Food Price and Body Weight Among Older Americans

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A. Introduction

Body weight has risen dramatically in the US since 1978. In 2005, for example, over one-third of the adult population was obese, approximately three times the rate observed before 1980. The Center for Disease Control declared that obesity is one of its top public health priorities (2000).

A great many policy approaches to the obesity epidemic have been proposed. A popular choice among these has been the imposition of a "fat tax" on selected foods that are deemed to promote obesity, as a result of high caloric density, low nutritional value, or high fat content (Jacobson and Brownell, 2000; Nestle and Jacobson, 2000). In the year 2000, for example, there were 19 states and cities in the United States that imposed taxes on less nutritious foods, like soft drinks, sweets, or snack foods (Jacobson and Brownell, 2000). In the past, policymakers viewed these primarily as "sin taxes" designed to raise revenue rather than influence health. Most localities use revenues for general purposes. Others earmark them for specific purposes, like violence prevention (Washington), Medicaid (Arkansas), or medical schools (West Virginia). Such taxes were strongly opposed by the soft drink and food industries. Perhaps as a result, 12 localities have reduced or repealed such taxes in recent years.

Understanding the public economics of "fat taxes" requires an understanding of how or even whether individuals respond to changes in food prices. Regardless of whether municipalities intend to influence health, there may be health effects that need to be quantified. To meet this public policy need, a literature on food prices and obesity has emerged in health economics. Chou, Grossman, and Saffer (Chou et al., 2004) found that the real fast-food restaurant price, the real food at home price and the real full-service restaurant price were negatively associated with weight in an adult population. Lakdawalla and Philipson (Lakdawalla and Philipson, 2002) find qualitatively similar, but larger, effects on a population of young adults. Among U.S. children from kindergarten to the third grade, lower real food prices of fruits and vegetables are significantly associated with lower weight gain (Sturm and Datar, 2005).

The study of the near-elderly and elderly is a notable gap in the literature. This is somewhat surprising, since elderly individuals living on fixed-incomes are often the hardest hit by consumption taxes of all kinds. Understanding whether or not such taxes have any salutary effects on their health seems important for assessing those consequences. Moreover, the prevalence of obesity and overweight is highest among this population, as are the associated health costs.

In this paper, we examine the associations between food prices of various kinds and body weight, for adults age 50 and over in the United States. We use the Health and Retirement Study (HRS), a longitudinal and nationally representative survey of older Americans, along with data on geographical and temporal variations in food price inside the United States to identify the associations. The results will provide valuable information on the potential effects of food tax/subsidy on curtailing the obesity epidemic in the US.

The rest of the paper is organized as follows: Section B outlines the conceptual framework. Section C describes the data, and Section D the methods. Section E reports the results, and Section F concludes.

B. Conceptual framework

Clearly, when we think of food as a homogeneous commodity with a single price, increases in that price will lead to less food intake and lower weight, under fairly weak conditions. However, considering various types of food, and differential changes in the relative prices of food types, the analysis becomes more nuanced. It is not always clear, for instance, that increases in the price of calorically dense foods lead to lower weight.

Consider an individual who maximizes utility across one high-calorie food F_h, one low-calorie food F_l, and non-food consumption C. Weight is a function of her food intake. Given income I she solves the following problem:

$$\begin{aligned} &\max_{F_h, F_l, C} U(W(F_l, F_h), F_l, F_h, C) \\ &s.t. C + p_h F_h + p_l F_l \leq I \end{aligned} \tag{1}$$

The prices for the two food types are p_h and p_l.

As emphasized in earlier work (Philipson and Posner, 1999), the marginal utility of weight gain depends on whether an individual is above or below her subjectively ideal weight. Without loss of generality, and because we are primarily focusing on food prices as a tool for weight-control, we consider the case where the individual is above her subjectively ideal weight, and $U_W < 0$.

Food is valuable to the individual for more than its effect on weight. For instance, people value taste, nutrition, and other food characteristics above and beyond its effects on weight. For these reasons, the food types enter directly into the individual's utility function. We make the standard assumption that utility is strictly monotonic and concave in both food types: $U_F > 0, U_{FF} < 0$. In addition, we presume that the high calorie food has a larger marginal impact on weight, in that $W_{F_h} > W_{F_l} > 0$.

Define optimal weight as $W^* = W(F_h^*, F_l^*)$. We are interested in how W^* shifts with changes in food prices. The effect of p_h on optimal weight W^* is given by:

$$\frac{\partial W^*}{\partial p_h} = \frac{\partial W^*}{\partial F_l^*}\frac{\partial F_l^*}{\partial p_h} + \frac{\partial W^*}{\partial F_h^*}\frac{\partial F_h^*}{\partial p_h} \tag{2}$$

The effect of p_l is given by:

$$\frac{\partial W^*}{\partial p_l} = \frac{\partial W^*}{\partial F_l^*}\frac{\partial F_l^*}{\partial p_l} + \frac{\partial W^*}{\partial F_h^*}\frac{\partial F_h^*}{\partial p_l} \tag{3}$$

We are interested in the conditions under which a price increase for each type of food leads to a lower optimal weight W^*. We assume that both types of foods have negative own-price elasticities, so that $\frac{\partial F_h^*}{\partial p_h} < 0$; $\frac{\partial F_l^*}{\partial p_l} < 0$. According to Equation (2):

$$\begin{aligned} &\frac{\partial W^*}{\partial p_h} = \frac{\partial W^*}{\partial F_h^*}\frac{\partial F_h^*}{\partial p_h} + \frac{\partial W^*}{\partial F_l^*}\frac{\partial F_l^*}{\partial p_h} < 0 \\ \Leftrightarrow &\frac{\frac{\partial W^*}{\partial F_h^*}}{\frac{\partial W^*}{\partial F_l^*}} > \frac{\frac{\partial F_l^*}{\partial p_h}}{(-\frac{\partial F_h^*}{\partial p_h})} \end{aligned} \tag{4}$$

Based on the definition of high- and low- calorie foods: $\frac{\frac{\partial W^*}{\partial F_h^*}}{\frac{\partial W^*}{\partial F_l^*}} > 1$. Therefore, increases in the price of high-calorie foods will lower weight if low-calorie and high-calorie foods are complements, If, however, they are substitutes, increases in the price of high-calorie foods might actually raise weight, if price growth stimulates low-calorie food consumption by more than it suppresses high-calorie food consumption.

Similar reasoning applies to the effect of changes in the price of low-calorie foods. The key issue is the nature of the cross-price elasticity. To take a concrete example, suppose that increases in the price of fatty foods leads to substitution towards leaner foods. However, in order to achieve the same level of satiety with leaner foods, the individual must increase her intake of calories substantially. In this case, the increase in the price of high-fat foods may actually lead to increases in weight by inducing an extremely large response in the consumption of alternative foods. This simple theoretical model illustrates that the impact of changes in the price of different kinds of food may vary from a theoretical point of view. Empirical analysis is needed.

Of course, the theoretical model also suggests an empirical challenge: one must in principle measure changes in the price of many individual foods, in order to isolate the true responses of weight. This is often impractical, due to limitations. One alternative, however, is to focus on nutrients that have more direct impacts on weight. Our approach is thus to construct a price index for calories. The idea here is that if calories become more expensive, people will consume less of them, and the result has to be a net reduction in energy intake, and thus weight. We also explore a price index for fat, for the sake of comparison.

C. Data

C.1 Health and Retirement Study Data

We use the Health and Retirement Study (HRS), a biennial survey of the population over age 50, to carry out the analysis. The original HRS cohort – first interviewed in 1992 –

was a nationally representative sample of approximately 7,600 households (n = 12,654 individuals) with at least one member who was born between 1931 and 1941. In every interview wave, HRS respondents are asked detailed questions about demographics, employment, occupation, income and wealth, and health insurance. Questions were also asked about self-reported general health status, prevalence and incidence of chronic conditions, functional status and disability, exercise, and self-reported body height and weight. County residence is available also, on a restricted-use basis; this allows us to link geographical information on food prices, as discussed below.

Body mass index in HRS is constructed from self-reported weight and height. Earlier research has identified systematic error in measurement for these variables; to address this issue, we employ the correction method developed by Cawley (1999). The Cawley procedure relies on the availability of external data on both actual and self-reported heights and weights. The relationship between the self-reported and actual numbers is then used to adjust the self-reports.

Objectively measured height and weight data are available for a subsample of the HRS. In the year 2006, HRS randomly selected half its households and measured their weight and height. The self-reported weight and height is also available for these households. Using these variables, we regressed actual weight on reported weight and its square, age and age squared, separately for the following eight sub-groups: white male non-Hispanic, white female non-Hispanic, black male non-Hispanic, black female non-Hispanic, Hispanic male, Hispanic female, other male, and other female. Figure F-A 1 to Figure F-A 4 shows the relationship between predicted weight and height versus self-reported weight and height. Non-Hispanic white (male and female) and black female tend to under-report weight when self-reported weight is high. There is s slight over-report of height across all race-gender groups, especially among “other male”.

C.2 Food Price Data

We obtain prices for food and other goods from the ACCRA Cost of Living data, published quarterly by the American Chamber of Commerce Researchers Association (ACCRA), for more than 200 cities. We use data from 1992 to 2003.

ACCRA collects prices for 57 distinct but standardized items, which are all listed in Table B F-1. Some examples include: 5 lb bag of sugar, cane or beet; 3 lb can of Crisco brand shortening; 12 oz can of Minute Maid brand frozen concentrated orange juice. For each city, ACCRA collects mean prices for each of the 57 items. It also report the expenditure weight of each item in the budget of a nationally representative household with a “middle-management” lifestyle.

Since the ACCRA data are reported quarterly, we average prices over the available quarters to obtain annual prices. ACCRA reports prices at the level of metropolitan areas, but the HRS data codes residence at the county-level. Therefore, we use the population-weighted averages of city prices to construct prices at the county-level. We calculate “real” prices by deflating using the Bureau of Labor Statistics (BLS) consumer price index for all goods.

Using the ACCRA data, we calculate the following price indices: price per calorie, price of food at home, price of fast food, price of fat, price of cigarettes, and price of gasoline.

C.2.1 *Individual Item Prices*

We use the price of cigarettes and of gasoline, as collected by ACCRA. The price of gasoline is the cash price at a self-service pump, if available, for one gallon of regular unleaded, national brand gasoline, inclusive of all taxes. The price of cigarettes is calculated as the price of a carton of Winston king-size (85mm) cigarettes.

