity of food as Lakdawalla and Philipson (2002) would have suggested. Although the demand for unhealthy food is slightly larger than of healthy food, they are inelastic nonetheless. Furthermore, the cross-price elasticities between healthy and unhealthy food though positive, the magnitudes are very small and not statistically different from zero. Thus, the lack of a substantial and significant substitution effect between healthy and unhealthy food would reject the hypothesis that people have substituted unhealthy food for healthy food because healthy food has become more expensive relative to unhealthy food (Gelbach, Klick, and Stratmann, 2007). Our findings appear to be more in agreement with Lakdawalla and Philipson (2002) who suggested that falling food price is a likely cause for the prevalence of overweight and obesity in the United States.

The reminder of the paper is organized as follows. The theoretical framework of the AIDS demand system used in this study is presented and briefly discussed in the next section. We then discuss the data sources and the time series properties of the data with the formulation of an error correction model (ECM) to estimate the dynamic version of the AIDS. The results of the empirical model are interpreted and discussed next. The final section concludes the paper with some policy implications drawn from the study.

Theoretical Framework

For empirical implementation, we use the well-known almost ideal demand system (AIDS) developed by Deaton and Muellbauer (1980). More specifically, the AIDS model in budget-share form is written as:

$$(1) \qquad w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} ln p_j + \beta_i ln\left(\frac{Y}{P}\right) + \varepsilon_i$$

where w_i is the budget share of the ith commodity, p_j is the price of the jth good, α_i, γ_{ij}, and β_i are unknown parameters to be estimated and they represent the intercept, the price and income coefficients, respectively, and Y represents the per capita total expenditure on all goods and services included in the system. $\boldsymbol{P}$ is an aggregate price index, which is defined as:

(2) $$ln\boldsymbol{P} = \alpha_0 + \sum_k \alpha_k lnp_k + \tfrac{1}{2}\sum_k \sum_j \gamma^*_{kj} lnp_k lnp_j,$$

and ε_i denotes the normally distributed random disturbance terms. Note that γ_{ij} in equation (1) is defined in terms of γ^*_{kj} in equation (2) such that $\gamma_{ij} = \frac{\gamma^*_{ij} + \gamma^*_{ji}}{2}$.

Theoretical restrictions of adding-up, homogeneity, and symmetry are imposed on the parameters of equation (1) to ensure the demand equations possess the desirable properties and are consistent with consumer demand theory. The restrictions are:

(3) $$\sum_{i=1}^{n} \alpha_i = 1,\ \sum_{i=1}^{n} \beta_i = 0,\ \sum_{i}^{n} \gamma_{ij} = \sum_{j}^{n} \gamma_{ij} = 0, \text{ and } \gamma_{ij} = \gamma_{ji},\ \forall_i \neq_j.$$

The Marshallian (uncompensated) demand elasticities based on this model are calculated as:

(4) $$e_{ij} = \left(\frac{\gamma_{ij}}{w_i}\right) - \beta_i \left(\frac{\alpha_i + \sum_k \gamma_{ik} lnp_k}{w_i}\right) - \delta, \qquad \text{(Price elasticity)}$$

where $\delta = 1$ if $i = j$, $= 0$ if $i \neq j$, and

(5) $$\eta_i = 1 + \frac{\beta_i}{w_i} \qquad \text{(Expenditure or income elasticity).}$$

Furthermore, the Hicksian (compensated) price elasticities are obtained through Slutsky equation in elasticity form by adjusting the Marshallian price elasticities with the product of expenditure elasticity and budget share, i.e., $h_{ij} = e_{ij} + \eta_i w_j$, where h_{ij} is the Hicksian elasticity, e_{ij} is the Mashallian elasticity from equation (4), and η_i and w_j represent expenditure elasticity and budget share, respectively.

