Food Prices and Obesity: long-run effect in US metropolitan areas

By

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Presented at the 2009 Pre-Conference Workshop, August 16, 2009, Diet and Obesity: Role of Prices and Policies

August 2009

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Abstract

Once considered as a serious public health issue only in developed countries, now overweight and obesity have dramatically increased in low- and middle-income countries, especially in urban settings (WHO, 2008). The main purpose of this study is to explore the economic incentives for this rapid growth in obesity rates, by studying variations in obesity over time and across geographic regions in the United States.

Although a number of researchers and policymakers have devoted significant resources to address the recent rapid rise in obesity in the United States, "the prevalence of overweight and obesity has increased sharply since the mid 1970s" (Centers for Disease Control, 2008) and most of this increase occurred in the 1980s and 1990s (Cutler, *et al.*, 2003). More importantly, changes in food prices have also occurred over the past 30 years and have occurred simultaneously with the obesity epidemic (Finkelstein, *et al.*, 2005).

In this study, we investigate how the decline in food prices in the last three decades affects the long-run growth of obesity rates. We take the advantage of the large panel data that cover for the time periods with the fastest growth of obesity rates, by using metropolitan samples from the National Health Interview Survey (NHIS) and information on prices of food at home and food away from home from these major metropolitan areas for years 1976 to 2001. Specifically, instead of using absolute food prices, we explore the impacts from changes in relative prices of food at home and food away from home (i.e. food prices relative to prices for a market basket of consumer goods and services in these metropolitan areas), as well as changes in prices of food at home and food away from home on the growth in obesity rates during this time frame. We also control for the changes in contextual factors and changes in value of female in these metropolitan areas. Our findings reveal the important fact that changes in relative food prices can explain about 20 percent of the obesity growth during this time period and such effect is more pronounced for the low-educated. The results of the study provide an interpretation of the long-run growth of obesity rates in urban settings.

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Food prices and obesity: long-run effect in US metropolitan areas

The main purpose of the study is to explore the effects of food prices, both prices of food at home and prices of food away from home on the upward obesity trend since 1970s. Specifically, this study focuses on the effect of relative prices of food at home and food away from home, as well as changes in prices of food at home and food away from home on the growth in obesity rates during this time frame.

Data

Our data for the empirical analysis come from three major resources: (1) the sample of individuals from the National Health Interview Survey (NHIS) for the years 1976 to 2001 living in 23 major metropolitan areas of the U.S., (2) economic variables at these metropolitan areas during this time period obtained from the Curret Population Survey (CPS), including hours of work for both males and females, wage rates for both males and females, unemployment rates, and income per capita, and (3) food price variables for these 23 metropolitan areas obtained from the Bureau of Labor Statistics, specifically price index for food at home, price index for food away from home and price index for all items.

As pointed out by the Bureau of Labor Statistics (BLS 2004), the Consumer Price Index (CPI) and its components (e.g., food price index) is location specific and thus “the

composition of the market basket and relative prices of goods and services in the market basket during the expenditure base period varies substantially across areas." That is to say, performing cross-sectional analysis using any CPI figures directly would be incorrect. One way to get around this data issue is to compare the percentage change in price indexes over years (Kelton & Weiss 1989)

Therefore, we construct two sets of price variables at metropolitan level: changes in food prices and changes in relative food prices. The former variables, including both Δ Food Prices at Home and Δ Food Prices away from Home are obtained as the following,

$$\left(Food\ \mathrm{Pr}_t - Food\ \mathrm{Pr}_{t-1}\right) \Big/ \left(Food\ \mathrm{Pr}_t + Food\ \mathrm{Pr}_{t-1}\right)/2 * 100 \quad (1)$$

while the latter variables, including Δ Relative Food Prices at Home and Δ Relative Food Prices away from Home, are obtained as the following.

$$\left(RtFood\ \mathrm{Pr}_t - RtFood\ \mathrm{Pr}_{t-1}\right) \Big/ \left(RtFood\ \mathrm{Pr}_t + RtFood\ \mathrm{Pr}_{t-1}\right)/2 * 100 \quad (2)$$

Similar to Lakdawalla & Philipson (2002), the relative food prices (RtFoodPr) at these metropolitan areas are defined as food price index divided by price index for all items.

The first differenced price variables are matched with first-differenced variables created from NHIS and CPS. By adopting a first-differences approach, we implicitly control for metropolitan-specific, time-invariant confounding factors that may affect the growth of obesity rates. The changes in obesity rates are obtained from a longitudinal pseudo-panel created from the NHIS. The NHIS observations are grouped into aggregated samples by

race, education, gender, metropolitan and year. For example, one aggregated sample (which equals a group of people) is "white, high school graduates, male, living in New York metropolitan area in year 1976", another one is "African American, high school graduates, male, living in New York metropolitan area in year 1976", and so on. The value of each variable of each aggregated sample is the weighted mean of that group of people. With aggregated sub-group samples, we have the data in longitudinal form, which is then used to obtain the first-differences.

The final aggregated sample used in the analysis contains 15,035 observations which represent 630,541 individuals (99.04% of the total of 636,672) from the original NHIS sample. Sample means are reported in Table 1. The total sample size should equal to 18,400 (23 MSAs * 25 years * 4 races * 4 education categories* 2 gender groups) if there were no missing information. Unfortunately, food price index for Miami-Fort Lauderdale metropolitan area are available only from 1978, Tampa-St. Petersburg-Clearwater from 1987, and food price index are not available for Cincinnati-Hamilton for years 1988 and 1989, and Denver-Boulder-Greeley for year 1988. Therefore, after discarding the corresponding cells, we have 15,647 group samples with some missing values in marital status and body mass index.