C.2.2 *Price Indices*

There are two basic types of food price indices. Laspeyres index measures the changes in the cost of a fixed basket of goods from a base period. It presumes that consumers do not substitute one good within the basket for another, as a result of relative price changes. As a result of substitution behavior, it overestimates the true growth in the price of composite consumption. An alternative is the Paasche index, which weights prices by current consumption patterns. This index likely overstates substitution and thus underestimates the true growth in the price of composite consumption. The two indices can be viewed as the “upper bound” and “lower bound” of the price change.

There is also a “blended” choice between the Laspeyres and Paasche indices. These are called “superlative” indices (Hill, 2006). A detailed description of the three superlative indices is in Appendix C. In this study we construct both Laspeyres-type price indices and Paasche-type price indices. Estimates for the two sets of price indices will provide upper and lower bounds for the true price effects.

Price of Food At Home

The price of food at home is constructed using ACCRA's basket of "grocery goods" excluding laundry detergent, facial tissue, and cigarettes.

Price of Fast Food

The price of fast food is constructed as a basket of all the fast-food items available in ACCRA: McDonald's Quarter-Pounder with cheese, 12 to 13 inch thin crust cheese pizza from Pizza Hut or Pizza Inn, and a fried chicken thigh and drumstick (with or without extras, whichever is less expensive) at Kentucky Fried Chicken or Church's.

Price Per Calorie

It is not generally possible to construct an empirical analogue to our theoretical concepts of a single "composite high-calorie" food and a single "composite low-calorie" food. As an alternative, we construct a measure of the price per calorie. Increases in this index we interpret as relative increases in the price of high-calorie foods.

To construct this index, we need information on calories per unit of food purchased. We obtain these data from the USDA website of "What's In The Foods You Eat *Search Tool*."[1] For each item j, we obtain calories per purchase unit, unit prices across areas and years, and its share in expenditure. Based on these variables, our price per calorie measure is constructed as:

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[1] http://www.ars.usda.gov/Services/docs.htm?docid=17032

$$price\_percal_{at} = \frac{1}{\sum\limits_{j=1}^{27} \exp\_share_{j} \times \frac{Calories\_per\_purchase\_unit_{j}}{price_{atj}}}$$

a : area
t : year
j : food item (1)
$\exp\_share_{j}$: share of item j in all expenditure
$Calories\_per\_purchased\_unit_{j}$: Calories per unit of purchase for food j
$price_{atj}$: Price per unit of purchase for food j at area a and time t

Price per calories in area a and time t is a calorie- and expenditure-weighted average of goods prices in area a and time t.

Price of Fat

The price per gram of fat is constructed using the same USDA database on nutrition. We follow the same procedure as in constructing the price per calorie, except we measure grams of fat per purchase unit instead of calories per purchase unit.

C.3 Analytic Sample

We begin with 9,733 HRS respondents born between 1931 and 1941, first interviewed in 1992 and with positive HRS sampling weight. Those who did not die or drop out of the sample were followed biennially until 2004. Due to the nature of the analysis, we exclude several segments of the sample. First, we exclude individuals residing in counties for which ACCRA collects no data. Second, we exclude individuals with missing values for any of the variables used in the regression analysis. Third, we exclude observations with non-adjacent waves of data. For example, if an individual was interviewed in wave 1, wave 3, and wave 4, we exclude the wave 1 data, but retain the data from waves 3 and 4. Finally, we exclude individuals who moved from one county to another. These individuals moved at some point between interviews, which are spaced 24 months apart. Given the substantial between-city variation in food prices, this induces considerable error in measuring the "true" price that the individual faces over the relevant time-frame. The detailed sample selection process is shown in Figure F-1. 3,178 individuals are included in the final analytic sample. Below, we investigate the possibility of sample selection bias.

D. Methods

D.1 Econometric analysis

Body weight is determined by a dynamic process, during which an individual maintains, gains, or loses weight, as a result of energy expenditure. A simple way to represent this process is with the following model:

$$W_{igt} = \gamma W_{ig,t-1} + \beta_0 + P_{gt}\beta_1 + Z_{gt}\beta_2 + X_{igt}\beta_3 + \alpha_i + \phi_g + \tau_t + \varepsilon_{igt} \tag{2}$$

Weight for individual i in geographic region g and time t is modeled as a function of: last period's weight; food-price related variables P_{gt}; time-varying individual characteristics X_{igt}, including age, income, wealth, health status, smoking behavior, and exercise; regional variables Z_{gt}; individual fixed-effects α_i; geographic region fixed-effects ϕ_g; and year fixed-effects τ_t. Finally, in several specifications, we examine whether or not key responses vary by a household's position in the distribution of wealth.

The regression equation above is a dynamic linear model. If $\gamma \neq 0$, fixed-effects or first-difference estimation may generate inconsistent estimates by failing to account for the $\gamma W_{ig,t-1}$ term properly. To test this hypothesis, we use the method proposed by Arellano and Bond (1991) to generate estimates that are robust to $\gamma \neq 0$. Specifically, we first-difference the regression equation, to obtain:

$$\Delta W_{igt} = \gamma \Delta W_{ig,t-1} + \beta_1 \Delta P_{gt} + \beta_2 \Delta Z_{gt} + \beta_3 \Delta X_{igt} + \Delta \tau_t + \Delta \varepsilon_{igt}$$

We then use $(W_{igt1},\ldots,W_{igt-2},\Delta Z_{gt},\Delta X_{igt},\Delta P_{gt})$ as instruments for the model. The results, shown in Table F-8, fail to reject the hypothesis that $\gamma \neq 0$. As a result, we proceed with first-difference estimation for the balance of the paper.

D.1.1 *County Characteristics*

Apart from the food price vectors, we include the following county-level characteristics in the regressions: log of price of cigarettes, log of price of gasoline, and log of price of non-food goods (excluding cigarettes and gasoline).

Following Chou, Grossman, and Saffer (2004), we include cigarette prices in the weight equation, since cigarettes may serve a weight-control function. If smoking reduces weight, cheaper cigarettes might contribute to weight-reduction, holding food prices constant.

The effects of gasoline prices are more complex. On the one hand, it affects the cost of transportation and the incentives for exercise. For instance, in areas where gasoline is expensive, people may choose to live closer to work, and take public transportation, both of which involves more exercise than driving. The price of gasoline is also correlated with the cost of agricultural output. In principle, this could also absorb some of the cost-driven variation in the price of food: increases in the price of gasoline may increase the cost of producing and transporting food; this may have different effects in different parts of the country. In practice, however, including the price of gasoline had little impact on the estimated effects of food price variation.

Finally, the price of non-food goods captures the substitution and income effects that occur when the overall cost of living rises.

D.1.2 *Individual Characteristics*

We include the following time-varying individual characteristics in our regression models: age, self-reported diagnosis of chronic conditions (cancer, diabetes, heart disease, hypertension, lung disease, stroke, arthritis, mental problems), whether self-rated health is fair or poor, current smoking status, marital status, whether the respondent is working for pay, total household income, and total household wealth.

D.2 Correction for sample attrition bias

Since we include only 32.7% of the initial sample (3,178 out of 9,733) in our analysis, sample selection bias may be an issue, in the sense that our analytic sample may no longer be representative of the study population. In particular, the question is whether our sample selection criteria are correlated with food price and weight changes.

To address sample selection bias, we adjust the sampling weights to account for our secondary selection criteria. We first estimate a probit model of whether an individual in the study sample will appear in the analytic sample. Regressors include demographics, health, and economic status at the 1992 interview. We then predict the probability of sample inclusion for those in the analytic sample, and multiply the sampling weight by the inverse of the predicted probability. All descriptive and regression analyses are carried out using the modified sampling weight. This procedure addresses selection bias on the basis of observables, but we may still suffer from selection on the basis of unobservables (Wooldridge, 2002).

The selection model is presented in Table F-1. It shows that residing in rural areas greatly decreases the probability of being included in the analytic sample. This is because the ACCRA price data is only collected in cities. Even though we aggregate data at the county level, those in rural counties are excluded. Individuals with diabetes at the baseline interview are also less likely to appear in the analytic sample. In addition, non-Hispanic blacks, Hispanic, and those with less than high school education are more likely to be included. Finally, those with higher household wealth are also more likely to appear in the analytic sample.

The original sampling weight has a mean of 2,340, standard deviation of 1,048, a minimum of 563 and a maximum of 7,710. After multiplying by the inverse of the probability, the mean is raised to 5,813, the standard deviation 3,560, the minimum 921, and the maximum is 26,687. Descriptive statistics of the analytic sample is shown in Table F-2.

E. Results

The key outcome variable is either BMI or the natural logarithm of BMI. We examined different sets of food price specifications: (1) log of price per 1,000 Calories; (2) log of price of food at home, log of fast food price; (3) log of price per gram of fat.

E.1 Unadjusted Associations

Figure F-2 to Figure F-5 show the average 2-year change in BMI at the individual level, against the terciles of average 2-year declines in the log of relative prices using a variety of different metrics. Figure F-2 plots the log relative price per 1000 calories, defined as the price per 1000 calories divided by the price of the composite good. The heights of the bars indicate means, while the red “whiskers” denote 95% confidence intervals.

To be sure, there is a substantial amount of noise in the unadjusted price and BMI series. This leads to substantial confidence intervals. Regression controls will help to address this. However, a few qualitative findings appear even in these crude analyses. For the composite measures of food – price per calorie, price per gram of fat, and price of food at-home – there is reasonably consistent evidence that individuals experiencing price declines in the top third of the distribution exhibit BMI gains that are significantly higher than their peers. The unadjusted relationships are not monotonic, but the difference between the upper tercile and the lower terciles appears for these series. However, there is relatively little evidence of an association between declines in the price of fast food and changes in weight.

E.2 First-difference estimation results

We next turn to the regression analysis. All regressions cluster their standard errors at the county-level. All regressions include the following variables: log of price of cigarettes, log of price of gasoline, log of price of non-food goods excluding cigarettes and gasoline, self-reported diagnosis of chronic conditions, self-rated health, current smoking status, marital status, whether working for pay, total household income, total household wealth, and time dummies.

Table F-3 analyzes the impact of price per calorie on BMI change. The columns vary in their definition of the dependent variable as BMI levels or logarithms, and in the type of price index – Laspeyres or Paasche. Recall that Laspeyres yields an upper bound on the magnitude, while Paasche yields a lower bound. In addition, there are two panels of the table, corresponding to: baseline models, and models with interactions for wealth terciles.