Data and Estimation Procedure

To estimate the AIDS model specified in equations (1) and (2), we need the time series data of food prices, quantities, and per capita total expenditure, including nonfood category. The required data were obtained from various sources such as the U.S. Department of Labor's *CPI Detailed Report*, the U.S. Department of Agriculture's *Agricultural Statistics*, the U.S. Department of Commerce's *Survey of Current Business*, and Putnam and Allshouse (1999). More specifically, the quantity data were obtained from U.S. Department of Agriculture's Agricultural Statistics, U.S. Department of Commerce's Survey of Current Business and U.S. Department of Agriculture's Food Availability (Per Capita) Data System. Retail prices or price indexes were collected from U.S. Department of Labor's CPI Detailed Report, and Putnam and Allshouse (1999). Per capita total expenditure was calculated by dividing the personal consumption expenditures (obtained from the U.S. Department of Commerce, Bureau of Economic Analysis, and National Economic Accounts) by the civilian population (obtained from the U.S. Census Bureau, Population Division) of the United States on July 1 from 1953 through 2008. The data collected for the study cover a period of 56 years from 1953 to 2008. The demand system estimated consists of three broad categories of goods, the healthful food, the unhealthful food, and other good (includes all other goods and services except food). We follow Gelbach, Klick, and Stramann (2007) and use their food product categories as a guide in the classification of foods into the unhealthful (energy-dense) and healthful (low energy density) food group. Table 1 shows the individual food products that were included in the category of healthful and unhealthful foods.

Table 1. Classification of Foods

Healthful Foods	Unhealthful Foods
Poultry	Beef and veal, pork, and other meats
Fresh fish and seafood	Eggs
Processed fish and seafood	Evaporated milk
Fluid milk and cheese	Butter, margarine, and other fats and oils
Fresh fruits and vegetables	Ice cream, and other frozen dairy products
Processed fruits and vegetables	Wheat flour and rice
Tree nuts and peanuts	Sugar and sweeteners
Coffee and tea	

The price indices for healthful and unhealthful foods were constructed as weighted average of the consumer price index for individual food product with the weight being the expenditure share of each product within the food group. Figure 1 illustrates the trend of price indices for the three groups of goods examined in this study. It is interesting to note that prior to 1975, the consumer price index for unhealthful foods was consistently higher than the healthful foods. However, this trend was reversed after 1983; the price of healthy foods has increased steadily above the unhealthy foods. The gap between the price of healthy and unhealthy foods tended to widen especially during the period between 1993 and 2003. Furthermore, the price of food generally has increased less rapidly than the price of nonfood during the 1983-2008 period. This observation suggests that consumers could have substituted food for nonfood consumption and, in particular, unhealthy foods for healthy foods. The implication is consistent with Gelbach, Klick, and Stramann's (2007) assertion that changes in relative food prices between healthful and unhealthful foods may have contributed to the increase in BMI in the United States during the period of 1982-1996.

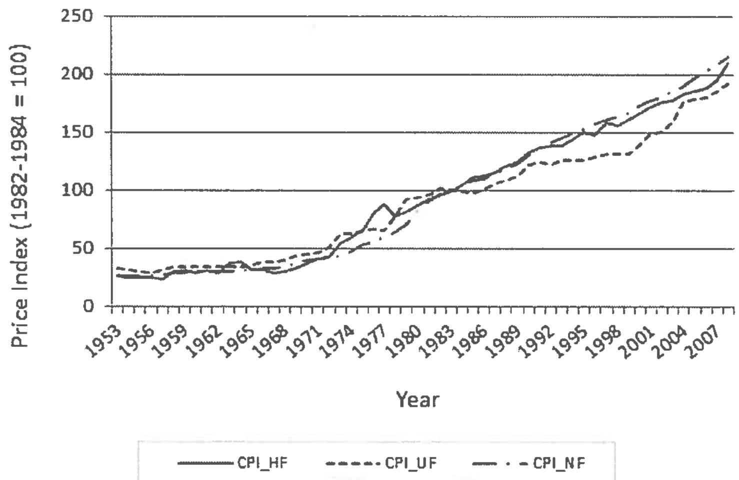

Figure 1. Price of healthy foods, unhealthy foods, and nonfood, 1953-2008

Until recently, the AIDS model has been routinely estimated with time-series data without investigating the properties of the data to determine if the underlying data processes are stationary and cointegrated. It is well known that regression models involving time-series data may very well lead to spurious regressions, if the underlying assumption of stationarity does not hold. Previous studies (Karagiannis and Velentzas, 1997; Karagiannis, Katranidis, and Velentzas, 2000; Karagiannis and Mergos, 2002) have shown that any time-series demand estimation has to deal with the issue of nonstationarity of prices and test for cointegration between the dependent variables and the corresponding explanatory variables. A number of tests, including the Dickey-Fuller, the augmented Dickey-Fuller (ADF), and the Philips-Perron test are available for testing unit root and cointegration. The test results on time-series properties of data used in this study is presented in Table 2.