Empirical Methodology

All models are estimated using the first difference approach with analytical weights.

Robust standard errors are clustered at metropolitan level. In the analysis, all the variables, both dependent and independent, are constructed as the percentage change in those variables between current and previous years, by using similar formulas to equation (1), except for the indicators of race, education and gender, which have been used as criteria for the aggregation. We estimate the following empirical specifications:

$$\Delta BMI_{ijt} = \alpha_j + \Delta Foodpr_{jt}\beta + \Delta X_{ijt}\gamma + Y_{ijt}\lambda + \Delta Z_{jt}\pi + u_{ijt} \quad (3)$$

$$\Delta BMI_{ijt} = \overline{\alpha}_j + \Delta Foodpr_{jt}\overline{\beta}_1 + \Delta Foodpr_{jt}{}^2\overline{\beta}_2 + \Delta X_{ijt}\overline{\gamma} + Y_{ijt}\overline{\lambda} + \Delta Z_{jt}\overline{\pi} + \Delta Z_{jt}{}^2\overline{\pi} + \overline{u}_{ijt} \quad (4)$$

In equation (3), the percentage change in BMI of aggregated samples *i* at metropolitan *j* in year *t* depend on percentage changes in food prices ($\Delta Foodpr_{jt}$), including both changes of food prices at home and food prices away from home, percentage changes in group characteristics (ΔX_{ijt}), including family income, age and marital status, group indicators (Y_{ijt}), including indicators for race, education and gender, and percentage changes in economic factors at metropolitan level (ΔZ_{jt}), including average wage rates and hours of work for both males and females, unemployment rates and income per capita. In equation (4), we relax the linear restrictions on the changes in food prices and economic factors at metropolitan level.

We use equations (5) and (6), we estimate the impacts of relative food prices on BMI:

$$\Delta BMI_{ijt} = \alpha_j + \Delta RtFoodpr_{jt}\beta + \Delta X_{ijt}\gamma + Y_{ijt}\lambda + \Delta Z_{jt}\pi + u_{ijt} \quad (5)$$

$$\Delta BMI_{ijt} = \overline{\alpha}_j + \Delta RtFoodpr_{jt}\overline{\beta}_1 + \Delta Foodpr_{jt}{}^2\overline{\beta}_2 + \Delta X_{ijt}\overline{\gamma} + Y_{ijt}\overline{\lambda} + \Delta Z_{jt}\overline{\pi} + \Delta Z_{jt}{}^2\overline{\pi} + \overline{u}_{ijt} \quad (6)$$

These equations are very much the same as equations (3) and (4), and the only difference is that we adopt the percentage changes in *relative* food prices ($\Delta RtFoodpr_{jt}$), instead of the percentage changes in food prices.

Preliminary Results

In general, our results suggest that changes in relative food prices can explain about 20 percent of the obesity growth in these metropolitan areas and our estimates are very robust across different specifications. Such effect from relative food prices is more pronounced for the low-educated. However, we do not find strong evidence for the effect of food price growth on obesity.

Summary statistics of the final sample are reported in table 1. Tables 2 and 3 represent the estimates of the effect of food price changes on changes in Body Mass Index and obesity respectively. We tried different specifications, depending on linear restrictions on food prices and the controls at metropolitan level. No food price effects are found in these tables.

Tables 4 and 5 report the estimates of the effect of *relative* food price changes on changes

in Body Mass Index and obesity respectively. Specifications in these two tables are the same as those in table 2 and 3. We find strong evidence that the declines in relative prices of food at home would increase obesity rates and such effect is independent of specifications. We also found some evidence of relative prices of food away from home. The estimates of changes in relative prices of food away from home are always negative and they are marginaly significant in the full specification. This might because we cannot distinguish unhealthy food from healthy food (or fast food from food from full service restaurants) in the food away from home.

In tables 6-9, we repeat the estimates in tables 2-5 with different aggregated samples, as robustness tests (to see whether or not results are associated with grouping methods). Using table 9 as an example, columns 1 and 2 with method 1 represent the estimates from the original aggregated sample, so these numbers are the same as those in columns 2 and 5 of table 5.

The samples used to estimate the results in columns 3 and 4 are based on aggregation method 2. In this method, the individual observations are aggregated to group samples by education and gender, instead of race, education and gender. In other words, the total sample size this time should equal to 4,600 (23 MSAs * 25 years * 4 education categories* 2 gender), if there were no missing information. But because of some missing values, we finally have 4,448 aggregated samples.

Similarly, the samples used to estimate the results in columns 5 and 6 are based on aggregation method 3. Here, the individual observations are aggregated to group samples by gender only. In this case, the total sample size should equal to 1,150 (23 MSAs * 25 years * 2 gender), if there were no missing information. And we finally have 1,112 aggregated samples.

By comparing the estimates across the columns in table 9, it is very clear that our conclusions are very robust across different aggregation method, or say independent of different aggregated samples. More importantly, our estimated effects of changes in *relative* food prices are very similar in magnitude.