Using Laspeyres price indices, doubling the price per calorie is associated with a reduction of 0.94 BMI units, or 2.6 percent of BMI. Both effects are statistically significant at the 0.05 significance level. The price effects using Paasche indices are only slightly smaller – 0.82 BMI units, or 2.2 percent – and are significant at the 10%

significance level. The prices of cigarettes and other non-food items, on the other hand, do not have significant effects on weight in this specification. Doubling the price of gasoline, on the other hand, lowers BMI by about 0.70 units or 2.2%. These results are consistent with the idea that taxing calories can lead to behavioral change that lowers weight.

However, according to the middle panel, the entire food price effect is located in the bottom tercile of the wealth distribution. Doubling the price per calorie leads to a reduction in BMI between 6.3% and 7.8% for those in the lower third of the wealth distribution, or a reduction in BMI from 2.2 to 2.7 units. In contrast, there is no significant effect on the rest of the wealth distribution. This suggests that, while "calorie taxes" may be effective at lowering weight, they do so by influencing the behavior of the poorest in society. In sum, richer members of society will choose to pay the tax without altering behavior, while the poor will do the opposite.

Table F-4 studies the impact of prices for food at home, compared to fast food. This breakdown of the food price data does not reveal powerful effects on BMI. The theoretical model illustrated the difficulty of predicting with certainty the impact of changes in the price of calorie dense foods, compared to the price of low-calorie foods. By that reasoning, analyzing a basket of specific foods may provide even more problematic inferences. For example, the price of a basket of food may go up because high-calorie foods got more expensive, or because low-calorie foods got more expensive. These two scenarios would be treated as identical in this model, but clearly have different effects on individual incentives. The resulting measurement error may explain the imprecision in these estimates.

Given the difficulties associated with pricing baskets of food items, we return to our strategy of constructing price indices for nutrients. To supplement the analysis of price per calorie, we next estimate the effect for price per gram of fat. Table F-5 displays the results. Doubling the price of fat reduces BMI by 0.8 units, or about 2.4%.   The elasticity is fairly similar to that on the price of calories, where doubling the price led to declines in BMI ranging between 0.8 and 0.94 units. We continue to see that the effect is driven primarily by the lowest wealth tercile. For that group, doubling the price of fat lowers BMI by 2.0 to 2.2 units. However, as far as the interactions are concerned, the magnitudes are smaller and the effects not as consistently significant as in the case of price per calorie.

Next, we compare the effects of changes in the price of calories, to changes in the price of fat. Unfortunately, we lack sufficient variation to identify this decomposition. The correlation coefficient between fat price and calorie price is approximately 0.92. Variation in the price of calories is highly coincident with the price of fat. This likely explains the results in Table F-6, which reports regressions that include both the price of fat and the price of calories. Including both yields insignificant coefficients on both variables, for the dependent variable of BMI. We interpret these findings to suggest that the price of calories falls when the price of fat falls, and vice-versa.

Partly, this result owes itself to sparseness in the set of foods we observe in our data. For example, we lack information on high-sugar, low-fat products (e.g., sugary cereals, low-fat baked goods, and the like) that might be high in calories but low in fat. Such items are necessary in order to separate the effects of individual nutrients.

E.3 Comparisons to the Previous Literature

Our results for the impact of prices on BMI appear to be roughly in line with the literature that focuses on other subpopulations. We estimate that the elasticity between the price of calories and body weight is approximately 0.02 to 0.03. For at-home food, Chou, Grossman, and Saffer (Chou et al., 2004) estimated a price elasticity of -0.04.

We did not, however, find an impact of fast-food prices on weight. On this question, the literature is mixed. Chou, Grossman, and Saffer (2004) estimated a significant price elasticity of -0.05, but Datar and Sturm (Sturm and Datar, 2005) do not find a significant effect of fast-food prices on children’s body weight. Finally, Schroeter (Schroeter et al., 2007) argues that rising fast food prices might actually raise body weight.

For “unhealthy” food, we found that doubling the price of fat is associated with 2% reductions in BMI. Gelbach et al (Gelbach et al., 2007) find that doubling the price of “unhealthy” food is associated with about 1 percent less BMI.

E.4 Identification

Our models are identified by local trends in food prices. The data reveal substantial variation across regions in local price trends. It is natural to inquire into the sources of these, but quite difficult to pinpoint an exact origin. We investigated several hypotheses.

Several studies have found that store formats are important in explaining cross-sectional regional price variations{Basker, 2005 #590; Hausman, 2004 #589; Leibtag, 2005 #588} Leibtag (2005) found that food sold at non-traditional food stores (supercenters, wholesale clubs, etc) are cheaper; for instance, dairy products are 5-25% cheaper. Basker (2005) examined the effects of Wal-Mart entry on the city-level prices of several non-food retail items, including aspirin, cigarettes, coke, detergent, and others. He finds negative price effects of Walmart entrance. Motivated by this result, we assessed whether geographic variation in the appearance of discount stores (e.g., Wal-Mart) generated significant differences in local price trends. This failed to provide much if any explanatory power.

Second, we tested the hypothesis that some areas were more exposed to increases in transportation costs for food. To test this, we tested for systematic price trend differences across states with large and small shares of agricultural land. To be sure, this is a fairly crude measure of local transportation costs. Perhaps due to this error in measurement, we failed to find systematic differences in price trends across areas with more or less agricultural land and agricultural output.

A third option, related to transportation costs, exploits variation in the price of gasoline (Gelbach, Klick and Stratmann, 2007). The Gelbach et al study has found that census-region level price variation in gasoline influence the relative price of healthy food. Moreover, while gasoline can affect incentives to exercise, its effects on the cost of transporting goods should vary systematically across the country, depending on how far retailers are from production sites. This serves as a source of identification that “nets out” the common impact on exercise, and isolates the impact on transportation costs.

Following this reasoning, we used the interactions of gasoline price and approximate measures of per capita food production (proportion of population employed in food manufacturing, and per capita farm area) as the instruments for price. The first-stage results were roughly consistent with our assumptions – the interactions of gasoline price and per capita food output measures have significant and negative effects on price per 1,000 Calories, and price of grocery food. However, the second-stage standard errors rose substantially, so that it would not have been possible to identify the effects we recovered from the fixed-effects specifications without IV. One interpretation is that the gasoline instrument introduces too much noise to be useful. But the second-stage results are insignificant.

The failure to identify a clean source of variation begs the question of whether price trends are correlated with other economic or social factors that also influence weight. As a partial test of this, we assessed the impact of including observable demographic and economic factors on the price coefficients of interest. The results are displayed in Table F-7. Models I and II differ in their inclusion of economic and demographic controls. Model II adds the following: self-rated health, chronic conditions, working status, marital status, household income and household wealth. The table demonstrates that the price effects are both quantitatively and statistically similar across the model types. This is evidence that observable economic and demographic factors are uncorrelated with the price variation. Naturally, we cannot rule out unobservable factors, but it is plausible to suppose that observables and unobservables are correlated.

E.5 Limitations

There are a number of limitations imposed by the data and the nature of the problem. First, as discussed above, local variation in food prices might not be exogenous. If the supply of food is upward-sloping (i.e., if food prices are not primarily cost-driven), the resulting simultaneity between supply and demand would create downward bias in our estimated price effects. Testing this possibility would require a plausibly valid instrument, but these are in short supply here. We explored several candidates. First, fuel prices may influence the supply of food and ultimately body weight. However, they may also influence incentives for exercise, and thus the demand for weight. Moreover, the first-stage relationships between local trends in fuel prices and local trends in food prices are – perhaps not surprisingly – quite weak. A second candidate is local weather variation, particularly extreme weather events. These may affect the costs of distribution and transportation of food. However, such major events also have a variety of additional causal effects that can impact exercise, metabolism, and economic status. In the absence of an instrument, we have presented evidence that observed variation in economic and demographic factors are unrelated to local trends in price. It remains possible that unobserved variation in these factors is still correlated with price.

As is typically the case with the analysis of price effects, measurement error is another important issue. ACCRA price data are based on sampling a number of local stores, but intra-city price variation may not be adequately captured. More generally, it is quite difficult to measure the basket of prices faced by a particular individual who lives in a particular part of a city. This also results in downward bias.

Finally, we have the common problem of measurement error in weight. Our approach was to correct for self-reporting bias using a subsample of HRS respondents for whom data are available on measured weight and self-reported weight. Following Cawley (2004), we impute the expected measurement error in self-reported weight for the rest of the sample. Naturally, this strategy does not purge the measurement error; it merely mitigates it, to the extent that our imputation contains some relevant information. This would be a problem if error in reporting were correlated with price trends. Unfortunately, we cannot test this directly, because we do not have a panel of data on reporting error, which is only measured in one wave of the HRS data.

F. Conclusions

We examined the relationships between food prices of various kinds and body weight, among older Americans. We found that doubling the price of calories, or doubling the price of fat, reduces average body weight by approximately two to three percent. However, this effect was concentrated among individuals in the bottom tercile of the household wealth distribution. Specifically, while doubling prices has no significant effect on the rest of the population, it reduces body weight in the bottom tercile by five to seven percent. Empirically, our results are best viewed as lower bounds on the true effects, due to the possibility of measurement error and simultaneity bias.

From a policy perspective, these results suggest that policies raising the price of calories or fat will have little effect on weight, except for the poorest segment of the population. In the upper part of the wealth distribution, food taxation is essentially equivalent to a lump-sum tax on income, since it appears to generate relatively little behavioral change. There may be some changes along margins we do not measure, such as the composition of diets. However, changes seem to occur among the poorest. If we view this weight change as a welfare-improvement, perhaps because the poorest segment of the wealth distribution is making “mistakes,” then this policy is highly progressive in the sense that it improves welfare for the poor and redistributes away from the rich. The motivation for food taxation is typically the view that “mistakes” are being made, but this is naturally a flashpoint for controversy, particularly between economists and other analysts. If we view weight changes as a distortionary reduction in welfare, our results imply that food taxes impose burdens throughout society: the poor bear this burden in the form of reduced weight, while others bear it in the form of higher spending.

A third, and more nuanced, view of the problem emphasizes the externalities in public health insurance as a motivation for policy intervention (Grossman and Rashad, 2004). People may be making privately optimal weight decisions, but the existence of public health insurance schemes implies that overweight individuals impose additional burdens on taxpayers. Under this view, one might wish to implement policies that target people in public health insurance programs like Medicare and Medicaid. Food taxes are clearly a blunt instrument for doing so, although there is some evidence that effects might be concentrated near (if not entirely toward) the population that is eligible for Medicaid.

