Assessing the Effect of Changes in Relative Food Prices and Income on Obesity Prevalence in the United States

A DISSERTATION
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
Doctor Of Philosophy

Terry Roe, Adviser
Timothy Kehoe, Co-Adviser

June, 2010

Acknowledgements

Above all, I would like to thank my husband Sebastien Buttet for his personal support and great patience at all times. I would not have survived the Ph.D. program, let alone finished it, without you!

This thesis would not have been possible without the help, support and patience of my two advisers, Prof. Terry Roe and Prof. Timothy Kehoe. Their good advice, support, and friendship has been invaluable on both an academic and a personal level, for which I am extremely grateful.

I am really grateful to the members of my PhD committee, Prof. Larry Jones, Prof. Benjamin Senauer, and Prof. Rodney Smith for their advice and support. I have learned a great deal from you and your mentorship has shaped how I think about research in Economics.

Finally, I want to dedicate this thesis to my parents, for having always believed in me (especially during times when I didn't) and for their love. Brez vajinih vzspodbud (ki so včasih mejile že na nadlegovanje) mi nikoli ne bi uspelo. Hvala za vse!

For any errors or inadequacies that may remain in this work, of course, the responsibility is entirely my own.

Abstract

Several empirical papers in the economics of obesity literature find that changes in aggregate food prices over time have little effect on the population's body-mass index or obesity prevalence, while changes in the price of selected food items drastically affects what people eat. The purpose of this research is to further examine the impact of changes over time in food prices and household real income on individuals' food choices and weight using a calibrated static model. Our first objective is to contribute to the debate about the impact of food prices and household real income on weight and food choices using a different modeling strategy. We ask how much of the increase in calories consumed away from home as well as changes in weight for men and women between 1971 and 2006 can be accounted for by changes in food prices and household real income. A second and perhaps even more critical objective is to use economic theory and available evidence from medical research on obesity to look inside the black box of how people make eating decisions. After careful calibration of the model, we find that prices determine the allocation of calories across food types, while income determine the total number of calories consumed and thus individuals' weight. Based on our results, we share the view that taxes on food will impact what people eat but will have limited effect on reducing the population body-mass index or the obesity prevalence.

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Chapter 1

Introduction

Two decades of intense research in the field of economics of obesity have improved our understanding of the impact of food prices on weight and food choices and two critical results have gained wide acceptance. First, several empirical studies show that changes in aggregate food prices over time have little effect on the population body-mass index or obesity prevalence (e.g., Chou, Grossman, and Saffer (2004), Gelbach, Klick, and Stratmann (2007)). Second, experimental studies show that changes in the price of selected food items drastically affects what people eat. For example, French, Jeffery, Story, Breitlow, Baxter, Hannan, and Snyder (2001) find that a fifty percent price reduction on low-fat snacks in vending machines at schools and work places increase the percentage of low-fat snack sales by ninety three percent. These two results about the (lack of) effect of food prices on weight and food choices are important because of their influence on the public health debate about the effectiveness of fiscal policies for winning the fight against the obesity epidemic. A common view held by policymakers is that taxes applied selectively to different food items work effectively to reduce consumption of a particular type of food or ingredient (e.g., ban of trans-fats in New-York City) but are unlikely to produce significant changes in body-mass index or obesity prevalence (Powell and Chaloupka (2009) and Chouinard, Davis, LaFrance, Perloff (2007)).

In this research, we further examine the impact of changes over time in food prices and household real income on individuals' food choices and weight using a calibrated static model. Our first objective is to contribute to the debate about the impact of food prices and household real income on weight and food choices using a different modeling strategy. We ask how much of the increase in calories consumed away from home as well as changes in weight for men and women in different age groups between 1971 and 2006 can be accounted for by changes in food prices and household real income. A second and perhaps even more critical objective is to use economic theory and available evidence from medical research on obesity to look inside the black box of how people make eating decisions, in particular improve our understanding of what determines the (low) food price elasticity of weight.

We assume that there is a one-to-one relationship between agent's weight and total calories consumed. In addition, weight affects the probability that agents are alive. Given household real disposable income and the relative price of a calorie (at home versus away from home), agents decide how much to eat at each location as well as how much of the non-food good to consume to maximize their expected utility.

Identification of the model is clean. On the one hand, we use available evidence from medical research on nutrition to calibrate the parameters of the weight function and medical research on obesity-related diseases to fit the survival probability function. On the other hand, we choose the remaining preferences parameters to match the mean weight and fraction of calories away from home observed in NHANES 1971-75, allowing some preference heterogeneity between men and women. We use the calibrated model to assess the impact of changes in food prices and household real income on food choices and weight between 1971 and 2006. In a nutshell, prices determine the allocation of calories across food types, while income determine the total number of calories consumed. Quantitatively, changes in per calorie food prices and real income taken altogether account for more than seventy percent of the increase in weight and the fraction of calories consumed away from home for men and women in different age groups between 1971 and 2006.

Chapter 2

Nutritional and Economic Data

2.1 Calorie Intake and Obesity Prevalence

In Figure 2.1, we present data about changes in daily calorie intake and obesity prevalence in the United States between 1970 and 2007. Following the U.S. Department of Agriculture (USDA) classification, daily calories intake is calculated as the sum of daily calories consumption from six different food categories: (i) meat, eggs, and nuts, (ii) dairy, (iii) fruits and vegetables, (iv) flour and cereal products, (v) added fats, and (vi) added sugars.[1] On the other hand, obesity prevalence is defined as the fraction of

[1]The data used in this paper is called the "Loss-adjusted food availability" or "Food Guide Pyramid Servings" data that adjusts aggregate food availability data; nonedible food parts and food lost through spoilage, plate waste, and other losses in the home and marketing system are not included. It should be distinguished from commonly used "Food availability" data also know as 'US food supply" or "Disappearance data" which

Americans whose body-mass index (BMI) is greater than thirty. The BMI is a measure of body fat based on height and weight that applies to both men and women and is proportional to the ratio between a person's weight expressed in pounds and her height squared, where height is expressed in inches:

$$BMI = 703 \times \frac{\text{Weight(lb.)}}{\text{Height}^2((\text{in})^2)} \tag{2.1}$$

An adult with a BMI lower than nineteen, between twenty and twenty-four, between twenty-five and twenty-nine, and above thirty is considered to be underweight, normal, overweight, and obese, respectively.

Two important facts emerge from Figure 2.1. First, the prevalence of obesity among adults aged 20-74 years has more than doubled, from 15.5 percent in 1970 to 34.3 percent in 2005 (see Flegal, Carroll, Ogden, and Johnson (2002) and Ogden, Carroll, McDowell, and Flegal (2007)). Second, total daily calorie intake of Americans has increased by more than six hundred calories between 1970 and 2007.