In tables 10 and 11, we estimate the effects of changes in food prices and relative food prices by education, while such effects are estimated by gender in tables 12 and 13. The high-educated here is defined as college graduates or above, while low-educated contains high school gradates or less. Still we do not find strong evidence for the influence of changes in food prices, but consistent effects from changes in relative prices. Interestingly, and also reasonably, we find the effect of changes in relative prices on the growth of obesity rates is more pronounced for the low-educated and some what muted for the high-educated (although the sign and magnitude of the estimates are still there). Similar situation in tables 12 and 13, it seems that the effect of changes in relative prices is more pronounced for men, but given the magnitude of the estimates we do think we

can statistically tell the difference in the estimates across gender.

How large is the estimated effect? The weighted average relative prices of food at home in our sample are about 1.11 in 1976 and 0.99 in 2001, while obesity rates are 0.08 and 0.20 respectively. That is to say, using equation (2), the percentage decline in food prices at home is around 11.43, while the percentage growth in obesity rates is about 85.71. Our estimated price effect is around 1.085 to 1.368. If we pick the middle point of the estimates, 1.25, our results at least can explain about 17% of the growth in obesity rates (11.43*1.25/85.71).

Future Steps:

(1) Obtain food prices and cost of living index at the MSAs from the CE and the ACCRA to perform analysis at individual level.

(2) Obtain contextual information such as number of restaurants, grocery stores etc. from the County Business Patterns.

(3) Examine why food at home prices have a larger influence that food away from home prices.

(4) Your comments and suggestions are more than welcome!

References

Bureau of Labor Statistics. (2004). Addendum to Frequently Asked Questions. Retrieved January 15, 2005, from www.bls.gov/cpi/cpiadd.htm.

Kelton, C.M.L., and Weiss, L.W. (1989). Change in Price, Change in Cost, Change in Demand, and Change in Concentration. In W.W. Leonard (Ed.), *Concentration and Price*. Cambridge, MA: MIT Press.

Anderson, P.M., Butcher, K.E. 2006. "Childhood Obesity: Trends and Potential Causes." *Future Child* 16: 19-45.

Beydoun, M., Powell, L. and Wang, Y. 2008. "The Association of Fast Food, Fruit and Vegetable Prices with Dietary Intakes among US Adults: Is There Modification by Family Income?" *Social Science & Medicine* 66: 2218-2229.

Bureau of the Census, US Department of Commerce, 1976, 1986, 1989, 1994, 2000. 1972, 1982, 1987, 1992, and 1997 Census of Retail Trade. US Government Printing Office, Washington, DC.

Chou, S., Grossman, M., and Saffer, H. 2004. "An Economic Analysis of Adult Obesity: Results from the Behavioral Risk Factor Surveillance System." *Journal of Health Economics* 23: 565-587.

Cutler, D., Glaeser, M., and Shapiro, J. 2003. "Why Have Americans Become More Obese?" *Journal of Economic Perspectives* 17: 93-118.

Drewnowski, A. 2004. "Obesity and the Food Environment: Dietary Energy Density and Diet Costs." *American Journal of Preventive Medicine*27:154-62.

Finkelstein, E.A., Fiebelkorn, I.C., and Wang, G. 2003. "National Medical Spending Attributable to Overweight and Obesity: How Much, and Who's Paying?" *Health Affairs* W3:219–226.

Finkelstein, E.A., Ruhm, C.J., and Kosa, K.M. 2005. "Economic Causes and Consequences of Obesity. *Annual Review of Public Health* 26: 239-57.

Flegal, K.M., Carroll, M.D., Ogden, C.L., and Johnson, C.L. 2002. "Prevalence and Trends in Obesity among U.S. Adults, 1999–2000." *Journal of the American Medical Association* 288:1723–1727.

Jetter, K.M. and Cassady, D.L. 2006. "The Availability and Cost of Healthier Food Alternatives." *American Journal of Preventive Medicine* 30:38-44.

Kopelman, P.G. 2000. "Obesity as a Medical Problem." *Nature* 404: 635-43.

Koplan, J.P., Dietz, W.H. 1999. "Caloric Imbalance and Public Health Policy." *Journal of the American Medical Association* 282:1579-81.

Lakdawalla, D. and Philipson, T. 2002. "The Growth of Obesity and Technological Change: A Theoretical and Empirical Analysis." *NBER Working Paper* 8946.

Lakdawalla, D. and Philipson, T. and Bhattacharya, J. 2005. "Welfare-Enhancing Technological Change and the Growth of Obesity." *American Economic Review*, 95(2): 253-57.

MacDonald, J.M. and Nelson, P.E. 1991. "Do the Poor Still Pay More? Food Price Variations in Large Metropolitan Areas." *Journal of Urban Economics* 30: 344-359.

Mokdad, A., Marks, J., Stroup, D., and Gerberding, J. 2005. "Correction: Actual Causes of Death in the United States, 2000." *Journal of the American Medical Association*, 293: 293-294.

Ogden, C.L., Carroll, M.D., Curtin, L.R., McDowell, M.A., Tabak, C.J., and Flegal, K.M., 2006. "Prevalence of Overweight and Obesity in the United States, 1999–2004." *Journal of the American Medical Association* 295: 1549–1555.

Ogden, C.L., Carroll, M.D., and Flegal, K.M. 2003. "Epidemiologic Trends in Overweight and Obesity." *Endocrinology & Metabolism Clinics of North America*, 32(4): 741-760.

Peeters, A., Barendregt, J.J., Willekens, F., Mackenbach, J.P., Al Mamun, A., and Bonneux, L. 2003. "Obesity in Adulthood and Its Consequences for Life Expectancy: A Life-Table Analysis." *Annals of Internal Medicine* 138: 24-32.