Figure F-1 Flow chart of forming the analytic sample

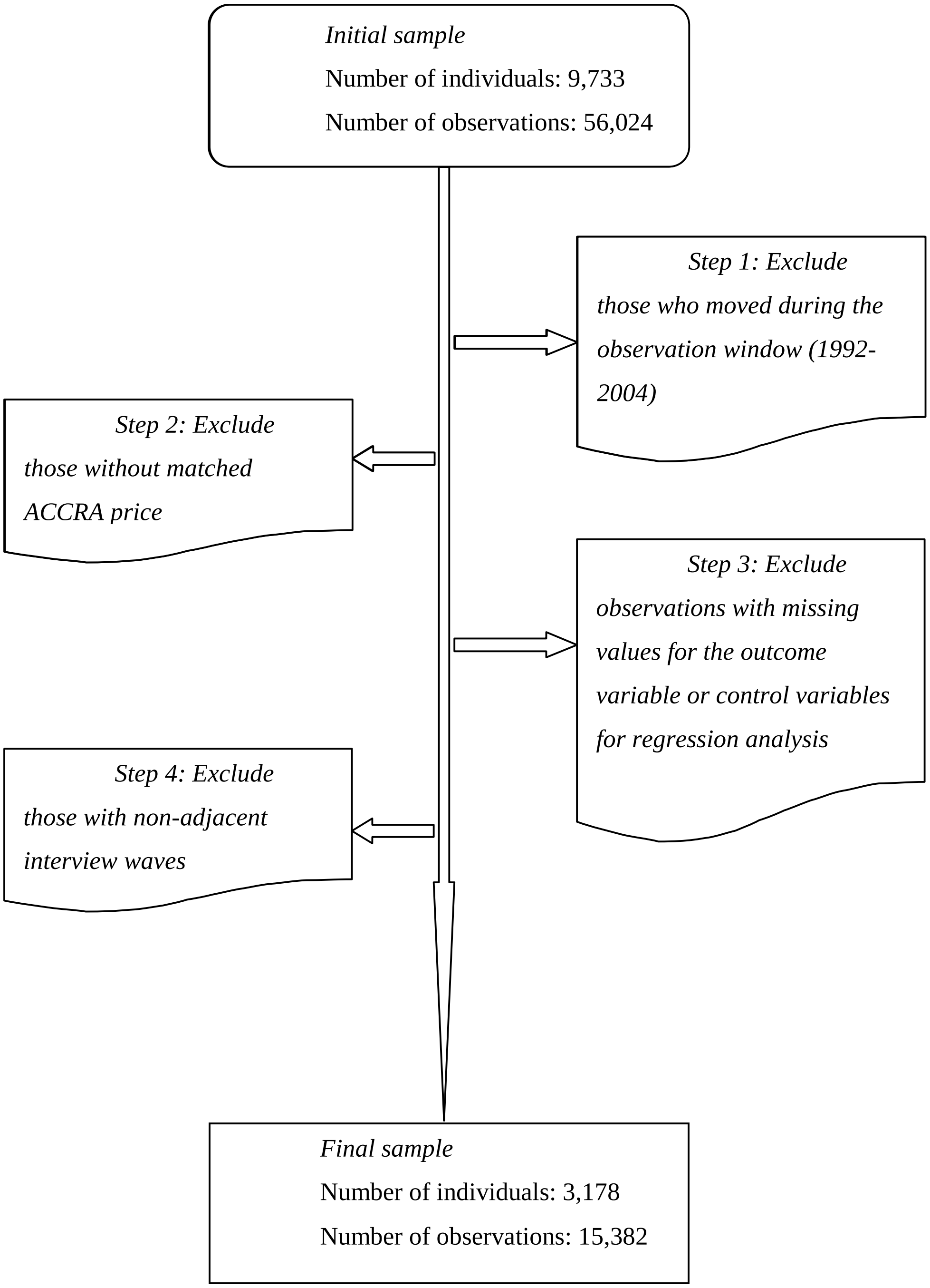


Figure F-2. BMI change and the decline of price per 1,000 Calories

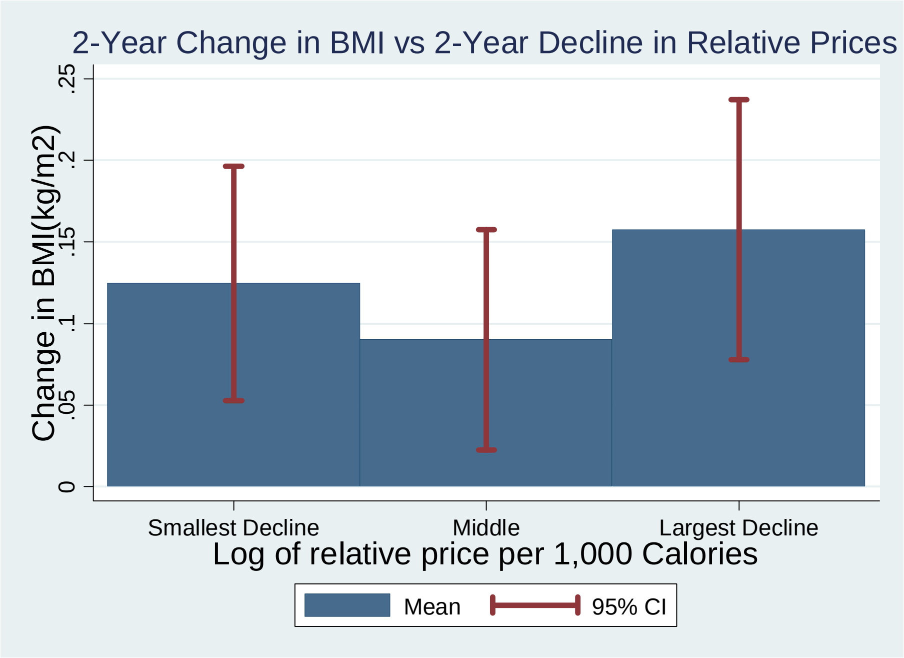


Figure F-3. BMI change and the decline of price of at-home food

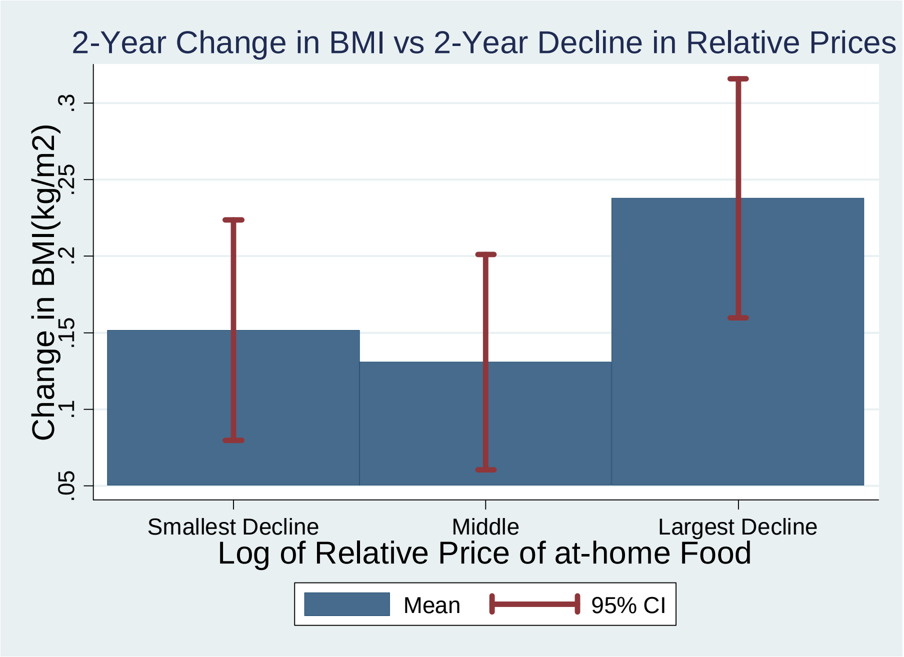


Figure F-4. BMI change and the decline of price of fast food

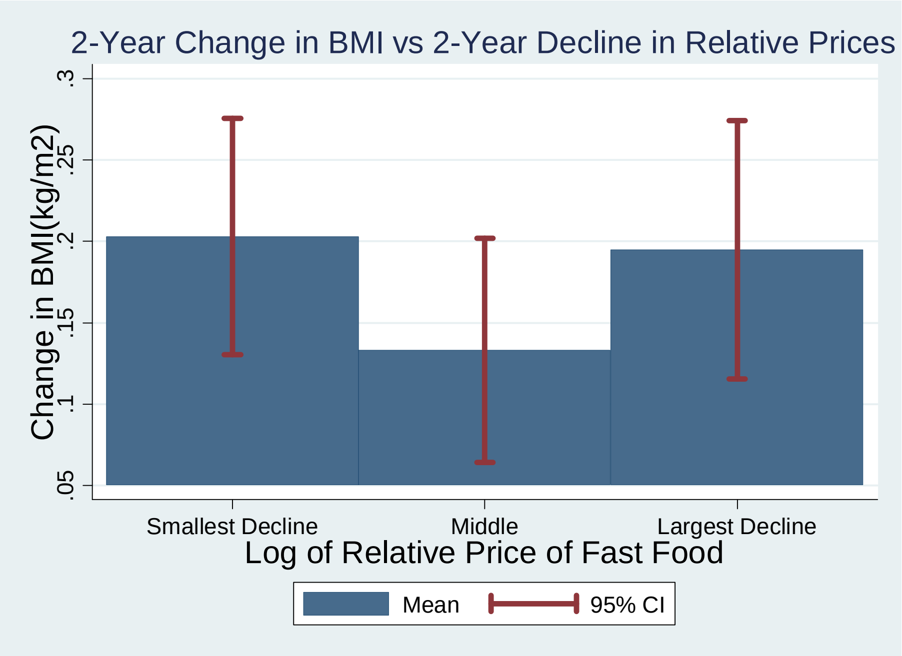


Figure F-5 BMI change and the decline of price per gram of fat

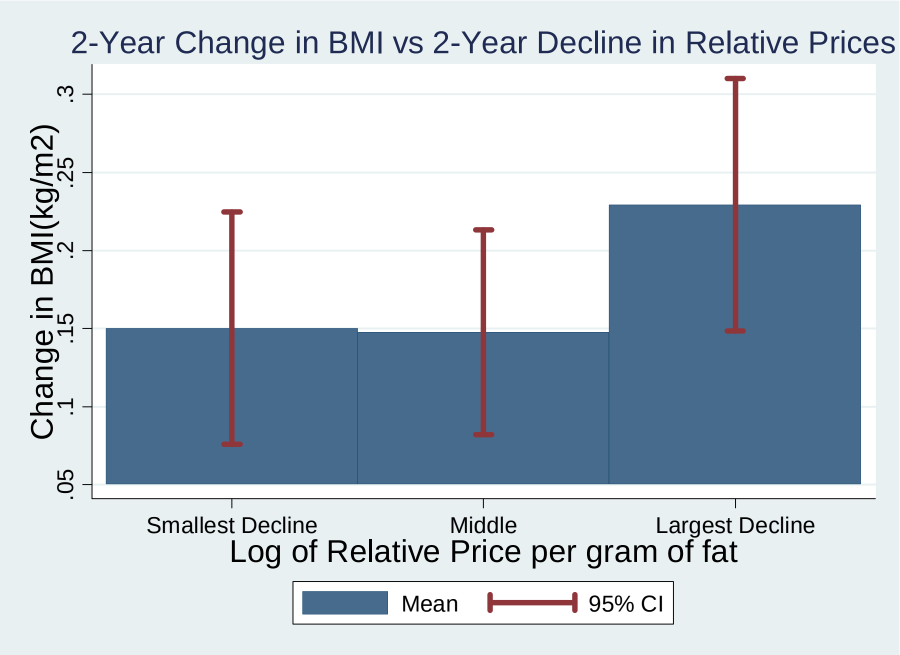


Table F-1. Probit Model of whether being included in the analytic sample

Covariate	Being included in the analytic sample
Male	-0.0213
	(0.0283)
Non-Hispanic black	0.2899***
	(0.0388)
Hispanic	0.3803***
	(0.0500)
Less than high school	0.0916**
	(0.0363)
Some college and above	0.0389
	(0.0319)
Suburban area	-0.0404
	(0.0309)
Rural area	-0.7872***
	(0.0353)
Initial Cancer	0.0960
	(0.0627)
Initial Diabetes	-0.0928*
	(0.0480)
Initial Heart disease	-0.0209
	(0.0460)
Initial Hypertension	0.0077
	(0.0296)
Initial Lung disease	0.0232
	(0.0609)
Initial Stroke	-0.0998
	(0.0876)
Initial Arthritis	0.0285
	(0.0295)
Initial Psyche problems	0.0204
	(0.0532)
Initial Current smoking	-0.0083
	(0.0310)
Initial Self-rated Health is Fair/Poor	0.0085
	(0.0394)
Initial Age	0.4489***
	(0.1589)
Initial Age squared	-0.0040***
	(0.0014)
Initial Log of household income	-0.0091
	(0.0100)
Initial Non-positive household wealth	0.0385
	(0.1092)
Initial Log of household wealth	0.0218**
	(0.0099)
Initial Widowed	-0.0034
	(0.0582)

Initial Single	0.0891**
	(0.0384)
Initial R working for pay	0.0164
	(0.0324)
N	9715

* p<0.10, ** p<0.05, *** p<0.01

Data source: Health and Retirement Study 1992-2004, ACCRA 1992-2003
Note: A Probit model is used to model the probability that a HRS respondent who is born between year 1931 and 1941 is included in the analytic sample.

Table F-2. HRS summary statistics for variables used in regression analysis

Number of individuals: 3,178; Number of observations: 15,382

Variable	Mean	Standard deviation (total)	Standard deviation (between)	Standard deviation (within)
Body mass index (kg/m2)	29.10	6.25	5.98	1.96
Prices (Laspeyres type of price index)				
Price per 1,000 Calories	0.79	0.07	0.07	0.04
Price per 100 grams of fat	1.80	0.23	0.20	0.10
Price of at-home food	1.14	0.10	0.09	0.04
Price of fast food	2.74	0.18	0.14	0.12
Price of margarine	0.46	0.11	0.10	0.06
Price of cigarettes	15.27	5.00	3.67	3.95
Price of gasoline	0.78	0.09	0.06	0.07
Price of non-food items excl.cigarettes and gasoline	220.00	99.98	93.06	40.05
Health conditions (%)				
Cancer	9.0%	28.6%	25.5%	13.6%
Diabetes	15.7%	36.3%	33.9%	15.2%
Heart disease	16.2%	36.9%	34.5%	15.9%
Hypertension	45.8%	49.8%	46.1%	20.7%
Lung disease	7.2%	25.8%	24.7%	11.1%
Stroke	4.4%	20.6%	18.7%	10.2%
Arthritis	48.8%	50.0%	45.8%	21.5%
Psyche problems	11.4%	31.7%	30.6%	12.3%
Self-rated Health is Fair/Poor	26.1%	43.9%	36.8%	26.1%
Current smoking (%)	20.5%	40.4%	37.7%	17.3%
Demographics				
Age at interview	61.28	4.91	3.85	3.41
Widowed (%)	10.6%	30.8%	27.7%	14.8%
Single (%)	19.3%	39.5%	37.7%	13.0%
Economic conditions				
R working for pay (%)	51.4%	50.0%	41.3%	30.2%
HH total income	31,765	42,713	34,509	25,824
HH wealth	189,238	819,872	877,793	497,516

Data source: HRS 1992-2004, ACCRA 1992-2003.

Table F-3. First-difference estimations of BMI or Log(BMI), on price per calorie.

	Dependent variable: BMI		Dependent variable: Log(BMI)	
	Laspeyres	Paasche	Laspeyres	Paasche
Log of price per calorie	-0.944**	-0.818*	-0.026**	-0.022*
	(0.411)	(0.421)	(0.013)	(0.013)
Log of price of cigarettes	-0.214	-0.224	-0.003	-0.003
	(0.261)	(0.260)	(0.008)	(0.008)
Log of price of gasoline	-0.698*	-0.719*	-0.022**	-0.023**
	(0.360)	(0.367)	(0.011)	(0.011)
Log of price of non-food items excl. cigarettes and gasoline	0.079	0.094	0.005	0.005
	(0.183)	(0.177)	(0.005)	(0.005)
N	11,871	11,871	11,871	11,871
Add interactions of price variables and the indicator of at the bottom tirtile of the initial household wealth				
Log of price per calorie	-0.240	-0.236	-0.004	-0.005
	(0.477)	(0.457)	(0.015)	(0.014)
(Log of price per calorie)*Bottom tirtile of HH wealth	-2.437**	-1.999**	-0.074**	-0.058**