Note that a person's weight can increase substantially even if his calorie intake is slightly higher compared to what the levels recommended by dieticians. According to the Dietary Guidelines for Americans (2005), if the net daily calorie intake (total calories intake minus total calories expenditures) surpasses the daily dietary guideline by only one hundred calories, a person can gain up to one pound in a month, which cumulated over time, adds up to twelve pounds per year. The American Dietary Guidelines recommend

measures food supply or food available for consumption.

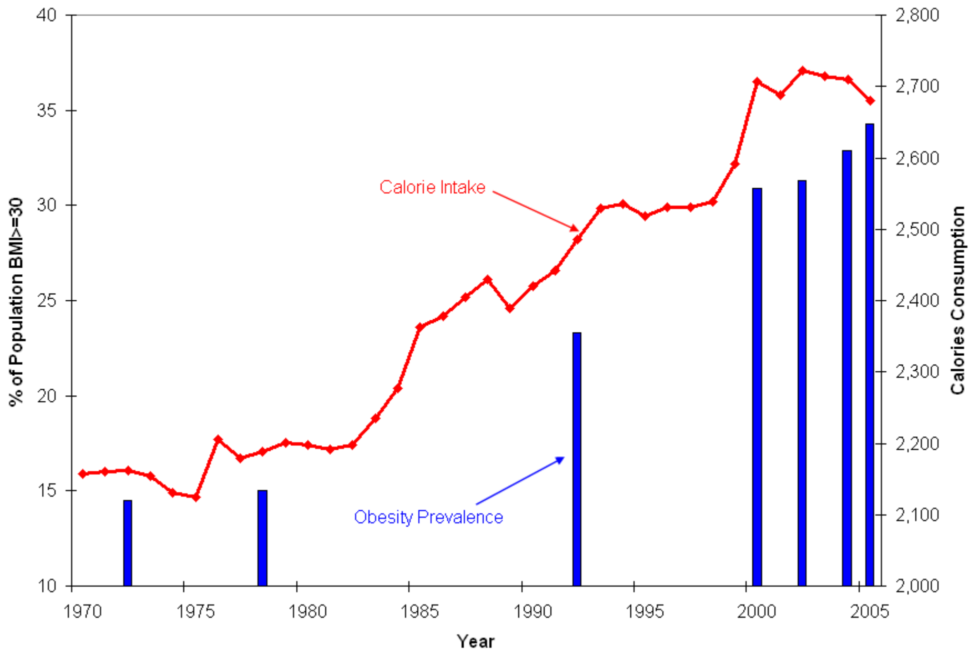
that an average American consume between 2,000 to 2,400 calories per day. On average, Americans consume about 2,700 calories per day, which is about 350 calories more than recommended. Given the example above, this leads to about thirty additional pounds per year.

The positive relationship that exists between prevalence of obesity and calorie intake follows from simple dieting accounting principles. In order to maintain a healthy BMI, calorie intake must be balanced with calories expenditures. Everything else equal, if calories intake goes up while calorie expenditures remain roughly constant or declines over time, a person's weight increases (Cutler, Gleaser, and Shapiro (2003) or Philipson and Posner (2003)). Cutler, Gleaser, and Shapiro (2003) show that increased caloric intake is far more important than reduced caloric expenditure in explaining recent increases in obesity in the US. Alternatively, Philipson and Posner (2003), Lakdawalla and Philipson (2002), Lakdawalla, Philipson and Bhattacharya (2005)argue that an important factor behind this rise in weight is due to the decline in the amount of physical exertion, particulary when supplying labor. They argue that, due to technological progress, our jobs have become less strenuous so that work entails less exercise. Given that we now expand less calories on the job, we gain weight.

2.2 Calorie Intake and BMI by Gender

In this section, we use two distinct sample data from the National Health and Nutritional Examination Survey (NHANES) to document changes over

Fig. 2.1: Change in total calorie intake over time



Source: USDA/Economic Research Service. Data last updated Feb. 15, 2007.

time in body-mass index, weight, and the fraction of calories consumed away from home for men and women for the period between 1971 and 2006 (see Table 2.1).Data about weight comes from the examination component of NHANES. NHANES is a program of studies administered by the National Center for Health Statistics at the Centers for Disease Control and Prevention (CDC) designed to assess the health and nutritional status of adults and children in the United States. It is unique in that it combines interviews and physical examinations. Information from interview surveys is self-reported by individuals and consists of answers to demographic, socioeconomic, dietary, and health-related questions. The examination component, on the other hand, consists of medical, dental, and physiological measurements, as well as laboratory tests administered by highly trained medical personnel.

Body-Mass Index (BMI): Information about weight and height comes from the examination component of NHANES and is thus measured by medical personnel. BMI is a measure of body fat based on height and weight that applies to both men and women and is calculated as 703 times weight measured in pounds divided by height squared measured in inches squared. Individuals with BMI lower than 18.5 are considered underweight, between 18.5 and 24.9 normal weight, between 25 and 30 overweight, and 30 or greater obese. BMI combined with other information about waist circumference and other factors such as physical activity, cigarette smoking, or low-density cholesterol levels gives a risk assessment of developing obesity-associated diseases such as heart attacks, diabetes II, stokes, etc.

During the medical and dental examination a 24-hour dietary recall is administered to collect information about eating habits and behavior. Data collected in the 24-hour dietary recall contains detailed description about foods reported; information about food type, form, and brand name, in addition to the amount of food consumed (i.e. calories), amounts of nutrients from each food, and the location where the food was consumed.[2]

[2]Note the bias problem: there is a general tendency across the population to under-report dietary intake. This tendency varies by body weight status of the individual, such that overweight individuals under-report to a greater degree than do normal weight persons. Unfortunately, no standard adjustment currently exists for correcting under-reporting bias. Therefore, our model and methods require an assumption that 24-hour recalls are unbiased for usual intake, in spite the evidence to the contrary. Nonetheless,

Fraction of calories eaten away from home: Individuals self-report the location where food was eaten. Survey questions changed over time, however.[3] In NHANES I, individuals can choose among the following four locations: at home, in school, in restaurants, and other. In NHANES 2005-06, the location question is: "Did you eat this food at home?" and the possible answers are yes, no, refused to answer, do not know, and missing information. To maintain consistency across the three data sets, we define food eaten at home as any food item for which individuals answered "at home" in NHANES I and yes in NHANES 2005-06. We define food eaten away from home as all food items not eaten at home. We then calculate the fraction of calories eaten away from home as one minus the fraction of calories eaten at home.