Philipson, T.J., and Posner, R.A. 2003. "The Long-Run Growth in Obesity as A Function of Technological Change." *Perspectives in Biology and Medicine* 46(3): S87-S107.

Powell, L., Auld, C., Chaloupka, F., O'Malley, P., and Johnston, L. 2007. "Access to Fast Food and Food Prices: Relationship with Fruit and Vegetable Consumption and Overweight among Adolescents." *Advances in Health Economics and Health Services Research* 17: 23-48.

Sturm, R., and Datar, A. 2005. "Body Mass Index in Elementary School Children, Metropolitan Area Food Prices and Food Outlet Density." *Public Health* 119:1059–1068.

Surgeon General, US Department of Health and Human Services. 2001. "The Surgeon General's Call to Action to Prevent and Decrease Overweight and Obesity. Washington, DC: US Government Printing Office, 2001.
http://www.surgeongeneral.gov/topics/obesity/calltoaction/CalltoAction.pdf

Wellman, N.S. and Friedberg, B. 2002. "Causes and Consequences of Adult Obesity: Health, Social and Economic Impacts in the United States. *Asia Pacific Journal of Clinical Nutrition* 11: S705-9.

Table 1: Summary Statistics of Weighted Samples

	Mean	Std. Dev.
Dependent Variables		
Δ Body Mass Index (BMI)	0.392	4.430
Δ Obesity	5.003	65.627
Independent Variables at MSA Level		
Δ Food Prices at Home	4.255	2.760
Δ Food Prices away from Home	4.421	2.855
Δ Relative Food Prices at Home	-0.499	2.156
Δ Relative Food Prices away from Home	-0.333	1.884
Δ Female Hours of Work per Week	1.285	4.383
Δ Female Wage Rates	1.852	11.881
Δ Male Hours of Work per Week	-0.024	8.427
Δ Male Wage Rates	-0.016	2.702
Δ Unemployment Rates	-1.140	30.020
Δ Income per Capita	0.977	4.257
Independent Variables at Individual Level		
Δ Family Income indicator 1 (≤ $14,999)	-6.328	60.003
Δ Family Income indicator 2 ($15,000 ~ $24,999)	-3.663	56.899
Δ Family Income indicator 3 ($25,000 +)	5.707	40.977
Δ Family Income indicator 3 (missing)	5.249	63.844
Δ Age indicator 1 (18 ~ 30)	-1.329	39.368
Δ Age indicator 2 (31 ~ 45)	0.967	37.577
Δ Age indicator 3 (46 ~ 60)	0.747	47.261
Δ Age indicator 4 (60 +)	3.014	56.140
Δ Single	1.471	45.913
Δ Married	-0.806	26.654
Δ Others Marital Status	1.961	55.890
White	0.692	0.462
African American	0.141	0.348
Hispanic	0.130	0.336
Other Races	0.038	0.191
Less than High School	0.222	0.416
High School Graduates	0.353	0.478
Some College Education	0.202	0.402
College Graduates and above	0.222	0.416
Male	0.460	0.498
n	15,035	

Table 2: The Estimated Effects of Food Price Changes on Changes in Body Mass Index

			Δ BMI		
COEFFICIENT	(1)	(2)	(3)	(4)	(5)
Δ Food Prices at Home (percentage)	-0.030	-0.029	-0.028	-0.027	-0.036
	(0.031)	(0.030)	(0.060)	(0.058)	(0.058)
Δ Food Prices at Home Squared (percentage)	-	-	-0.000	-0.000	0.000
			(0.007)	(0.007)	(0.007)
Δ Food Prices away from Home (percentage)	-0.015	-0.017	-0.007	-0.008	-0.003
	(0.020)	(0.019)	(0.048)	(0.049)	(0.051)
Δ Food Prices away from Home Squared (percentage)	-	-	-0.001	-0.001	-0.001
			(0.004)	(0.004)	(0.004)
Δ Unemployment Rates	Yes	Yes	Yes	Yes	Yes
Δ Income Per Capita	Yes	Yes	Yes	Yes	Yes
Δ Female Wages and Hours of work	Yes	Yes	Yes	Yes	Yes
Δ Male Wages and Hours of work	No	Yes	No	Yes	Yes
Δ Unemployment Rates Squared	No	No	No	No	Yes
Δ Income Per Capita Squared	No	No	No	No	Yes
Δ Female Wages and Hours of work Squared	No	No	No	No	Yes
Δ Male Wages and Hours of Work Squared	No	No	No	No	Yes
n			15,035		

Notes: All models are estimated using the first difference approach and based on weighted aggregated samples from the NHIS for years 1976 to 2001. Robust standard errors, calculated assuming that observations are independent across metropolitans, but not within metropolitans, are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All regressions control for individual demographic variables, including indicators for gender, race (White, African American, Hispanic and Others), and education (Less than High School, High School, Some College, and College and above). In addition, each regression also includes controls for changes in marital status, age and family income in percentages, as well as year fixed effects.