Based on the Philips-Perron test, the hypothesis that all the variables in the AIDS model contain a unit root cannot be rejected at the 10% significance level except for the budget share of healthful food, W_1. However, when first differences are used, the null hypothesis of non-stationarity was rejected for the variables at the same level of significance, except for the nonfood price, *ln p3*, and the total expenditure, *ln Y*. The results are consistent with the hypothesis that unit root nonstationarity characterizes the time-series data used in this study. Having established the nonstationarity of each of the variables included in the model, the next step is to test the demand system for cointegration. Cointegration tests are necessary to assess if the budget shares are jointly determined with their respective prices and real expenditure. According to Karagiannis, Katranidis, and Velentzas (2000), cointegration ensures that shocks affecting commodity prices or real expenditures will be reflected on different expenditure shares in a similar way to show these variables are moving together and obeying an equilibrium constraint. The results of cointegration test show that only the budget share of healthy food is cointegrated with the vector of independent variables.

Table 2. Tests for Unit Root and Cointegration

	Unit Root Test		
Variable	Level	First Difference	Cointegration Test
W_1	-3.91	-9.60	-5.10
W_2	-2.44	-5.88	-1.85
W_3	-3.03	-8.20	-2.88
lnp_1	-1.84	-6.98	
lnp_2	-2.06	-5.74	
lnp_3	-1.26	-2.58	
lnY	-0.90	-2.97	

Notes: The tabulated critical values at the .10 significance level are -3.13 and -4.43 for unit root and cointegration tests, respectively. SHAZAM version 8.0 was used to perform the tests.

An alternative method of using an error correction model (ECM) to test for cointegration was suggested by Kremers, Ericsson, and Dolado (1992). They suggested that a test for cointegration can be accomplished by testing for the significance of the error correction term in an ECM. Essentially, a *t*-test is employed to test the null hypothesis that the coefficient of the error correcting term is equal to zero. If the null hypothesis is rejected, then the series is cointegrated, otherwise the series is not cointegrated. Karagiannis and Velentzas (1997) and Karagiannis and Mergos (2002) extended the application of ECM to formulate a dynamic specification of a linearized AIDS that can be used for cointegration tests. Specifically, the so-called "Stone price index" was used to replace the aggregate price index of equation (2) to achieve linearity. In this study, we estimate the nonlinear version of the AIDS model instead. The ECM version of the AIDS is given as:

$$(6) \qquad \Delta w_i = \delta_i \Delta w_{it-1} + \sum_{j=1}^{n} \gamma_{ij} \Delta ln p_j + \beta_i \Delta ln\left(\frac{Y}{P}\right) + \lambda_i u_{it-1} + \epsilon_i,$$

where Δ denotes the difference operator, δ_i is the coefficient associated with the lagged changes in budget shares, Δw_{it-1}, and u_{it-1} are the lagged residuals from estimation of equation (1), and λ_i is expected to be negative.

The demand system specified in equation (6) represents a dynamic process in which some kind of habit formation is assumed in the sense that current consumption might be affect by previous level of consumption. Thus, equation (6) has an important advantage that the short- and long-run demand relationships can be established and analyzed (Arnade, Kuchler, and Calvin, 2011; Karagiannis, Katranidis, and Velentzas, 2000; Johnson et al., 1992). In this framework, the short-run elasticities are estimated by using equations (4) and (5) with the demand parameters obtained from equation (6). The long-run elasticities are then computed using the partial adjustment formulation proposed by Johnson et al. (1992). Specifically, in the partial adjustment formulation, the speed of adjustment or the coefficient of adjustment is represented by $\tau_i = (1 - \delta_i)$ and the long-run elasticities can be derived by dividing the short-run elasticities by the coefficient of adjustment, τ_i (Karagiannis, Katranidis, and Velentzas, 2000).