Our estimates for the fraction of food eaten away from home are higher than those found by Lin, Frazão, and Guthrie (1999) who use data from the Nationwide Food Consumption Surveys (NFCS) for two time periods 1977-78 and 1987-88. In their data set, people report where the food was either bought or made, compared to where the food was eaten in NHANES. Consider the case of an individual who prepares food at home and brings it

these are the best methods available and represent state-of-the-art practice. (NHANES Web Tutorial, 2009)

[3]Information about calories consumed daily is included in the interview part of NHANES and thus is self-reported by individuals rather than directly measured by medical staff. We believe that three possible reasons lead individuals to under-report their daily calorie intake. First, it is hard to remember all food items consumed in an entire day. Second, people who tend to eat in excess of dietary guidelines can feel embarrassed by their eating habits and misreport their food consumption. Finally, if individuals know the interview date in advance, they might change their dietary habits and adjust their calories consumed downward for one day in order to exhibit "good behavior". As a result, we do not use self-reported data on calorie intake in our analysis.

and eat it at school or work. In NHANES, the number of calories consumed is counted as eaten away from home, while it is counted as eaten at home in NFCS. On the other hand, consider the case of an individual who order a meal at a restaurant and brings part or all of it back to her home and eats it there. In NHANES, the number of calories consumed is counted as eaten at home, while it is counted as eaten away from home in NFCS. If there are more people who prepare their food at home and eat it outside compared to people who buy their food at restaurants and bring it back home, our estimates for the fraction of food eaten away from home are higher than those found by Lin, Frazão, and Guthrie (1999).

Finally, NHANES uses a complex, multistage, unequal probability, and cluster sampling methods. NHANES is designed to sample larger numbers of certain subgroups (i.e. African Americans, very low income people) of particular public health interest. Hence, in order to make statistically valid inferences for the population, we must incorporate the sample design in the data analysis. Traditional SAS procedures, such as MEANS and REG procedures, compute statistics under the assumption that the sample is drawn from an infinite population by simple random sampling. These procedures generally do not correctly estimate standard errors of means, geometric means, percentages, and other statistics if they are applied to a sample drawn by a complex sample design. Therefore, throughout this paper we use SURVEYMEANS procedures to obtain our results.

In the last thirty years, men have gained on average 23 pounds and

Tab. 2.1: Changes in body-mass index, weight, calories, and fraction of calories consumed away from home for men and women

	1971-75	2005-06	%Change
Men:			
BMI	25.6	28.7	11.7
Weight (lbs.)	173.0	195.9	13.2
Calories	2,419	2,693	11.3
Fraction of Calories Away from Home	28.6	39.2	37.1
Women:			
BMI	25.0	28.7	15.0
Weight (lbs.)	143.8	167.5	16.5
Calories	1,558	1,838	18.0
Fraction of Calories Away from Home	19.9	34.6	62.8

their body-mass index increased from 25.9 (slightly overweight) to 29.0 (borderline obese).[4] The increase in average weight and body-mass index is even more pronounced in percentage terms for women who also gained 23 pounds.[5] In addition, men and women changed their eating habits dramatically and ate out more. Total daily calories consumed increased by roughly 280 calories for both, while the fraction of calories away from home increased by 11 and 17 percentage points for men and women, respectively.

[4]Simple t-tests show that differences in mean weight and mean body-mass index over time are statistically significant for both men and women.

[5]Information about calories consumed daily is included in the interview part of NHANES and thus is self-reported by individuals rather than directly measured by medical staff. We believe that three possible reasons lead individuals to under-report their daily calorie intake. First, it is hard to remember all food items consumed in an entire day. Second, people who tend to eat in excess of dietary guidelines can feel embarrassed by their eating habits and misreport their food consumption. Finally, if individuals know the interview date in advance, they might change their dietary habits and adjust their calories consumed downward for one day in order to exhibit “good behavior”. As a result, we do not use self-reported data on calorie intake in our analysis.

2.3 Changes in Real Income and Per Calorie Food Prices

Our goal in this research is to determine how much of the increase in weight and the fraction of calories consumed away from home can be accounted for by the decline in the relative price of food (at home versus away from home) as well as increases in household real income. To measure changes in food prices, we introduce a new measure which considers the *price per calorie consumed* rather than prices of specific food items. We calculate price per calorie for food consumed away from home, $p_{A,t}$, and food consumed at home, $p_{H,t}$, as the dollar amount spent by households on each food category divided by the number of calories consumed:

$$p_{A,t} = \frac{\alpha_{A,t} I_t}{\text{Calories}_{A,t}}, \quad p_{H,t} = \frac{\alpha_{H,t} I_t}{\text{Calories}_{H,t}} \tag{2.2}$$

We calculate the dollar amount spent by households on food as household real disposable income, I_t, multiplied by the expenditure share on food consumed away from home $\alpha_{A,t}$ or at home $\alpha_{H,t}$. Information about the expenditure share on food away from home and food at home is obtained from household expenditures data published by the US Department of Agriculture (USDA). The expenditure for food away from home is equal to 3.5 and 4.1 percent, respectively, for the periods 1971-75 and 2005-06. The expenditure for food away from home is equal to 9.9 and 5.7 percent, respectively, for the same time periods. Information about nominal

Tab. 2.2: Changes in per calorie food prices and real income

	1971-1975	2005-2006	% Change
Relative price (Away/Home)	1.61	1.34	-16.7
Mean Real Income in 2006 $	$59,742	$74,089	24.0

disposable income comes from the Bureau of Economic Analysis (BEA) and we use the consumer price index (CPI) published by BLS to calculate the real disposable income expressed in 2006 dollars. Between 1971 and 2006, household real disposable income increased by 24 percent, while the per calorie price of food consumed away from home declined by seventeen percent (see Table 2.2).

The price per calorie has two significant advantages over traditional food prices.[6] First, it provides a simple method for aggregating food items in different categories. Second, it is intuitively appealing as it controls for changes in portion sizes at restaurants (Young and Nestle, 2002). Note that the relative price of food away from home is always greater that one, implying that eating out is more costly than eating at home, even after adjusting for differences in the number of calories. In addition, we looked at changes in food prices published by the Bureau of Labor Statistics. We find that the price of food consumed away from home increased by 40 percent from 1971 to 2006. The increase in food prices away from home is clearly at odds with the observed increase in the fraction of calories eaten away from home.

[6]For more detailed descriptions see Appendix B.