Table 3: The Estimated Effects of Food Price Changes on Changes in Obesity

	Δ Obesity				
COEFFICIENT	(1)	(2)	(3)	(4)	(5)
Δ Food Prices at Home (percentage)	-0.736	-0.714	-0.312	-0.352	-0.416
	(0.537)	(0.527)	(0.960)	(0.948)	(0.899)
Δ Food Prices at Home Squared (percentage)	-	-	-0.060	-0.052	-0.049
			(0.171)	(0.170)	(0.169)
Δ Food Prices away from Home (percentage)	-0.240	-0.277	0.331	0.354	0.532
	(0.314)	(0.305)	(1.198)	(1.212)	(1.161)
Δ Food Prices away from Home Squared (percentage)	-	-	-0.047	-0.052	-0.072
			(0.096)	(0.098)	(0.096)
Δ Unemployment Rates	Yes	Yes	Yes	Yes	Yes
Δ Income Per Capita	Yes	Yes	Yes	Yes	Yes
Δ Female Wages and Hours of work	Yes	Yes	Yes	Yes	Yes
Δ Male Wages and Hours of work	No	Yes	No	Yes	Yes
Δ Unemployment Rates Squared	No	No	No	No	Yes
Δ Income Per Capita Squared	No	No	No	No	Yes
Δ Female Wages and Hours of work Squared	No	No	No	No	Yes
Δ Male Wages and Hours of Work Squared	No	No	No	No	Yes
n			15,035		

Notes: All models are estimated using the first difference approach and based on weighted aggregated samples from the NHIS for years 1976 to 2001. Robust standard errors, calculated assuming that observations are independent across metropolitans, but not within metropolitans, are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All regressions control for individual demographic variables, including indicators for gender, race (White, African American, Hispanic and Others), and education (Less than High School, High School, Some College, and College and above). In addition, each regression also includes controls for changes in marital status, age and family income in percentages, as well as year fixed effects.

Table 4: The Estimated Effects of Relative Food Price Changes on Changes in Body Mass Index

			Δ BMI		
COEFFICIENT	(1)	(2)	(3)	(4)	(5)
Δ Relative Food Prices at Home (percentage)	-0.025	-0.022	-0.024	-0.022	-0.024
	(0.031)	(0.031)	(0.033)	(0.033)	(0.033)
Δ Relative Food Prices at Home Squared (percentage)	-	-	0.003	0.002	0.003
			(0.004)	(0.003)	(0.004)
Δ Relative Food Prices away from Home (percentage)	-0.013	-0.014	-0.014	-0.016	-0.017
	(0.019)	(0.019)	(0.019)	(0.018)	(0.019)
Δ Relative Food Prices away from Home Squared (percentage)	-	-	-0.006	-0.006	-0.006
			(0.004)	(0.004)	(0.004)
Δ Unemployment Rates	Yes	Yes	Yes	Yes	Yes
Δ Income Per Capita	Yes	Yes	Yes	Yes	Yes
Δ Female Wages and Hours of work	Yes	Yes	Yes	Yes	Yes
Δ Male Wages and Hours of work	No	Yes	No	Yes	Yes
Δ Unemployment Rates Squared	No	No	No	No	Yes
Δ Income Per Capita Squared	No	No	No	No	Yes
Δ Female Wages and Hours of work Squared	No	No	No	No	Yes
Δ Male Wages and Hours of Work Squared	No	No	No	No	Yes
n			15,035		

Notes: All models are estimated using the first difference approach and based on weighted aggregated samples from the NHIS for years 1976 to 2001. Robust standard errors, calculated assuming that observations are independent across metropolitans, but not within metropolitans, are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All regressions control for individual demographic variables, including indicators for gender, race (White, African American, Hispanic and Others), and education (Less than High School, High School, Some College, and College and above). In addition, each regression also includes controls for changes in marital status, age and family income in percentages, as well as year fixed effects.

Table 5: The Estimated Effects of Relative Food Price Changes on Changes in Obesity

			Δ Obesity		
COEFFICIENT	(1)	(2)	(3)	(4)	(5)
Δ Relative Food Prices at Home (percentage)	-1.111*	-1.085*	-1.351**	-1.316**	-1.368**
	(0.543)	(0.539)	(0.618)	(0.611)	(0.627)
Δ Relative Food Prices at Home Squared (percentage)	-	-	-0.164	-0.160	-0.168
			(0.112)	(0.110)	(0.113)
Δ Relative Food Prices away from Home (percentage)	-0.475	-0.506	-0.629	-0.659	-0.723*
	(0.345)	(0.339)	(0.396)	(0.392)	(0.396)
Δ Relative Food Prices away from Home Squared (percentage)	-	-	-0.026	-0.026	-0.027
			(0.100)	(0.102)	(0.105)
Δ Unemployment Rates	Yes	Yes	Yes	Yes	Yes
Δ Income Per Capita	Yes	Yes	Yes	Yes	Yes
Δ Female Wages and Hours of work	Yes	Yes	Yes	Yes	Yes
Δ Male Wages and Hours of work	No	Yes	No	Yes	Yes
Δ Unemployment Rates Squared	No	No	No	No	Yes
Δ Income Per Capita Squared	No	No	No	No	Yes
Δ Female Wages and Hours of work Squared	No	No	No	No	Yes
Δ Male Wages and Hours of Work Squared	No	No	No	No	Yes
n			15,035		

Notes: All models are estimated using the first difference approach and based on weighted aggregated samples from the NHIS for years 1976 to 2001. Robust standard errors, calculated assuming that observations are independent across metropolitans, but not within metropolitans, are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All regressions control for individual demographic variables, including indicators for gender, race (White, African American, Hispanic and Others), and education (Less than High School, High School, Some College, and College and above). In addition, each regression also includes controls for changes in marital status, age and family income in percentages, as well as year fixed effects.