For empirical analysis, equation (6) was estimated using SAS' iterated seemingly unrelated regression (ITSUR) procedure with the budget share equation of nonfood omitted to satisfy the adding-up property and to ensure nonsingularity of the variance-covariance matrix. Furthermore, the theoretical demand properties of homogeneity and symmetry conditions presented in equation (3) were imposed in the estimation process.

Empirical Results

The results obtained from the estimation of equation (6) are presented in Table 3. Note that the estimated coefficients of the error correction terms, λ_i, are negative as expected and all statistically significantly different from zero at less than the 1% significance level. This result confirms that the series are cointegrated and deviations from long-run equilibrium are corrected within the time period. As shown in Table 3, the habit formation effects embedded in equation (6) are found to be statistically significant at less than the 5% level for unhealthy food. The results suggest that changes in previous expenditure share on unhealthful food have a positive effect on current allocation decision. In contrast, changes in previous healthful food and nonfood budget shares are found to have negative but statistically insignificant effects on their respective current budget shares. This finding implies that consumption of unhealthy food seems to be dominated by habit formation effect. Consumers are more likely to form a habit of expending on unhealthy than healthy food. All the estimated coefficients on price and real expenditure are statistically significant at less than the 1% significance level, except for the cross-price effect between healthy and unhealthy foods, which is not significant at all.

The uncompensated short-run price and expenditure elasticities for the demand system are calculated based on the formula presented in equations (4) and (5), respectively. The resulting estimated price and expenditure elasticities are shown in Table 4. All the own-price elasticities are found to be negative and highly significant as expected. Demand for food, healthy or unhealthy, is price inelastic, while demand for nonfood is found to be price elastic. The finding of inelastic demand for healthy and unhealthy foods with respect to own prices is reasonable and consistent with previous findings. Andreyeva, Long, and Brownell (2010) show that the mean price elasticities for foods and nonalcoholic beverages in absolute values ranged from 0.27 (eggs) to 0.81 (food away from home). In this study, we find the magnitudes of the uncompensated own-price elasticity for food to be -0.468 and -0.546 for healthful and unhealthful food, respectively. This result indicates that consumers' demand for food, to some extent, do respond to price changes. In addition, the results show that the magnitude of own-price elasticity for unhealthful food is about 17% larger than that of healthful food. Thus, other things being equal, consumers will demand more unhealthful than healthful food given a 1% decrease in the price of healthful and unhealthful foods.

Our estimates of own-price elasticities are consistent with and fairly close to that of Zheng and Zhen (2008). In general, our estimated elasticities are slightly larger in magnitude with greater statistical significance. Zheng and Zhen (2008) report the own-price elasticities to be -0.5226 (unhealthy food), -0.3351 (healthy food), and -1.0002 (nonfood) for the United States. Their results show that own-price elasticities are statistically significantly different from zero at the 10% and 5% significance level for healthy food and nonfood, respectively, while own-price elasticity for unhealthy food is found to be statistically insignificant. This study provides additional and perhaps stronger evidence in partial support of Lakdawalla and Philipson's (2002) conclusion that falling food prices may be one of the primary reasons for the growing obesity problem.

Table 3. Estimated Parameters of an AIDS-ECM of Demand for Healthy and Unhealthy Food

Variable	Healthy Food	Unhealthy Food	Nonfood
Δw_{it-1}	-0.082	0.243^{**}	-0.161
	(0.064)	(0.117)	(0.135)
Δlnp_1	0.026^{***}		
	(0.002)		
Δlnp_2	0.001	0.023^{***}	
	(0.002)	(0.004)	
Δlnp_3	-0.028^{***}	-0.025^{***}	0.052^{***}
	(0.003)	(0.005)	(0.007)
$\Delta ln(Y/P)$	-0.038^{***}	-0.036^{***}	0.074^{***}
	(0.008)	(0.012)	(0.016)
u_{it-1}	-0.473^{***}	-0.172^{***}	
	(0.140)	(0.061)	
Constant	-0.0001	-0.0002	1.0003^{***}
	(0.0002)	(0.0003)	(0.0004)
Adjusted R^2	0.822	0.421	

Notes: Numbers in parentheses are standard errors.