The increase in calories consumed away from home and larger portions at restaurants are often blamed for the weight gain of Americans. Between 1977 and 1995, calories from food away from home increased from eighteen to thirty-three percent of total daily calories consumed (Guthrie, Lin, and Frazão, E. (2002)). Moreover, food portions are larger today than they were in the past. According to Young and Nestle (2002), "in the mid-1950s, McDonald's offered only one size of french fries; that size is now considered small and is one third the weight of the largest size available in 2001" (p.248).

Chapter 3

Literature Review

In this section, we review two separate strands of the literature that studies different causes of obesity. The first strand comes from the public health literature and focus on two main behaviors that effect the weight: eating and physical activity. The second strand looks at different economic explanations of the increase in obesity, including technological improvement in food processing, decline in the relative price of food, and changes in the opportunity cost of women's time.

3.1 Public Health Literature

Finkelstein, Ruhm, and Kosa (2005) and French, Story, and Jeffery (2001) provide a comprehensive review of the literature on the various causes of obesity. They focus on two main behaviors that effect the weight: eating and physical activity. One reason why there is an increase in the obesity prevalence is that people eat too much food. The authors mention that one of the reasons why Americans today consume more calories is due to the increasing frequency of eating out at restaurants and eating food prepared away from home. They show the data on the number of fast-food restaurants, the amount of money spent on away-from-home foods, and the restaurants sales. All of these have increased significantly over the past few decades.

Eating away from home might not be an issue by itself, if people simply substitute home made meals for restaurant food. However, studies show that the energy and fat content of away-from-home food in significantly higher compared to the food prepared at home. Young and Nestle (2002) believe that larger (or supersized) marketplace food portions are a major contributing factor to the increase in the prevalence of obesity. They present data on food sold for immediate consumption in the most popular take-out and fast-food restaurants and show that portion sizes began to grow in the 1970s, rose sharply in the 1980s, and have continued in parallel with increasing body weights. For example, "in the mid-1950s McDonald's offered only 1 size of french fries; that size is now considered 'Small' and is one third the weight of the largest size available in 2001. Today's 'Large' weights the same as the 1998 'Supersize', and the 2001 'Supersize' weights nearly an ounce more." More importantly, these larger sizes not only contain more calories but they also encourage people to eat more.

French, Story, and Jeffery (2001) point out that there has also been a dramatic change in exposure to commercial messages on television that encourage food consumption. Food manufacturers, retailers, and food services spend billions of dollars per year in mass media advertising and are second only to the automotive industry. More importantly, foods that are most heavily advertised are those that are over-consumed relative to national dietary recommendation, while those that receive less advertising are under-consumed (fruits and vegetables). In fact, children are exposed to more than ten commercials per hour of viewing most for fast food, soft drinks, sweets, and sugar-sweet cereals. In addition, television may also contribute to higher energy or fat intake due to snacking in front of the TV.

Chou, Grossman, and Saffer (2004) link the rise in the body weight to the increase in the availability of fast-food and full-service restaurants. They show that there is a positive correlation between the number of fast food restaurants in an area and the BMI of individuals living in that area, as well as a positive relation with the likelihood that an individual is obese.

Another reason for the increase in the obesity prevalence is due to the decline in physical activity. French, Story, and Jeffery (2001) point out that in 1985 people spent six times more time watching TV then they did exercising or doing sports. Moreover, television viewing time has increased forty-four percent between 1965 and 1985, from 10.4 hours per week to 15.1 hours per week. Increasing time devoted to TV viewing (and other related media such as video game, computer and internet use) has been cited as an important contributing factor to the increase in the prevalence of sedentary behavior during leisure time and the decline in the physical activity in the US.

Ewing, Killingsworth, Zlot, and Raudenbush (2003) focus on urban sprawl and show that it has has also been correlated with obesity. They show that residents of sprawling communities were less likely to walk during leisure time, weight more, and have a greater prevalence of hypertension than residents of compact communities. One reason behind this observation is the urban planning of these sprawls. Sprawl is an environment characterized by a population widely dispersed in low-density residential development; a lack of distinct, thriving activity centers; rigid separation of homes, shops, and work place; and a network of roads marked by large block size and poor access from one place to another. In other words, an urban sprawl is characterized by poor accessibility where nothing is within easy walking distance of anything else. Hence, people are less likely to walk or bike for transportation. In fact, a decline in walking and bicycling has been observed throughout the US. According to census data, in 1980, six percent of all workers commuted to work by walking or bicycle, while only 4.5 percent did in 1990. At the same time an increasing proportion of Americans are now using automobiles for commuting to work and other short trips (French, Story, and Jeffery 2001).

In addition to transportation-related physical activity, it has been suggested that decreases in work-related physical activity may also be a contributing to the trend of lower physical activity levels. Lakdawalla and Philipson (2002) and Philipson and Posner (2003) believe that technological improvements made work less intensive and due to this decline in physical activity people gained weight. In an agricultural or an industrial society, work is strenuous and in effect the worker is paid to exercise. Technological change has freed up time from producing food, enabling a reallocation of time to producing other goods and services. In these economies work entails little exercise and overall obesity may rise as a result of a growth in the sedentary nature of work. Hence, people must pay for physical activity. This payment is mostly in terms of forgone leisure, so that leisure weight control must substitute for job weight control.

Most of the above mentioned work (with the exception of the last two) focuses on environmental influences on eating and physical activity and relies heavily on empirical analysis. There have also been attempts to approach this issue using standard economic theory. Recently a new set of research has been focusing on the idea that changes in opportunity cost, specifically lower relative monetary and time costs, are behind observed obesity trends.

3.2 Economic Literature

3.2.1 Technological Improvement in Food Processing

Cutler, Glaeser, Shapiro (2003) hypothesize that the rise in caloric intake and obesity primary result form changes in food production technology that reduced the price of mass-produces, calorie-dense foods. Innovation in food processing and packaging over the last three decades have enabled food manufacturers to produce food in one location that will be nearly ready for consumption in another location. Reduction in the time cost of food preparation should lead to an increase in the amount of food consumed, just as reductions in any good's price should lead to increased consumption of that good. In other words, the lower time cost and increased availability of processed foods are key factors behind the dramatic decline in cooking times and home meals, and also behind the higher consumption of processed food, which may account for the observed increase in calorie intake. This increase can occur through several channels: (i) increased variety of foods consumed, (ii) increased frequency of food consumed, (iii) a switch to high-calorie/high-flavor prepared foods that had previously been unavailable; or (iv) an increase in the overall consumption of each individual food item.

Based on empirical analysis, the authors conclude that : (i) lower costs of food preparation means that individuals consume a wider range of products at more time during the day, (ii) the increase in food consumption comes mostly in food that had an improvement in mass preparation technology, (iii) individual who have taken the most advantage of the new technologies have had the biggest increase in obesity (mostly married women), and (iv) obesity rates are higher in countries with greater access to technological changes in food consumption.