Table 6: The Estimated Effects of Food Price Changes on Changes in Body Mass Index: By Grouping Method

COEFFICIENT	Δ BMI Method 1		Method 2		Method 3	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Food Prices at Home (percentage)	-0.029	-0.036	-0.021	-0.040	-0.029	-0.061
	(0.030)	(0.058)	(0.028)	(0.059)	(0.031)	(0.062)
Δ Food Prices at Home Squared (percentage)	-	0.000	-	0.002	-	0.004
		(0.007)		(0.006)		(0.007)
Δ Food Prices away from Home (percentage)	-0.017	-0.003	-0.028	-0.033	-0.024	-0.005
	(0.019)	(0.051)	(0.020)	(0.048)	(0.019)	(0.048)
Δ Food Prices away from Home Squared (percentage)	-	-0.001	-	0.000	-	-0.002
		(0.004)		(0.004)		(0.004)
Δ Unemployment Rates Δ Income Per Capita Δ Female Wages and Hours of work Δ Male Wages and Hours of work	Yes	Yes	Yes	Yes	Yes	Yes
Δ Unemployment Rates Squared Δ Income Per Capita Squared Δ Female Wages and Hours of work Squared Δ Male Wages and Hours of Work Squared	No	Yes	No	Yes	No	Yes
n	15,035		4,448		1,112	

Notes: All models are estimated using the first difference approach and based on weighted aggregated samples from the NHIS for years 1976 to 2001. Robust standard errors, calculated assuming that observations are independent across metropolitans, but not within metropolitans, are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All regressions control for individual demographic variables, including gender, race, education, marital status, age and family income (indicators or changes in percentage when applicable), as well as year fixed effects.

Table 7: The Estimated Effects of Food Price Changes on Changes in Obesity: By Grouping Method

COEFFICIENT	Δ Obesity Method 1		Method 2		Method 3	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Food Prices at Home (percentage)	-0.714	-0.416	-0.760	-0.275	-0.947*	-0.036
	(0.527)	(0.899)	(0.528)	(0.962)	(0.521)	(0.749)
Δ Food Prices at Home Squared (percentage)	-	-0.049	-	-0.077	-	-0.137
		(0.169)		(0.165)		(0.136)
Δ Food Prices away from Home (percentage)	-0.277	0.532	-0.377	0.865	-0.231	0.552
	(0.305)	(1.161)	(0.291)	(0.989)	(0.324)	(0.887)
Δ Food Prices away from Home Squared (percentage)	-	-0.072	-	-0.110	-	-0.070
		(0.096)		(0.087)		(0.074)
Δ Unemployment Rates Δ Income Per Capita Δ Female Wages and Hours of work Δ Male Wages and Hours of work	Yes	Yes	Yes	Yes	Yes	Yes
Δ Unemployment Rates Squared Δ Income Per Capita Squared Δ Female Wages and Hours of work Squared Δ Male Wages and Hours of Work Squared	No	Yes	No	Yes	No	Yes
n	15,035		4,448		1,112	

Notes: All models are estimated using the first difference approach and based on weighted aggregated samples from the NHIS for years 1976 to 2001. Robust standard errors, calculated assuming that observations are independent across metropolitans, but not within metropolitans, are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All regressions control for individual demographic variables, including gender, race, education, marital status, age and family income (indicators or changes in percentage when applicable), as well as year fixed effects.

Table 8: The Estimated Effects of Relative Food Price Changes on Changes in Body Mass Index: By Grouping Method

COEFFICIENT	Δ BMI					
	Method 1		Method 2		Method 3	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Relative Food Prices at Home (percentage)	-0.022	-0.024	-0.008	-0.009	-0.017	-0.014
	(0.031)	(0.033)	(0.028)	(0.030)	(0.027)	(0.030)
Δ Relative Food Prices at Home Squared (percentage)	-	0.003	-	0.004	-	0.006
		(0.004)		(0.004)		(0.004)
Δ Relative Food Prices away from Home (percentage)	-0.014	-0.017	-0.021	-0.024	-0.018	-0.021
	(0.019)	(0.019)	(0.019)	(0.020)	(0.019)	(0.021)
Δ Relative Food Prices away from Home Squared (percentage)	-	-0.006	-	-0.006	-	-0.007
		(0.004)		(0.004)		(0.004)
Δ Unemployment Rates Δ Income Per Capita Δ Female Wages and Hours of work Δ Male Wages and Hours of work	Yes	Yes	Yes	Yes	Yes	Yes
Δ Unemployment Rates Squared Δ Income Per Capita Squared Δ Female Wages and Hours of work Squared Δ Male Wages and Hours of Work Squared	No	Yes	No	Yes	No	Yes
n	15,035		4,448		1,112	

Notes: All models are estimated using the first difference approach and based on weighted aggregated samples from the NHIS for years 1976 to 2001. Robust standard errors, calculated assuming that observations are independent across metropolitans, but not within metropolitans, are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All regressions control for individual demographic variables, including gender, race, education, marital status, age and family income (indicators or changes in percentage when applicable), as well as year fixed effects.