*** and ** denote the estimated coefficients are statistically significantly different from zero at the 0.01 and 0.05 significance levels, respectively.

Table 4. Estimated Short-Run Demand Elasticities for the AIDS-ECM Model

Category	Healthy Food	Unhealthy Food	Nonfood	Expenditure Elasticities
	Uncompensated (Marshallian) price elasticities			
Healthy Food	-0.468***	0.029	-0.560***	0.222
	(0.038)	(0.041)	(0.059)	(0.166)
Unhealthy Food	0.028	-0.546***	-0.481***	0.294
	(0.039)	(0.083)	(0.095)	(0.233)
Nonfood	-0.113***	-0.110***	-1.025***	1.082***
	(0.018)	(0.020)	(0.016)	(0.017)
	Compensated (Hicksian) price elasticities			
Healthy Food	-0.457***	0.040	-0.360**	
	(0.038)	(0.040)	(0.174)	
Unhealthy Food	0.042	-0.531***	-0.216	
	(0.039)	(0.080)	(0.258)	
Nonfood	-0.060***	-0.055***	-0.051***	
	(0.018)	(0.019)	(0.007)	

Notes: Numbers in parentheses are standard errors.

*** *and* ** *denote the estimated elasticities are statistically significantly different from zero at the 0.01 and 0.05 significance levels, respectively.*

The results show that the cross-price effects between healthy and unhealthy foods are positive implying they are substitutes. However, the magnitudes of the estimated coefficient as well as the cross-price elasticities between unhealthy and healthy foods are small and negligible, and they do not amount to be statistically different from zero. Nonfood and food appear to be complements as suggested by the negative signs associated with the uncompensated and compensated cross-price elasticities shown in Table 4. It is noted that the demands for healthy and unhealthy foods are more responsive to changes in nonfood price than the other way around. In the short-run, a 1% increase in nonfood price would cause a 0.56% and 0.48% decrease in consumers' demand for healthy and unhealthy foods, respectively, while a similar increase in either healthful or unhealthful food price would only cause about 0.11% reduction in the consumption of nonfood. The results also indicate that the Hicksian cross-price elasticity between unhealthful food and nonfood price is not statistically significant and a change in nonfood price would affect primarily the demand for healthful food.

The estimated expenditure elasticities show that food in general, healthy or otherwise, is a necessity while nonfood category is a luxury good (Table 4). The large and elastic expenditure elasticity for the nonfood category is noteworthy in the sense that Hicksian own-price elasticity for nonfood becomes negligible (-0.051), though highly significant, after compensating for the income effect. Our estimated expenditure elasticity for nonfood (1.082) is comparable with the expenditure elasticity (1.2424) reported by Zheng and Zhen (2008). However, Zheng and Zhen (2008) also found statistically significant income elasticity for healthy food, while we find income elasticities for healthful and unhealthful foods are statistically insignificant. The estimated income coefficients, however, are positive and statistically significant from the ECM-AIDS regression model.

Table 5. Estimated Long-Run Demand Elasticities for Unhealthy Food

	Unhealthy Food	
Price Variable	Marshallian Elasticities	Hicksian Elasticities
Healthy Food	0.036	0.055
	(0.052)	(0.052)
Unhealthy Food	-0.722***	-0.702***
	(0.153)	(0.143)
Nonfood	-0.635***	-0.285
	(0.159)	(0.328)
Expenditure	0.389	
	(0.338)	

Notes: Numbers in parentheses are standard errors.

**** denotes the estimated elasticities are statistically significantly different from zero at the 0.01 significance level.*

As noted previously, there is a significant positive persistence effect associated with the demand for unhealthy food suggesting that the hypothesis of habit formation cannot be rejected. On the other hand, habits seem to be of no significant importance in explaining consumption patterns of healthy food and nonfood. The results suggest that consumers appear to be able to adjust their consumption of healthy food and nonfood almost instantaneously to the long-run equilibrium as compared with a much slower adjustment process for unhealthy food. The coefficient of adjustment for unhealthy food is estimated to be about 0.76. That is, at the first time period about 76% adjustment will be made toward the long-run equilibrium and then another 76% of the remaining adjustment will be made in the next time period and so on. The estimated long-run elasticities for unhealthful food are presented in Table 5. As expected, the long-run elasticities are larger in magnitudes than their counterparts in the short-run. It is interesting to note that demand for unhealthy food is still considered price inelastic in the long-run.