	(1.122)	(0.877)	(0.033)	(0.024)
Log of price of cigarettes	-0.220	-0.233	-0.002	-0.002
	(0.260)	(0.260)	(0.008)	(0.008)
(Log of price of cigaretttes)*Bottom tirtile of HH wealth	-0.036	-0.017	-0.006	-0.006
	(0.268)	(0.263)	(0.009)	(0.008)
Log of price of gasoline	-0.701*	-0.713*	-0.023**	-0.024**
	(0.379)	(0.388)	(0.011)	(0.012)
(Log of price of gasoline)*Bottom tirtile of HH wealth	0.094	0.014	0.006	0.004
	(0.387)	(0.404)	(0.013)	(0.013)
Log of price of non-food items	0.074	0.067	0.003	0.003
	(0.206)	(0.199)	(0.007)	(0.007)
(Log of price of non-food items excl. cigarettes and gasoline)*Bottom tirtile of HH wealth	0.037	0.103	0.007	0.008
	(0.339)	(0.350)	(0.012)	(0.012)
N	11,871	11,871	11,871	11,871
Add interactions of price variables and the indicator of less than high school education				
Log of price per calorie	-0.908**	-0.797*	-0.023*	-0.020
	(0.447)	(0.448)	(0.014)	(0.014)
(Log of price per calorie)*Less than high school	-0.282	-0.212	-0.020	-0.016
	(1.192)	(0.953)	(0.034)	(0.027)
Log of price of cigarettes	-0.132	-0.141	0.001	0.000
	(0.265)	(0.263)	(0.008)	(0.008)
(Log of price of cigaretttes)*Less than high school	-0.383	-0.386	-0.016	-0.016
	(0.468)	(0.468)	(0.013)	(0.013)
Log of price of gasoline	-0.747*	-0.769**	-0.024**	-0.024**
	(0.382)	(0.388)	(0.011)	(0.011)
(Log of price of gasoline)*Less than high school	0.359	0.356	0.010	0.009
	(0.415)	(0.416)	(0.013)	(0.013)
Log of price of non-food items	0.160	0.166	0.007	0.007
	(0.229)	(0.215)	(0.007)	(0.006)
(Log of price of non-food items excl. cigarettes and gasoline)*Less than high school	-0.379	-0.343	-0.009	-0.007
	(0.468)	(0.440)	(0.014)	(0.013)
N	11,871	11,871	11,871	11,871

* p<0.10, ** p<0.05, *** p<0.01

Data source: Health and Retirement Study, 1992-2004, ACCRA price data, 1992-2003
Notes: All models also include the following variables: year dummies, self-rated health, chronic conditions, working status, marital status, household income and household wealth.

Table F-4. First-difference estimations of BMI or Log(BMI), on the price of food at home and in fast-food restaurants.

	Dependent variable: BMI		Dependent variable: Log(BMI)	
	Laspeyres	Paasche	Laspeyres	Paasche
Log of price of at-home food	-1.028*	-0.751	-0.031*	-0.022
	(0.548)	(0.553)	(0.016)	(0.017)
Log of price of fast food	0.230	0.221	0.006	0.006
	(0.416)	(0.422)	(0.013)	(0.013)
Log of price of cigarettes	-0.244	-0.239	-0.004	-0.003
	(0.260)	(0.260)	(0.008)	(0.008)
Log of price of gasoline	-0.700*	-0.754**	-0.022**	-0.024**
	(0.367)	(0.371)	(0.011)	(0.011)
Log of price of non-food items excl. cigarettes and gasoline	0.096	0.113	0.005	0.006
	(0.183)	(0.181)	(0.005)	(0.005)
N	11,871	11,871	11,871	11,871
Add interactions of price variables and the indicator of at the bottom tirtile of the initial household wealth				
Log of price of at-home food	-0.094	0.198	-0.005	0.006
	(0.656)	(0.671)	(0.020)	(0.020)
(Log of price of at-home food)*Bottom tirtile of HH wealth	-2.970**	-2.947**	-0.082*	-0.086**
	(1.420)	(1.186)	(0.042)	(0.036)
Log of price of fast food	0.225	0.119	0.007	0.004
	(0.605)	(0.621)	(0.019)	(0.019)
(Log of price of fast food)*Bottom tirtile of HH wealth	0.023	0.324	-0.001	0.009
	(0.994)	(1.059)	(0.029)	(0.031)
Log of price of cigarettes	-0.192	-0.206	-0.001	-0.001
	(0.264)	(0.262)	(0.008)	(0.008)
(Log of price of cigaretttes)*Bottom tirtile of HH wealth	-0.164	-0.106	-0.010	-0.008
	(0.279)	(0.286)	(0.009)	(0.009)
Log of price of gasoline	-0.762*	-0.826**	-0.025**	-0.027**
	(0.392)	(0.396)	(0.012)	(0.012)
(Log of price of gasoline)*Bottom tirtile of HH wealth	0.180	0.226	0.008	0.010
	(0.401)	(0.403)	(0.013)	(0.013)
Log of price of non-food items	0.038	0.073	0.002	0.003
	(0.217)	(0.208)	(0.007)	(0.007)
(Log of price of non-food items excl. cigarettes and gasoline)*Bottom tirtile of HH wealth	0.249	0.151	0.013	0.009
	(0.392)	(0.373)	(0.013)	(0.012)
N	11,871	11,871	11,871	11,871

* p<0.10, ** p<0.05, *** p<0.01

Data source: Health and Retirement Study, 1992-2004, ACCRA price data, 1992-2003
Notes: All models also include the following variables: year dummies, self-rated health, chronic conditions, working status, marital status, household income and household wealth.