Table 9: The Estimated Effects of Relative Food Price Changes on Changes in Obesity: By Grouping Methods

COEFFICIENT	Δ Obesity					
	Method 1		Method 2		Method 3	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Relative Food Prices at Home (percentage)	-1.085*	-1.368**	-0.981**	-1.277**	-1.025**	-1.286**
	(0.539)	(0.627)	(0.455)	(0.563)	(0.448)	(0.563)
Δ Relative Food Prices at Home Squared (percentage)	-	-0.168	-	-0.167	-	-0.141
		(0.113)		(0.117)		(0.114)
Δ Relative Food Prices away from Home (percentage)	-0.506	-0.723*	-0.521	-0.766*	-0.288	-0.480
	(0.339)	(0.396)	(0.326)	(0.381)	(0.335)	(0.364)
Δ Relative Food Prices away from Home Squared (percentage)	-	-0.027	-	-0.057	-	-0.005
		(0.105)		(0.078)		(0.086)
Δ Unemployment Rates Δ Income Per Capita Δ Female Wages and Hours of work Δ Male Wages and Hours of work	Yes	Yes	Yes	Yes	Yes	Yes
Δ Unemployment Rates Squared Δ Income Per Capita Squared Δ Female Wages and Hours of work Squared Δ Male Wages and Hours of Work Squared	No	Yes	No	Yes	No	Yes
n	15,035		4,448		1,112	

Notes: All models are estimated using the first difference approach and based on weighted aggregated samples from the NHIS for years 1976 to 2001. Robust standard errors, calculated assuming that observations are independent across metropolitans, but not within metropolitans, are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All regressions control for individual demographic variables, including gender, race, education, marital status, age and family income (indicators or changes in percentage when applicable), as well as year fixed effects.

Table 10: The Estimated Effects of Food Price Changes on Changes of Body Weight: By Education

	BMI		Obese	
All Samples	(1)	(2)	(1)	(2)
Δ Food Prices at Home	-0.029	-0.036	-0.714	-0.416
	(0.030)	(0.058)	(0.527)	(0.899)
Δ Food Prices at Home Squared	-	0.000	-	-0.049
		(0.007)		(0.169)
Δ Food Prices away from Home	-0.017	-0.003	-0.277	0.532
	(0.019)	(0.051)	(0.305)	(1.161)
Δ Food Prices away from Home Squared	-	-0.001	-	-0.072
		(0.004)		(0.096)
n		15,035		
High Educated Samples Only	(1)	(2)	(1)	(2)
Δ Food Prices at Home	0.006	-0.200*	-0.043	-4.321
	(0.052)	(0.114)	(1.351)	(2.639)
Δ Food Prices at Home Squared	-	0.028*	-	0.574
		(0.014)		(0.415)
Δ Food Prices away from Home	-0.042	0.073	0.565	2.144
	(0.047)	(0.085)	(0.922)	(2.294)
Δ Food Prices away from Home Squared	-	-0.010	-	-0.144
		(0.008)		(0.207)
n		3,764		
Low Educated Samples Only	(1)	(2)	(1)	(2)
Δ Food Prices at Home	-0.049	-0.009	-1.187**	-0.457
	(0.032)	(0.060)	(0.526)	(0.781)
Δ Food Prices at Home Squared	-	-0.006	-	-0.110
		(0.007)		(0.128)
Δ Food Prices away from Home	-0.022	-0.016	-0.326	-0.447
	(0.030)	(0.072)	(0.428)	(1.271)
Δ Food Prices away from Home Squared	-	-0.001	-	-0.003
		(0.005)		(0.094)
n		7,604		
Δ Linear Controls at MSA level	Yes	Yes	Yes	Yes
Δ Quadratic Controls at MSA level	No	Yes	No	Yes

Notes: All models are estimated using the first difference approach and based on weighted aggregated samples from the NHIS for years 1976 to 2001. Robust standard errors, calculated assuming that observations are independent across metropolitans, but not within metropolitans, are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All regressions control for individual demographic variables, including gender, race, education, marital status, age and family income (indicators or changes in percentage when applicable), as well as year fixed effects.

Table 11: The Estimated Effects of Relative Food Price Changes on Changes of Body Weight: By Education

	BMI		Obese	
All Samples	(1)	(2)	(1)	(2)
Δ Relative Food Prices at Home	-0.022	-0.024	-1.085*	-1.368**
	(0.031)	(0.033)	(0.539)	(0.627)
Δ Relative Food Prices at Home Squared	-	0.003	-	-0.168
		(0.004)		(0.113)
Δ Relative Food Prices away from Home	-0.014	-0.017	-0.506	-0.723*
	(0.019)	(0.019)	(0.339)	(0.396)
Δ Relative Food Prices away from Home Squared	-	-0.006	-	-0.027
		(0.004)		(0.105)
n		15,035		
High Educated Samples Only	(1)	(2)	(1)	(2)
Δ Relative Food Prices at Home	0.001	0.012	-1.303	-1.236
	(0.057)	(0.060)	(1.454)	(1.852)
Δ Relative Food Prices at Home Squared	-	0.025***	-	0.254
		(0.008)		(0.454)
Δ Relative Food Prices away from Home	-0.046	-0.038	-0.259	-0.078
	(0.042)	(0.036)	(0.796)	(1.011)
Δ Relative Food Prices away from Home Squared	-	-0.025***	-	-0.115
		(0.009)		(0.301)
n		3,764		
Low Educated Samples Only	(1)	(2)	(1)	(2)
Δ Relative Food Prices at Home	-0.035	-0.041	-1.388***	-1.686***
	(0.031)	(0.034)	(0.466)	(0.464)
Δ Relative Food Prices at Home Squared	-	-0.002	-	-0.187*
		(0.005)		(0.100)
Δ Relative Food Prices away from Home	-0.016	-0.025	-0.458	-0.752*
	(0.028)	(0.028)	(0.373)	(0.391)
Δ Relative Food Prices away from Home Squared	-	-0.001	-	0.025
		(0.006)		(0.121)
n		7,604		
Δ Linear Controls at MSA level	Yes	Yes	Yes	Yes
Δ Quadratic Controls at MSA level	No	Yes	No	Yes

Notes: All models are estimated using the first difference approach and based on weighted aggregated samples from the NHIS for years 1976 to 2001. Robust standard errors, calculated assuming that observations are independent across metropolitans, but not within metropolitans, are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All

regressions control for individual demographic variables, including gender, race, education, marital status, age and family income (indicators or changes in percentage when applicable), as well as year fixed effects.