Concluding Remarks

In this study, we employ the AIDS model for estimating a three-good demand system including healthy and unhealthy foods, and a nonfood category. Our objective is to test a hypothesis, though indirectly, that relatively cheaper food price tends to cause the prevalence of overweight and obese people in the United States over time. Preliminary analysis on the properties of the data used in the study suggests that the time series are nonstationary and not cointegrated. Thus, an ECM version of the dynamic AIDS model is estimated and the results show the estimated coefficients on the error correction terms are negative and statistically significant and cointegration is indeed confirmed.

Several results are notable. First, own-price elasticities are all negative and all expenditure elasticities are positive as to be expected. Second, the demand for food is less elastic than demand for nonfood with respect to both price and expenditure. Third, the results suggest that both healthful and unhealthful foods are necessities while nonfood is a luxury. Fourth, the demand for food is price inelastic with the own-price effect for unhealthful food tends to be about 17% more responsive to price change than that of healthful food. Finally, the cross-price or the substitution effects between unhealthful and healthful foods appear negligible and statistically insignificant. Given the inelastic demand for both healthful and unhealthful foods and the lack of any sizeable and significant cross-price elasticities between healthful and unhealthful foods, our study is consistent with the findings reported in Zheng and Zhen (2008). Similarly, we find little evidence to support Gelbach, Klick, and Stratmann's (2007) hypothesis that substitution between healthful and unhealthful foods is an important factor contributing to the obesity epidemic in the United States.

Overall, the fact that demands for unhealthful food being more responsive with respect to changes in its own price than healthful food provides the economic perspective that may explain and account for the prevalence of the overweight and obesity epidemic in the United States. Thus, our findings lend support at least partially to Laddawalla and Philipson's (2002) hypothesis that relatively cheaper price for unhealthy food as a likely cause of the obesity epidemic. In addition, we find that consumers are more "addictive" to unhealthful than to healthful food. In other words, consumers react and adjust to price changes in healthful food at a speed that is considerably faster than for unhealthful food. The long-run demand elasticities are almost 33% larger than the short-run elasticities for unhealthy food, while they are essentially the same as the short-run elasticities for healthy food and nonfood. Thus, the habit of consuming unhealthful food is harder to change and it will take a longer period to adjust to the long-run equilibrium.

A policy implication that could be drawn from the study results is the potential effectiveness of levying the so-called "sin taxes" or "fat taxes" on unhealthful food products to discourage consumption of energy-dense foods. The goal of taxing unhealthy food is to influence consumers to eat healthier by raising the price of unhealthy food relative to healthy food. Based on our findings, we would consider such policy instruments as, perhaps, ineffective to reverse the trend in the prevalence of obesity. Our conjecture is that such policies do not seem likely to induce any significant changes in increasing consumption of healthful foods while they may reduce the consumption of unhealthful food to some extent.

The limitation and shortcoming of using Gelbach, Klick, and Stratmann's (2007) food product categories as a guide to classify the foods into unhealthful and healthful food groups should be recognized. The classification certainly is not ideal and may be questionable from a dietician's point of view. For example, most dieticians probably would not agree to classify beef and veal, pork, and other meat as unhealthful foods. However, the red meats are viewed as unhealthful as compared with poultry and fishery products. Chicken as a meat product may be healthful, but a piece of fried chicken is not necessarily any healthier than a pork chop. The food classification used in this study does not take into account how a food was prepared or consumed. Rather, it deals only with the nature of the food product in general and in broad aggregate. Last but not least, our findings are limited to demand for food at home. The demand for fast food or meals away from home in terms of convenience attributes as a cause of rising obesity suggested by Variyam (2005) and others (e.g., Binkley, Eales, and Calvin, 2000; Chou, Grossman, and Saffer, 2004) is beyond the scope of this study.

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