Table F-5. First-difference estimations of BMI or Log(BMI), on the price of fat per gram

	Dependent variable: BMI		Dependent variable: Log(BMI)	
	Laspeyres	Paasche	Laspeyres	Paasche
Log of price per gram of fat	-0.834***	-0.822**	-0.024***	-0.023**
	(0.293)	(0.322)	(0.009)	(0.010)
Log of price of cigarettes	-0.183	-0.191	-0.002	-0.002
	(0.252)	(0.251)	(0.008)	(0.008)
Log of price of gasoline	-0.760**	-0.766**	-0.024**	-0.024**
	(0.332)	(0.338)	(0.010)	(0.010)
Log of price of non-food items excl. cigarettes and gasoline	0.107	0.127	0.006	0.006
	(0.185)	(0.178)	(0.005)	(0.005)
N	11,871	11,871	11,871	11,871
Add interactions of price variables and the indicator of at the bottom tirtile of the initial household wealth				
Log of price per gram of fat	-0.312	-0.340	-0.009	-0.011
	(0.370)	(0.391)	(0.011)	(0.012)
(Log of price per gram of fat)* Bottom tirtile of HH wealth	-1.845**	-1.727**	-0.052**	-0.045*
	(0.848)	(0.872)	(0.026)	(0.026)
Log of price of cigarettes	-0.183	-0.179	-0.000	-0.000
	(0.261)	(0.262)	(0.008)	(0.008)
(Log of price of cigaretttes)* Bottom tirtile of HH wealth	-0.101	-0.123	-0.009	-0.009
	(0.260)	(0.262)	(0.009)	(0.009)
Log of price of gasoline	-0.757**	-0.748**	-0.025**	-0.025**
	(0.355)	(0.363)	(0.011)	(0.011)
(Log of price of gasoline)* Bottom tirtile of HH wealth	0.019	-0.083	0.004	0.001
	(0.396)	(0.408)	(0.013)	(0.013)
Log of price of non-food items	0.066	0.064	0.003	0.003
	(0.212)	(0.205)	(0.007)	(0.007)
(Log of price of non-food items excl. cigarettes and gasoline)* Bottom tirtile of HH wealth	0.191	0.277	0.011	0.013
	(0.368)	(0.369)	(0.013)	(0.012)
N	11,871	11,871	11,871	11,871

* p<0.10, ** p<0.05, *** p<0.01

Data source: Health and Retirement Study, 1992-2004, ACCRA price data, 1992-2003
Notes: All models also include the following variables: year dummies, self-rated health, chronic conditions, working status, marital status, household income and household wealth.

Table F-6. First-difference estimations of BMI or Log(BMI), on the price of fat per gram and price per calorie

	Dependent variable: BMI		Dependent variable: Log(BMI)	
	Laspeyres	Paasche	Laspeyres	Paasche
Log of price per gram of fat	-0.861	-0.892	-0.028*	-0.028*
	(0.554)	(0.558)	(0.016)	(0.016)
Log of price per calorie	0.042	0.107	0.006	0.007
	(0.745)	(0.699)	(0.021)	(0.020)
Log of price of cigarettes	-0.182	-0.190	-0.002	-0.002
	(0.253)	(0.252)	(0.008)	(0.008)
Log of price of gasoline	-0.764**	-0.775**	-0.024**	-0.025**
	(0.351)	(0.355)	(0.011)	(0.011)
Log of price of non-food items excl. cigarettes and gasoline	0.108	0.129	0.006	0.006
	(0.187)	(0.182)	(0.006)	(0.005)
N	11,871	11,871	11,871	11,871
Add interactions of price variables and the indicator of at the bottom tirtile of the initial household wealth				
Log of price per gram of fat	-0.747	-0.783	-0.028	-0.029
	(0.730)	(0.676)	(0.022)	(0.021)
(Log of price per gram of fat)*Bottom tirtile of HH wealth	-0.405	-0.428	-0.001	0.000
	(1.473)	(1.426)	(0.049)	(0.048)
Log of price per calorie	0.633	0.601	0.028	0.025
	(0.910)	(0.762)	(0.029)	(0.024)
(Log of price per calorie)*Bottom tirtile of HH wealth	-2.033	-1.654	-0.072	-0.058
	(1.970)	(1.442)	(0.062)	(0.044)
Log of price of cigarettes	-0.189	-0.196	-0.000	-0.001
	(0.256)	(0.253)	(0.008)	(0.008)
(Log of price of cigarettes)*Bottom tirtile of HH wealth	-0.046	-0.034	-0.007	-0.006
	(0.266)	(0.262)	(0.009)	(0.008)
Log of price of gasoline	-0.763**	-0.762**	-0.026**	-0.026**
	(0.373)	(0.379)	(0.011)	(0.011)
(Log of price of gasoline)*Bottom tirtile of HH wealth	0.073	-0.024	0.006	0.004
	(0.382)	(0.398)	(0.012)	(0.013)
Log of price of non-food items	0.095	0.094	0.004	0.004
	(0.210)	(0.205)	(0.007)	(0.007)
(Log of price of non-food items excl. cigarettes and gasoline)*Bottom tirtile of HH wealth	0.073	0.149	0.007	0.009
	(0.329)	(0.327)	(0.011)	(0.011)
N	11,871	11,871	11,871	11,871

* p<0.10, ** p<0.05, *** p<0.01

Data source: Health and Retirement Study, 1992-2004, ACCRA price data, 1992-2003
Notes: All models also include the following variables: year dummies, self-rated health, chronic conditions, working status, marital status, household income and household wealth.

Table F-7. Compare different specifications of First-difference regressions of BMI or Log(BMI)

	Dependent variable: BMI		Dependent variable: Log(BMI)	
	I	II	I	II
Log of price per calorie(Laspeyres index)	-0.972**	-0.944**	-0.027**	-0.026**
	(0.405)	(0.411)	(0.012)	(0.013)
Log of price of gasoline	-0.660*	-0.698*	-0.022**	-0.022**
	(0.364)	(0.360)	(0.011)	(0.011)
Log of price of cigarettes	-0.240	-0.214	-0.004	-0.003
	(0.252)	(0.261)	(0.008)	(0.008)
Log of price of non-food exclude cigaret and gasoline(Laspeyres index)	0.120	0.079	0.006	0.005
	(0.187)	(0.183)	(0.006)	(0.005)
Age	-0.003*	-0.003	-0.000*	-0.000
	(0.002)	(0.002)	(0.000)	(0.000)
Age squared	0.457*	0.409*	0.013*	0.011
	(0.245)	(0.247)	(0.007)	(0.008)
Self-rated Health is Fair/Poor		0.145*		0.002
		(0.078)		(0.003)
Psyche problems		0.074		0.001
		(0.189)		(0.006)
Arthritis		0.144*		0.005
		(0.084)		(0.003)
Stroke		-0.875**		-0.027***
		(0.377)		(0.010)
Lung disease		-0.048		-0.004
		(0.214)		(0.007)
Hypertension		0.077		0.004
		(0.125)		(0.004)
Heart disease		-0.345**		-0.012**
		(0.175)		(0.005)
Diabetes		-1.057***		-0.031***
		(0.261)		(0.008)
Cancer		-0.345*		-0.014**
		(0.191)		(0.006)
R working for pay		-0.020		-0.001
		(0.071)		(0.002)
Single		-0.161		-0.005
		(0.142)		(0.005)
Widowed		-0.329**		-0.013***
		(0.143)		(0.004)
Log of household wealth		0.005		0.000
		(0.021)		(0.001)
Non-positive household wealth		-0.115		-0.005
		(0.255)		(0.008)
Log of household income		-0.010		-0.000
		(0.018)		(0.001)
Constant	-0.187	-0.182	-0.004	-0.004
	(0.166)	(0.167)	(0.005)	(0.005)
N	11,871	11,871	11,871	11,871

* p<0.10, ** p<0.05, *** p<0.01

Data source: Health and Retirement Study, 1992-2004, ACCRA price data, 1992-2003
Notes: All models include year dummies.
Model I doesn't include the following variables: self-rated health, smoking status, chronic conditions, working status, marital status, household income and household wealth.