Table 12: The Estimated Effects of Food Price Changes on Changes of Body Weight: By Gender

	BMI		Obese	
All Samples	(1)	(2)	(1)	(2)
Δ Food Prices at Home	-0.029	-0.036	-0.714	-0.416
	(0.030)	(0.058)	(0.527)	(0.899)
Δ Food Prices at Home Squared	-	0.000	-	-0.049
		(0.007)		(0.169)
Δ Food Prices away from Home	-0.017	-0.003	-0.277	0.532
	(0.019)	(0.051)	(0.305)	(1.161)
Δ Food Prices away from Home Squared	-	-0.001	-	-0.072
		(0.004)		(0.096)
n		15,035		
Male Samples Only	(1)	(2)	(1)	(2)
Δ Food Prices at Home	0.000	-0.036	-0.627	-0.389
	(0.031)	(0.056)	(0.711)	(1.331)
Δ Food Prices at Home Squared	-	0.004	-	-0.050
		(0.006)		(0.232)
Δ Food Prices away from Home	-0.017	0.020	-0.370	2.727*
	(0.021)	(0.070)	(0.484)	(1.571)
Δ Food Prices away from Home Squared	-	-0.003	-	-0.271**
		(0.005)		(0.128)
n		7,402		
Female Samples Only	(1)	(2)	(1)	(2)
Δ Food Prices at Home	-0.052	-0.043	-0.800	-0.513
	(0.037)	(0.082)	(0.576)	(1.372)
Δ Food Prices at Home Squared	-	-0.002	-	-0.040
		(0.010)		(0.196)
Δ Food Prices away from Home	-0.017	-0.020	-0.192	-1.307
	(0.027)	(0.072)	(0.426)	(1.388)
Δ Food Prices away from Home Squared	-	-0.000	-	0.095
		(0.005)		(0.113)
n		7,633		
Δ Linear Controls at MSA level	Yes	Yes	Yes	Yes
Δ Quadratic Controls at MSA level	No	Yes	No	Yes

Notes: All models are estimated using the first difference approach and based on weighted aggregated samples from the NHIS for years 1976 to 2001. Robust standard errors, calculated assuming that observations are independent across metropolitans, but not within metropolitans, are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All

regressions control for individual demographic variables, including gender, race, education, marital status, age and family income (indicators or changes in percentage when applicable), as well as year fixed effects.

Table 13: The Estimated Effects of Relative Food Price Changes on Changes of Body Weight: By Gender

	BMI		Obese	
All Samples	(1)	(2)	(1)	(2)
Δ Relative Food Prices at Home	-0.022	-0.024	-1.085*	-1.368**
	(0.031)	(0.033)	(0.539)	(0.627)
Δ Relative Food Prices at Home Squared	-	0.003	-	-0.168
		(0.004)		(0.113)
Δ Relative Food Prices away from Home	-0.014	-0.017	-0.506	-0.723*
	(0.019)	(0.019)	(0.339)	(0.396)
Δ Relative Food Prices away from Home Squared	-	-0.006	-	-0.027
		(0.004)		(0.105)
n		15,035		
Male Samples Only	(1)	(2)	(1)	(2)
Δ Relative Food Prices at Home	0.022	0.019	-0.958*	-1.435*
	(0.025)	(0.031)	(0.520)	(0.722)
Δ Relative Food Prices at Home Squared	-	0.001	-	-0.289
		(0.007)		(0.216)
Δ Relative Food Prices away from Home	-0.005	-0.005	-0.580	-1.013
	(0.022)	(0.024)	(0.566)	(0.639)
Δ Relative Food Prices away from Home Squared	-	-0.002	-	-0.126
		(0.005)		(0.118)
n		7,402		
Female Samples Only	(1)	(2)	(1)	(2)
Δ Relative Food Prices at Home	-0.059	-0.061	-1.192	-1.330
	(0.041)	(0.039)	(0.707)	(0.832)
Δ Relative Food Prices at Home Squared	-	0.003	-	-0.074
		(0.005)		(0.180)
Δ Relative Food Prices away from Home	-0.021	-0.028	-0.430	-0.483
	(0.027)	(0.027)	(0.491)	(0.574)
Δ Relative Food Prices away from Home Squared	-	-0.010	-	0.049
		(0.006)		(0.165)
n		7,633		
Δ Linear Controls at MSA level	Yes	Yes	Yes	Yes
Δ Quadratic Controls at MSA level	No	Yes	No	Yes

Notes: All models are estimated using the first difference approach and based on weighted aggregated samples from the NHIS for years 1976 to 2001. Robust standard errors, calculated assuming that observations are independent across metropolitans, but not within metropolitans, are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. All

regressions control for individual demographic variables, including gender, race, education, marital status, age and family income (indicators or changes in percentage when applicable), as well as year fixed effects.