By looking at the data from Continuing Survey of Food Intake they observe that most of the increase in calories is form calories consumed during snacks. They calculate that only about twenty-eight percent of people in 1977-78 reported two or more snacks per day, forty-five percent reported two or more snacks in 1994-96. The average number of snacks per day increase by sixty percent over this period. In addition, they present the data that shows that food items with large amounts of commercial preparation have increased in consumption (grains, sugar, fats) and food items with less commercial preparation have fallen (eggs, meat, dairy).

3.2.2 The Effect of Relative Prices on Obesity

The first paper that makes an explicit distinction between healthful and unhealthful food is written by Gelbach, Klick, and Stratmann (2007). The authors find that as healthful food become more expensive relative to unhealthful foods, individuals exhibit higher BMI, as well as higher likelihoods of being overweight or obese, and these effects are statistically significant.

Their results suggest that individuals do substitute between healthful and unhealthful foods when relative prices change, however, this relative price effect accounts for only about one percent of the rise in average BMI.

In addition, they find that there is substantial heterogeneity in the sensitivity of individuals to relative price changes by education level. More educated individuals exhibit less sensitivity to changes in relative prices. This is consistent with the notion that more informed individuals will weigh non price elements of the cost of food more heavily in their decisions. Finally, the author conclude, that given such a small sensitivity of individuals to relative food prices, a "fat tax" would have very little effect. For example, a hundred percent tax on unhealthful foods would reduce average BMI by less than one percent. Although our question is very close to theirs, our methodology differs as we use the tools of dynamic optimization where agents fully understand the impact of obesity on health.

The current research on taxing snack foods seems to be inconclusive. Some studies show that on the individual level, the pricing has a strong effect on food choices. According to a study by French, Jeffery, Story, Breitlow, Baxter, Hannan, and Snyder (2001) price reductions of ten percent, twenty five percent, and fifty percent on low-fat snacks in vending machines increase the percentage of low-fat snack sales by nine, thirty nine, ninety three percent respectively. Another study by Jeffery, French, Raether, and Baxter (1994) showed that lower prices on fresh fruits and vegetables have also a positive effect on the consumption. More importantly, pricing effects were observed despite minimal advertising or promotion and were equally effective in adolescent and adult populations.

On the other hand, Kuchler, Tagene, and Harris (2005) show that taxing snack foods does not have a big impact on its consumption. A one percent tax would reduce annual household purchases by 0.28 ounces of potato chips per person per year, or by 42 calories. The twenty percent tax reduces purchases by 5.54 ounces per person per year, or 830 calories.

3.2.3 Decline in Costs of Food Away-From-Home and Gender Wage Gap

The first paper that approaches the issue of obesity within a macroeconomic setting with a dynamic general equilibrium model is written by Gomis-Porqueras and Peralta-Alva (2007). They consider two channels that lower the relative cost of food prepared away from home. The first is through productivity improvements in the production of processed foods, which lowers their price. This is the same idea as the one proposed by Cutler, Glaeser, Shapiro (2003). The second is through the decline in income taxes and the gender wage gap, which increases the opportunity cost of cooking at home. Households respond optimally to this decline in relative costs by consuming more food prepared away from home.

The authors find that productivity improvements in the production of food prepared away from home are qualitatively consistent with expenditure trends in food items, but fall short of accounting for the magnitude of the observed changes. When productivity is set to match the observed expenditure increase on food away from home, the model generated a too large decline in groceries expenditures. When productivity is to match the decline in cooking times or groceries expenditures then the increased consumption of food prepared away from home is not large enough.

In the second experiment, the authors lower income taxes and gender wage gap which increase the cost of time, and thus the cost of consuming home made food. In addition, lower gender wage gap also changes specialization patterns within married households so that women work more and cook less. Hence, a lower gender wage gap amplifies the impact of any given decline in the relative cost of processed food on lower groceries consumption, cooking times, and on the increased consumption of food prepared away from home. This amplifying effect is capable of matching most of the observed decline in groceries expenditure, the higher expenditure on food prepared away from home, and the higher labor force participation for women during the last forty years.

Chapter 4

Optimization Model of Eating Decisions and Weight

We propose a static model where agents decide how much and where to eat (out or at home) as well as non-food consumption. We let a and h be the number of calories consumed away and at home, respectively, and c^{nf} represents non-food consumption. Calories away and at home are aggregated using a constant elasticity of substitution (CES) function to obtain food consumption:

$$c^f = (\eta a^\rho + (1-\eta)h^\rho)^{\frac{1}{\rho}} \tag{4.1}$$

with $\eta \in (0,1)$ and $\rho \in (-\infty, 1]$. Food away and at home are perfect substitutes, Cobb-Douglas, or perfect complements when the parameter ρ is equal to one, zero, or minus infinity, respectively. The parameter η

reflects consumer's preference for eating at home or eating out, a smaller η indicating that consumers prefer to eat at home.

Preferences of the representative agent are Cobb-Douglas and are given by:

$$U(c^f, c^{nf}) = (c^f)^\alpha (c^{nf})^{1-\alpha} \tag{4.2}$$

with $\alpha \in (0, 1)$.

Agents make ex-ante eating decisions understanding that weight affects the probability $\pi(W)$ of being alive. We assume that the function π is an inverted U-shape function of body-mass index which implies that agents who are either over- or underweight have a greater chance to die. Finally, agents receives utility $\underline{U} \leq 0$ when they die. The expected utility is equal to:

$$\pi(W)U(c^f, c^{nf}) + (1 - \pi(W))\underline{U} \tag{4.3}$$

Note that it is never optimal for people to eat so much that they would die with certainty since $U(c^f, c^{nf})$ is positive and $\underline{U} \leq 0$.

The relationship between weight and calorie consumption is given by the simple linear relationship:

$$W = \mu + \theta(a + h) \tag{4.4}$$

with $\theta > 0$.

Finally, the budget constraint of the representative agent is given by:

$$c^{nf} + p_h h + p_a a = I \tag{4.5}$$

where we normalized the price of non-food to one, p_h and p_a are the real price of food at and away from home, respectively, and agents are endowed with real income I.

For any prices and income, $\{p_h, p_a, I\}$, the representative agent chooses optimal calories from food away and at home as well as non-food consumption, $\{a, h, c^{nf}\}$, to maximize the expected utility in equation (4.3) subject to the budget constraint (4.5), the weight function (4.4), the food aggregation equation (4.1), and non-negativity constraints for calorie and non-food consumption.