Table F-8. Dynamic model of BMI or Log(BMI)

	Dependent variable: BMI			Dependent variable: Log of BMI		
Lag of BMI(kg/m^2)	-0.085	-0.085	-0.086			
	(0.093)	(0.093)	(0.093)			
Lag of log of BMI				0.025	0.026	0.025
				(0.068)	(0.068)	(0.068)
Log of price per 1000 Calories(Laspeyres index)	-0.880			-0.028		
	(0.558)			(0.018)		
Log of price of at-home food (Laspeyres index)		-0.942			-0.032	
		(0.678)			(0.022)	
Log of price of fast food(Laspeyres index)		0.053			0.004	
		(0.510)			(0.017)	
Log of price per gram of fat(Laspeyres index)			-0.644			-0.020
			(0.446)			(0.014)
Log of price of cigarettes	-0.195	-0.200	-0.187	-0.000	-0.001	-0.000
	(0.415)	(0.415)	(0.416)	(0.014)	(0.014)	(0.014)
Log of price of gasoline	-0.021	0.001	-0.101	-0.002	-0.002	-0.005
	(0.568)	(0.573)	(0.566)	(0.019)	(0.019)	(0.019)
Log of price of non-food exclude cigaret and gasoline(Laspeyres index)	0.396	0.427	0.409	0.013	0.015	0.014
	(0.319)	(0.323)	(0.315)	(0.011)	(0.011)	(0.011)
Age	0.617***	0.617***	0.615***	0.016**	0.016**	0.016**
	(0.223)	(0.223)	(0.223)	(0.007)	(0.007)	(0.007)
Age squared	-0.005***	-0.005***	-0.004***	-0.000**	-0.000**	-0.000**
	(0.002)	(0.002)	(0.002)	(0.000)	(0.000)	(0.000)
Log of household income	-0.008	-0.008	-0.008	-0.000	-0.000	-0.000
	(0.023)	(0.023)	(0.023)	(0.001)	(0.001)	(0.001)
Non-positive household wealth	-0.249	-0.245	-0.249	-0.010	-0.010	-0.010
	(0.268)	(0.268)	(0.268)	(0.009)	(0.009)	(0.009)
Log of household wealth	0.005	0.005	0.005	0.000	0.000	0.000
	(0.027)	(0.027)	(0.027)	(0.001)	(0.001)	(0.001)
Widowed	-0.393**	-0.388**	-0.394**	-0.014**	-0.014**	-0.014**
	(0.185)	(0.185)	(0.184)	(0.006)	(0.006)	(0.006)
Single	-0.131	-0.129	-0.134	-0.006	-0.006	-0.006
	(0.177)	(0.177)	(0.177)	(0.006)	(0.006)	(0.006)
R working for pay	0.032	0.032	0.031	0.001	0.001	0.001
	(0.068)	(0.068)	(0.067)	(0.002)	(0.002)	(0.002)
Cancer	-0.368*	-0.365*	-0.366*	-0.015**	-0.014**	-0.014**
	(0.219)	(0.218)	(0.219)	(0.007)	(0.007)	(0.007)
Diabetes	-0.988***	-0.988***	-0.988***	-0.031***	-0.031***	-0.031***
	(0.290)	(0.290)	(0.290)	(0.009)	(0.009)	(0.009)
Heart disease	-0.242	-0.239	-0.243	-0.009	-0.009	-0.009
	(0.188)	(0.188)	(0.188)	(0.006)	(0.006)	(0.006)
Hypertension	0.116	0.112	0.119	0.003	0.003	0.003
	(0.122)	(0.122)	(0.122)	(0.004)	(0.004)	(0.004)
Lung disease	-0.128	-0.128	-0.127	-0.007	-0.007	-0.007
	(0.233)	(0.234)	(0.234)	(0.008)	(0.008)	(0.008)
Stroke	-0.625**	-0.624**	-0.627**	-0.022**	-0.022**	-0.022**
	(0.274)	(0.273)	(0.274)	(0.009)	(0.009)	(0.009)
Arthritis	0.172*	0.173*	0.171*	0.005	0.005	0.005
	(0.099)	(0.099)	(0.099)	(0.003)	(0.003)	(0.003)
Psyche problems	0.122	0.123	0.125	0.003	0.003	0.003
	(0.296)	(0.296)	(0.296)	(0.009)	(0.009)	(0.009)
Self-rated Health is Fair/Poor	0.094	0.092	0.095	0.001	0.001	0.001
	(0.090)	(0.090)	(0.090)	(0.003)	(0.003)	(0.003)
N	8,360	8,360	8,360	8,360	8,360	8,360

* p<0.10, ** p<0.05, *** p<0.01

Data source: Health and Retirement Study, 1992-2004, ACCRA price data, 1992-2003
Notes: All models include year dummies.

F.1 Appendix A

Figure F-A 1. Compare predicted and self-reported weight among females

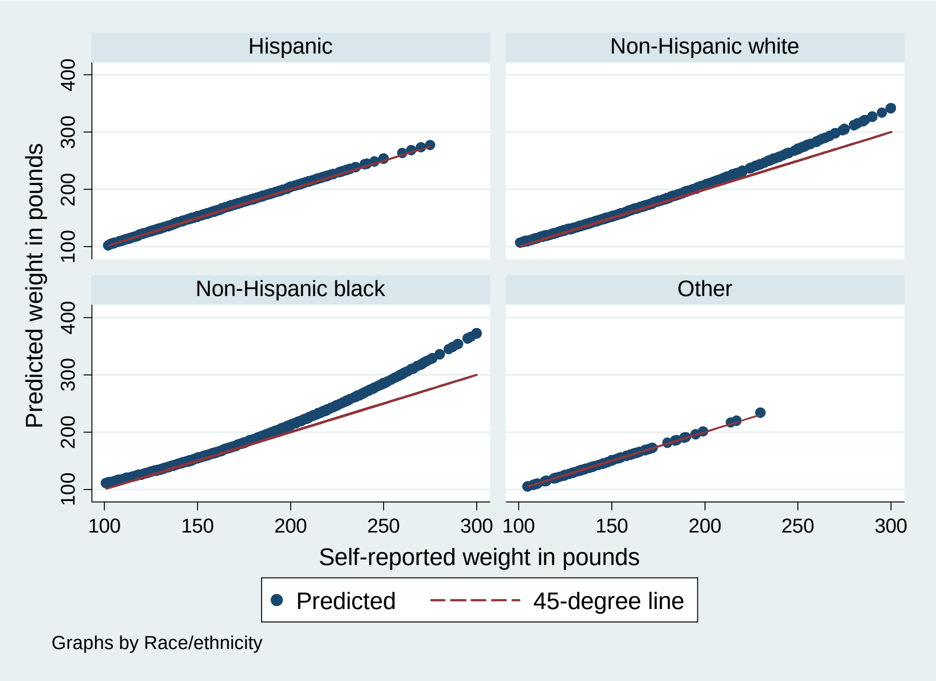


Figure F-A 2. Compare predicted and self-reported weight among males

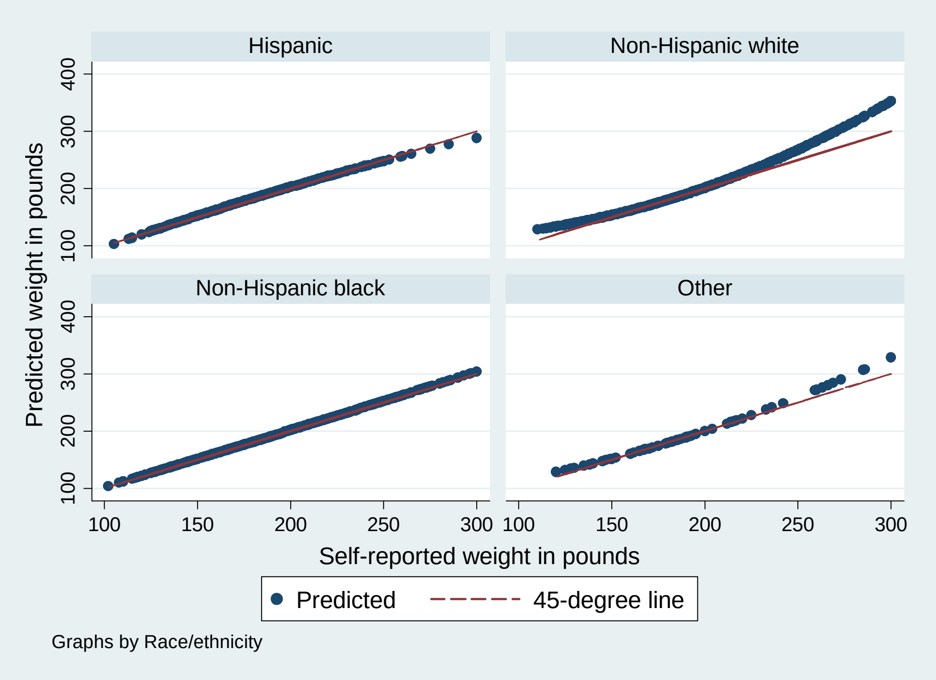


Figure F-A 3. Compare predicted and self-reported height among females

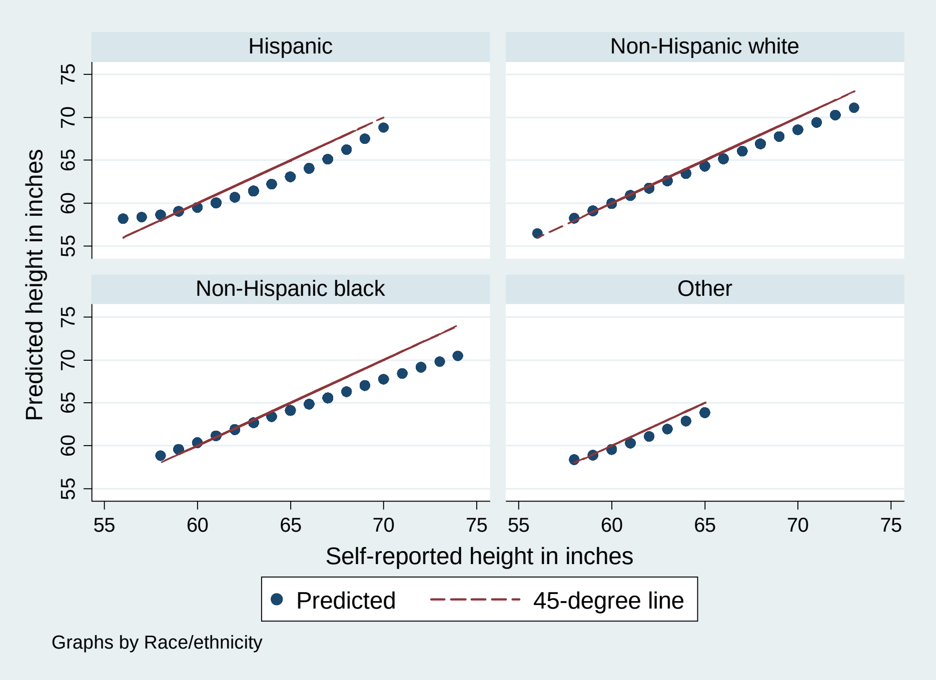
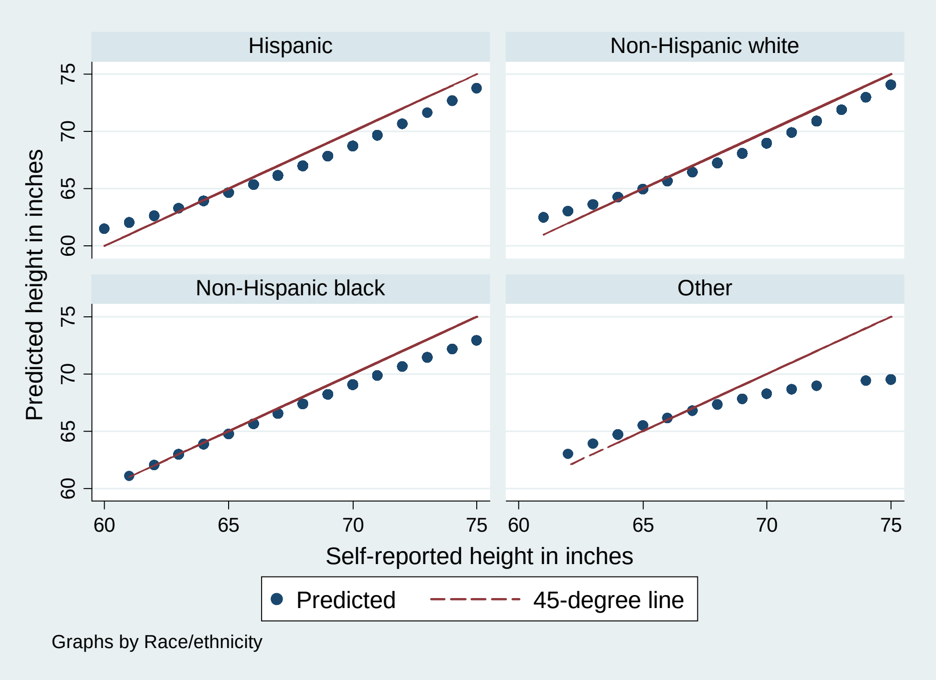