We substitute the weight relationship into the objective function in equation (4.3). The consumption of food away from home, a, and food at home, h, appear as follows in the objective function:

$$\pi(\mu + \theta(a+h))(\eta a^\rho + (1-\eta)h^\rho)^{\frac{\alpha}{\rho}}(I - p_h h - p_a a)^{1-\alpha} + (1 - \pi(\mu + \theta(a+h)))\underline{U} \tag{4.6}$$

We take first-order conditions with respect to food away from home, a, and food at home, h.

$$\begin{aligned} [a]: \quad & \theta\pi'(W)(U(c^f, c^{nf}) - \bar{U}) \\ & + \pi(W)U(c^f, c^{nf})(\frac{\alpha\eta a^{\rho-1}}{\eta a^\rho + (1-\eta)h^\rho} - \frac{p_a(1-\alpha)}{I - p_a a - p_h h}) = 0 \\ [h]: \quad & \theta\pi'(W)(U(c^f, c^{nf}) - \bar{U}) \\ & + \pi(W)U(c^f, c^{nf})(\frac{\alpha(1-\eta)h^{\rho-1}}{\eta a^\rho + (1-\eta)h^\rho} - \frac{p_h(1-\alpha)}{I - p_a a - p_h h}) = 0 \end{aligned} \tag{4.7}$$

Note that consumer's utility might not be strictly concave because the survival probability depends on consumer's weight. As a result, it is not clear whether first-order conditions are sufficient for optimality. Although we do not offer a formal proof, we check in our computer simulations that the allocations that satisfy the first-order conditions in equation (4.7) are also utility-maximizing (locally).

We rearrange the first-order conditions in equation (4.7). The optimal level of food away from home, a, and food at home, h, are obtained by solving the following system of equations (4.8):

$$\begin{aligned} \frac{\eta a^{\rho-1} - (1-\eta)h^{\rho-1}}{\eta a^\rho + (1-\eta)h^\rho} &= \frac{1-\alpha}{\alpha}\frac{p_a - p_h}{I - p_a a - p_h h} \\ \frac{\alpha\eta a^{\rho-1}}{\eta a^\rho + (1-\eta)h^\rho} - \frac{p_a(1-\alpha)}{I - p_a a - p_h h} &= -\theta\frac{\pi'(\mu + \eta(a+h))}{\pi(\mu + \eta(a+h))}(1 - \frac{\bar{U}}{U(c^f, c^{nf})}) \end{aligned} \tag{4.8}$$

In the reminder of the paper, we explain our method to calibrate the three key parts of our model: the weight function, the survival probability function, and the deep preference parameters. We then use the calibrated model to conduct a lab experiment where we assess the impact of food price and real income on weight and the fraction of calories away from home.

Chapter 5

Calibration

We use medical research on obesity to calibrate the weight law of motion and the survival probability function. We then chose the remaining preference parameters to match the average weight and calories away from home for men and women observed in the NHANES I sample.

5.1 Weight Function

The weight function in equation (4.4) contains two distinct important parameters. First, the constant θ converts calorie intake into weight. According to the dietary guidelines from the US Department of Agriculture, people gain ten pounds per year if they eat an extra one hundred calories every day above and beyond the recommended daily calorie intake. As a result, we fix $\theta = \frac{10}{100 \times 365} = 2.7397 \times 10^{-4}$.

Second, we use the average observed weight and calorie consumption by men and women in NHANES 1970 to fix μ^m and μ^f. The weight and total calories data comes from Table 2.1.

$$\mu^m = W^{m,1970} - \theta cal^{m,1970} = 173.0 - 2.7397 \times 10^{-4} \times 2419 \times 365 = -68.9$$

$$\mu^f = W^{f,1970} - \theta cal^{f,1970} = 143.8 - 2.7397 \times 10^{-4} \times 1558 \times 365 = -12.0 \tag{5.1}$$

5.2 Survival Probability Function

We posit that the survival probability function $\pi(W)$ is given by the following functional form:

$$\pi(W) = \frac{1}{1 + \kappa(W - W^*)^2} \tag{5.2}$$

with $\kappa > 0$ and $W^* > 0$ represents the agent's "best" weight where the survival probability is maximized and equal to one. Note that the survival probability increases with the agent's weight when $W \leq W^*$ but decreases once the agent's weight is greater than W^*.

First, we set the best weight $W^{*,m} = 170$ for men and $W^{*,f} = 140$ for women which corresponds to a body-mass index of just slightly less than 25 for both sex.[1]

Second, the parameter κ is identified by the increased mortality risk

[1] The relationship between weight, height, and body-mass index is: $BMI = \frac{Weight(lb.) \times 703}{Height(in.)^2}$. In the 2005-06 NHANES sample, the average height of men is equal to 69.3 inches, while the average woman measures 64.0 inches.

due to obesity alone. For two different weight W_1 and W_2, the increased mortality is equal to:

$$\frac{1-\pi(W_1)}{1-\pi(W_2)} = \frac{(W_1 - W^*)^2}{(W_2 - W^*)^2} \times \frac{1+\kappa(W_2 - W^*)^2}{1+\kappa(W_1 - W^*)^2} \tag{5.3}$$

Allison, Fontaine, Manson, Stevens, and VanItallie (1999) report the hazard ratios of death based on six large prospective cohort studies where subjects are placed into two distinct groups: the control group is comprised of individuals whose body-mass index (BMI) is between twenty-three and twenty-five; the treated group consists of individuals with BMI higher than twenty-five.

The death likelihood increases by a factor of 1.08 for overweight individuals (when BMI is between 25 and 28) and by a factor of 1.43 for obese people (when BMI is between 30 and 35). Choosing the middle point for each interval, a BMI of 26.5 corresponds of a weight of 181 pounds for a male of average height, while a BMI of 32.5 corresponds of a weight of 221 pounds. As a result, the parameter κ is obtained by solving the following equation:

$$\frac{121}{2601} \times \frac{1+2601\kappa}{1+121\kappa} = \frac{1.08}{1.43} \tag{5.4}$$

It is equal to $\kappa = 2.39 \times 10^{-2}$.

5.3 Preferences

We are now left with calibrating four preferences parameters, $(\alpha, \eta, \rho, \bar{U})$. First, since the utility function $U(c_t^f, c_t^{nf})$ is positive, we fix $\underline{U} = 0$ so that death coming from excess eating is never an optimal choice.

Second, we use the research of Reed, Levedahl, and Hallahan (2005) which estimates the elasticity of substitution between food away from home and food consumed at home. They find that both types of foods are substitutes and a result, we fix $\rho = 0.75$.

Finally, we use the two first-order conditions in equation (4.8) to determine (α, η) to match the observed average weight and fraction of calories consumed away from home for men and women in the NHANES I sample. For the period 1971-75, men's average weight, total calories, and fraction of calorie consumed away from home was equal 173.0 pounds, 2,419 calories, and 28.6 percent, respectively (see Table 2.1). This implies that calories at home and away from home are equal to $h^{m,1970} = 1727.2$ and $a^{m,1970} = 691.8$, respectively. Per calorie prices of food away from home and food at home are equal to $p_a^{1970} = 4.68 \times 10^{-3}$ and $p_h^{1970} = 2.90 \times 10^{-3}$, respectively. Using the information about real income from Table 2.2, non-food daily consumption is equal to:

$$c^{nf^{m,1970}} = I^{1970} - p_a^{1970} a^{m,1970} - p_h^{1970} h^{m,1970} = \$155.43 \qquad (5.5)$$

Note that food expenditures is equal to roughly five percent of income.

As a result, the parameters (α, η) are obtained by solving the following system of equations:

$$\frac{\alpha\eta 691.8^{-0.25}}{\eta 691.8^{0.75} + (1-\eta)1727.2^{0.75}} - \frac{4.23 \times 10^{-3}(1-\alpha)}{155.4} = \frac{\alpha(1-\eta)1727.2^{-0.25}}{\eta 691.8^{0.75} + (1-\eta)1727.2^{0.75}}$$

$$-\frac{2.97 \times 10^{-3}(1-\alpha)}{155.4}$$

$$\frac{\alpha\eta 691.8^{-0.25}}{\eta 691.8^{0.75} + (1-\eta)1727.2^{0.75}} - \frac{4.23 \times 10^{-3}(1-\alpha)}{155.6} = -2.7397 \times 10^{-4}\frac{\pi'(173.0)}{\pi(173.0)} \tag{5.6}$$

For men, we find that $\eta^m = 0.49$ and $\alpha^m = 0.12$.

Finally, we determine the coefficient α^w and η^w to match the observed average weight and fraction of calories consumed away from home for women in the NHANES I sample. For the period 1971-75, women's average weight, total calories, and fraction of calorie consumed away from home was equal 143.8 pounds, 1,558 calories, and 19.9 percent, respectively (see Table 2.1). This implies that calories at home and away from home are equal to $h^{f,1970} = 1247.6$ and $a^{f,1970} = 310.0$, respectively. Using the information about food prices and income from Table 2.2, non-food consumption is equal to $c^{nf*} = 158.6$. As a result, the parameters (α, η)

are obtained by solving the following system of equations:

$$\frac{\alpha\eta 310.0^{-0.25}}{\eta 310.0^{0.75}+(1-\eta)1247.6^{0.75}}-\frac{4.23\times 10^{-3}(1-\alpha)}{158.6}=\frac{\alpha(1-\eta)1247.6^{-0.25}}{\eta 288.3^{0.75}+(1-\eta)1247.6^{0.75}}$$

$$-\frac{2.97\times 10^{-3}(1-\alpha)}{158.6}$$

$$\frac{\alpha\eta 310.0^{-0.25}}{\eta 310.0^{0.75}+(1-\eta)1247.6^{0.75}}-\frac{4.23\times 10^{-3}(1-\alpha)}{158.6}=-2.7397\times 10^{-4}\frac{\pi'(143.8)}{\pi(143.8)} \tag{5.7}$$

For women, we find that $\eta^w = 0.46$ and $\alpha^w = 0.08$.

Note that men and women differ considerably in their preferences for food versus non-food goods and food at home versus food away from home. The food share, α, and the preference parameter for food away from home, η, are greater for men compared to women. Note that the heterogeneity across gender is not counter-intuitive since men tend to eat more than women and they also eat more away from home. In the next section, we use the calibrated model to assess the impact of changes in relative food prices and real income on eating habits and weight of Americans between 1971 and 2006.

Chapter 6

Simulations

We perform the following experiments. First, we change the price per calorie of food away from home from its 1971 value, $p_a^{1971} = 4.68 \times 10^{-3}$, to its 2006 value, $p_a^{2006} = 3.66 \times 10^{-3}$ leaving all other parameters of the model constant. From the first-order conditions in equation (4.8), we calculate the optimal food away from home and food at home. We then calculate weight for men and women from equation (4.4) as well as the resulting body-mass index. We report results of the first experiment in the first column of Table 6.1.

For men, the fraction of calories away from home increases by 9 percentage points from 29 percent (calibrated value from Table 2.1) to 38 percent. For women, the fraction of calories consumed away from home increases by 7 percentage points from 20 percent (calibrated value) to 27 percent.[1] The

[1]For men, results slightly overshoots the data as the observed fraction of calories consumed away from home in 2006 is equal 41 percent. For women, results do not fully account for the observed change in the data as the fraction of calories consumed away

impact on agent's weight is small as weight of men and women changes by less than one pound.

Tab. 6.1: Average body-mass index, weight, calorie requirement, and fraction of calories consumed away from home for men and women

	p_a	p_h	p_a/p_h	Income	All
Men:					
BMI	25.7	25.6	25.7	27.1	27.0
Weight (lbs.)	173.29	173.14	173.38	183.22	182.10
Calories	2,422	2,420	2,423	2,521	2509.89
Calories Away from Home (%)	37.8	27.35	36.38	31.10	37.95
Women:					
BMI	24.9	25.0	24.9	26.7	26.4
Weight (lbs.)	143.48	143.55	143.49	153.71	152.08
Calories	1,545	1,556	1,555	1,653	1,641
Calories Away from Home (%)	27.43	18.96	26.11	21.62	27.27

The second experiment consists of changing the price per calorie of food at home from its 1971 value, $p_h^{1971} = 2.90 \times 10^{-3}$, to its 2006 value, $p_h^{2006} = 2.74 \times 10^{-3}$ leaving all other parameters constant. We report the result in the second column of Table 6.1. For men, the fraction of calories away from home decreases by 2 percentage points from 29 percent to 27 percent. For women, the fraction of calories away from home decreases by one percentage point from 20 percent to 19 percent. Again, the decline in food prices has little impact on agent's weight.

The third experiment consists of changing household real disposable income from its 1971 value $I^{1971} = \$59,742$ to its 2006 value $I^{2006} = \$74,089$

from home by women in 2006 is equal to 36 percent.

(see Table 2.2) leaving all other parameters constant. We report the results in the third column of Table 6.1. Changes in income account for a large fraction of the observed change in individual's weight. The steady state weight of men and women increases to 183 and 153 pounds, respectively. Changes in income have little reallocation effect, however, as the fraction of calories consumed away from home by and women changes by less than one percentage point.