Figure F-A 4. Compare predicted and self-reported height among males



Note:
Weight prediction is based on the OLS regressions of measured weight against self-reported weight and self-reported weight squared, age and age squared, and predicted at the mean age, by gender and race. The estimation sample includes respondents aged 52 and over in the 2006 HRS survey and with both self-reported and measured weight.
Height prediction is based on the OLS regressions of measured height against self-reported height and self-reported height squared, age and age squared, and predicted at the mean age, by gender and races. The

estimation sample includes respondents aged 52 and over in the 2006 HRS survey and with both self-reported and measured height.

F.2 Appendix B

Table B F-1. Items, descriptions, and expenditure shares for ACCRA data collected in year 1992

Expenditure share within each category	Item	ItemDescription
Grocery (expenditure share 13%)		
0.0527	T-Bone Steak	Price per pound
0.0527	Ground Beef or hamburger	Price per pound, lowest price
0.0492	Sausage	Price per pound; Jimmy Dean 100% pork
0.0371	Frying Chicken	Price per pound, whole fryer
0.0306	Chunk Light Tuna	6.125-6.5 oz can, Starkist or Chicken of the Sea, packed in oil
0.0494	Whole Milk	Half-Gallon carton
0.009	Eggs	One Dozen, Grade A, Large
0.0376	Margarine	One Pound, cubes, Blue Bonnet or Parkay
0.0376	Parmesan Cheese, Grated	8 oz. Canister, Kraft Brand
0.0228	Potatoes	10 pound sack, white or red
0.0474	Bananas	Price per pound
0.0228	Iceberg Lettuce	Head, approximately 1.25 pounds
0.0818	Bread, White	24 oz. loaf, lowest price, or prorated 24-oz. equivalent, lowest price
0.0748	Cigarettes	Carton, Winston, king-size (85 mm.)
0.0513	Coffee, Vacuum-Packed	13 oz. can, Maxwell House, Hills Brothers, or Foldgers
0.0314	Sugar	5 pounds, Cane or Beet, lowest price
0.0419	Corn Flakes	18 oz., Kellog's or Post Toasties
0.0072	Sweet Peas	15-17 oz. can, Del Monte or Green Giant
0.0072	Tomatoes	14-1/2 oz. can, Hunts or Del Monte
0.0333	Peaches	29 oz. can, Hunt's, Del Monte, or Libby's, halves or slices
0.0221	Facial Tissues	175-count box, Kleenex brand
0.0417	Washing Powder	42 oz. ("Ultra"), Tide, Bold, or Cheer
0.0184	Shortening	3 pound can, all-vegetable, Crisco brand
0.0384	Frozen Orange Juice	12 oz. can, Minute Maid brand
0.0072	Frozen Corn	10 oz., Whole Kernel, lowest price
0.056	Baby Food	4-4.5 oz. jar, strained vegetables, lowest price
0.0384	Soft Drink	2 liter Coca Cola, excluding any deposit
Housing (expenditure share 28%)		
0.2631	Apartment, Monthly Rent	Two-Bedroom, unfurnished, excluding all utilities except water, 1-1/2 baths, approximately 950 sq.ft.
	Total Purchase Price	1,800 sq.ft. living area new house, 8,000 sq.ft. lot, urban area with all utilities
	Mortgage rate	Effective rate, including points and origination fee, for 30-year conventional fixed- or adjustable-rate mortgage
0.7369	Monthly Payment	Principal and Interest, using mortgage rate from Item 29B and assuming 25% down payment

Table B F-2. Items, descriptions, and expenditure shares for ACCRA data collected in year 1992 (cont.)

Expenditure share within each category	Item	ItemDescription
Utilities (expenditure share 9%)		
0.9	Total Home Energy Cost	Monthly Cost, at current rates, for average monthly consumption of all types of energy during the previous 12 months for the type of home specified in item 29A
	Electricity	Average monthly cost for all-electric homes is shown in column 30A; average monthly cost for homes using other types of energy as well is shown in column 30B
	Other Home Energy	Average monthly cost at current rates for natural gas, fuel oil, coal, wood and any other forms of energy except electricity
0.1	Telephone	Private residential line; Customer owns instruments. Price includes: basic monthly rate; additional local use charges, if any, incurred by a family of four; Touch Tone fee; all other mandatory monthly charges, such ass long distance access fee and 911 fee; and all taxes foregoing
Transportation (expenditure share 10%)		
0.1	Commuter Fare	One-way commuting fare, up to ten miles
0.3541	Auto Maintenance	Average price to computer- or spin balance- one front wheel
0.5459	Gasoline	One Gallon regular unleaded, national brand, including all taxes; cash price at self service pump if available
HealthCare (expenditure share 5%)		
0.175	Hospital room	Average cost per day for semi-private room
0.3509	Office Visit, Doctor	American Medical Association procedure 90050: general practitioner's routine examination of established patient
0.3509	Office Visit, Dentist	American Dental Association procedure 1110 (adult teeth cleaning) and 0120 (periodic oral examination)
0.1232	Aspirin	100 tablet bottle, Bayer brand, 325-mg., tablets

Table B F-3. Items, descriptions, and expenditure shares for ACCRA data collected in year 1992 (cont.)

Expenditure share within each category	Item	ItemDescription
Miscellaneous (expenditure share 35%)		
0.095	Hamburger Sandwich	1/4 pound patty with cheese, pickle, onion, mustard, and catsup. McDonald's Quarter-Pounder with Cheese, where available
0.095	Pizza	12"-13" thin crust cheese pizza. Pizza Hut or Pizza Inn, where available
0.095	Fried Chicken	Thigh and Drumstick, with or without extras, whichever is less expensive. Kentucky Fried Chicken or Church's, where available
0.0174	Haircut	Mans barber shop haircut, no styling
0.0174	Beauty Salon	Woman's shampoo, trim, and blow dry
0.0174	Toothpaste	6 oz.-7oz. tube, crest or colgate
0.0174	Shampoo	15 oz. Bottle, Alberto VO-5
0.0174	Dry Cleaning	Man's two-piece suit
0.115	Man's Dress Shirt	Arrow, Enro, Van Huesen, or J.C Penny's Stafford. White, cotton/polyester blend (at least 55% cotton), long sleeves
0.0523	Boy's Underwear	Package of three briefs, size 10-14, cotton, lowest price
0.115	Man's Denim Jeans	Levi's Brand, 501s or 505s, rinsed washed or bleached, size 28/30-34/36
0.0742	Major Appliance repair	Home service call, clothes washing machine; minimum labor charge, excluding parts
0.0271	Newspaper Subscription	Daily and Sunday home delivery, large-city newspaper
0.0459	Movie	First-run, indoor, evening, no discount
0.0459	Bowling	Price per line (game), evening rate
0.0654	Tennis Balls	Can of three extra duty, yellow, Wilson or Penn Brand
0.0384	Board Game	Parket Brothers "Monopoly", No. 9 edition
0.0163	Liquor	J&B Scotch, 750-ml. bottle
0.0162	Beer	Budweiser or Miller Lite, 6-pack, 12 oz. containers, excluding any deposit
0.0163	Wine	Gallo chablis blanc, 1.5-liter bottle

Data source: Council for Community and Economic Research (C2ER) - formerly known as ACCRA

F.3 Appendix C

Superlative price indices:

People also use one of three price indexes that stands in-between the Laspeyres index and the Paasche index. These are called superlative indices and there is no conclusion about which one is better[2].

The three price indices are:

(1) Fisher Ideal index: the geometric mean of the Laspeyres and Paasche indexes (the square root of their product)

(2) The Tornqvist index[3]: **Tornqvist index** is a discrete approximation to a continuous Divisia index. A Divisia index is a weighted sum of the growth rates of the various components, where the weights are the component's shares in total value. When a Tornqvist index is used as an approximation to the continuous Divisia index, the growth rates are defined as the difference in natural logarithms of successive observations of the components and the weights are equal to the mean of the factor shares of the components in the corresponding pair of years. D_t is the price index in year t, and D_{t-1} is the price index in year t-1; $s_{i,t}$ and $p_{i,t}$ are budget share and price for component i at year t.

$$\log(D_t) - \log(D_{t-1}) = \sum_{i=1}^{n} \frac{1}{2}[s_{i,t} + s_{i,t-1}][\log(p_{i,t}) - \log(p_{i,t-1})],$$

where

$$s_{i,t} = \frac{q_{i,t}\, p_{i,t}}{\sum_{j=1}^{n} q_{j,t}\, p_{j,t}} \qquad (\mathrm{i} = 1,\ldots\mathrm{n}).$$

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[2] Robert J. Hill, Superlative index numbers: not all of them are super, Journal of Econometrics,Volume 130, Issue 1, , January 2006, Pages 25-43.

[3] Hulten CR. Divisia Index numbers, 1973

3) The Walsh index[4]: the formula is as equation XXX.

$$D_t = \frac{\sum_{i=1}^{n} (p_{i,t} / \sqrt{p_{i,0} p_{i,t}}) \sqrt{s_{i,0} s_{i,t}}}{\sum_{i=1}^{n} (p_{i,0} / \sqrt{p_{i,0} p_{i,t}}) \sqrt{s_{i,0} s_{i,t}}}$$

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[4] IMF, new Export and Import Price Index Manual. Chapter 16.

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