Finally, the fourth experiment consists of changing food prices and income all at once. For men, the model predicts that a weight equal to 182 pounds and the fraction of calories away from home is equal to 38 percent. For women, the model predicts that a weight equal to 152 pounds and the fraction of calories away from home is equal to 27 percent.

The lessons learned from the model for eating decisions and weight can be summarized as follows. Changes in food prices have an "allocation" effect. As the price of one food category changes, households substitute from one food category to another. Between 1971 and 2006, the decline in the relative price of food (away from home versus at home) account for about half of the increase in the fraction of calories eaten away from home. Changes in food prices, however, have little impact on total calories consumed and weight. Changes in income, on the other hand, have a large impact on weight. Between 1971 and 2006, much of the increase in weight and body-mass index can be accounted for by increase in household real disposable income. In the Appendix A we show that the positive relationship between body-mass index and household income holds for men in several cross-sections of NHANES. For women, however, body-mass index is negatively related to household income suggesting that some other force not captured in our model is at work. We leave the task of reconciling the pattern differences for body-mass index and household income in cross-section and time-series data for men and women for future research.

Chapter 7

Conclusion and Discussion

Our results corroborates the existing knowledge on obesity in the following way. On the one hand, economists who use empirical models found that the impact of food prices on weight is small (e.g., Chou, Grossman, and Saffer (2004), Gelbach, Klick, and Stratmann (2007), or Chouinard, Davis, LaFrance, and Perloff (2007)). Using a fully specified calibrated static model, we also find that changes in food prices over time account for almost none of the weight gain by Americans in the last thirty years. On the other hand, researchers in the field of public health (e.g., French, Jeffery, Story, Breitlow, Baxter, Hannan, and Snyder (2001)) design small-scale experiments to show that even small changes in food prices can have strong local effect on individual's food choices. For example, the above-mentioned authors examined the effect of lower prices on sales of lower fat vending machine snacks in 12 work sites and 12 secondary schools. According to a study, price reductions of ten percent, twenty five percent, and fifty percent on low-fat snacks in vending machines increase the percentage of low-fat snack sales by nine, thirty nine, and ninety three percent, respectively. Using our calibrated dynamic model, we also find that change in food prices affect where people eat (at home or out).

We see two important avenues for academic research on obesity as well as policy recommendation. First, educating people about the benefits of eating healthy, exercising regularly, and the negative health consequences of being obese seem to be promising policies to win the fight against obesity epidemic. Economic research is needed to measure the impact of these education programs on individual's weight and body-mass index. Second, we derived our results for the impact of food prices on weight and food choices in an environment where agents are fully rational. An alternative view point is that there is nothing optimal in being obese and that individuals experience commitment problems when making food decisions. It is an open and interesting question to revisit the impact of food prices and household income in a set-up where agents have time-inconsistent preferences *à* la Laibson (1997). We leave these two tasks for future research.

Bibliography

[1] D. Allison, K. Fontaine, J. Manson, J. Stevens, and T. VanItallie. Annual deaths attributable to obesity in the Unites States. *The Journal of the American Medical Association*, 282(16):1530–1538, October 1999.

[2] J. Binkley, J. Eales, and M. Jekanowski. The relationship between dietary change and rising US obesity. *International Journal of Obesity*, 24:1032–1039, 2000.

[3] S. Chou, M. Grossman, and H. Saffer. An economic analysis of adult obesity: results from the behavioral risk factor surveillance system. *Journal of Health Economics*, 23(3):565–587, 2004.

[4] H. Chouinard, D. Davis, J. LaFrance, and J. Perloff. Fat taxes: Big money for small change. *Forum for Health Economics and Policy*, 10(2), 2007.

[5] D. Cutler, E. Glaeser, and J. Shapiro. Why have Americans become more obese? *The Journal of Economic Perspectives*, 17(3):93–118, 2003.

[6] A. Drewnowski, N. Darmon, and A. Briend. Replacing fats and sweets with vegetables and fruits - a question of cost. *American Journal of Public Health*, 94(9):1555–1559, 2004.

[7] R. Ewing, T. Schmid, R. Killingsworth, A. Zlot, and S. Raudenbush. Relationship between urban sprawl and physical activity, obesity, and morbidity. *American Journal of Health Promotion*, 18(1):47–57, 2003.

[8] E. Finkelstein, C. Ruhm, and K. Kosa. Economic causes and consequences of obesity. *Annual Review of Public Health*, 26:239–257, 2005.

[9] K. Flegal, M. Carroll, C. Ogden, and C. Johnson. Prevalence and trends in obesity among US adults, 1999-2000. *The Journal of the American Medical Association*, 288(14):1723–1727, October 2002.

[10] S. French, R. Jeffery, M. Story, K. Breitlow, J. Baxter, P. Hannan, and P. Snyder. Pricing and promotion effects on low fat vending snack purchases: the chips study. *American Journal of Public Health*, 91(1):112–117, January 2001.

[11] S. French, M. Story, and R. Jeffery. Environmental influences on eating and physical activity. *Annual Review of Public Health*, 22:309–335, 2001.

[12] J. Gelbach, J. Klick, and T. Stratmann. Cheap donuts and expensive broccoli: the effect of relative prices on obesity. March 2007.

[13] P. Gomis-Porqueras and A. Peralta-Alva. A macroeconomic analysis of obesity in the U.S. 2007.

[14] J. Guthrie, B. Lin, and E. Frazão. Role of food prepared away from home in the american diet, 1977-78 versus 1994-96: Changes and con-

sequences. *Journal of Nutrition Education and Behavior*, 34(3):140–150, 2002.

[15] R. Jeffery, S. French, C. Raether, and J. Baxter. An environmental intervention to increase fruit and salad purchases in a cafeteria. *Preventive Medicine*, 23(6):788–792, 1994.

[16] A. Kant and B. Graubard. Eating out in America, 1987-2000: trends and nutritional correlates. *Preventive Medicine*, 38:243–249, 2004.

[17] F. Kuchler, A. Tegene, and M. Harris. Taxing snack foods: manipulating diet quality or financing information programs? *Review of Agricultural Economics*, 27(1):4–20, 2005.

[18] D. Laibson. Golden eggs and hyperbolic discounting. *Quarterly Journal of Economics, 62, May, pp. 443-77*, 62:443–77, May 1997.

[19] D. Lakdawalla and T. Philipson. The growth of obesity and technological change: A theoretical and empirical examination. *Working Paper No. 8946*, National Beureau of Economic Research, May 2002.

[20] D. Lakdawalla, T. Philipson, and J. Bhattacharya. Welfare-enhancing technological change and the growth of obesity. *The American Economic Review*, 95(2):253–257, May 2005.

[21] B.H-. Lin and E. Frazão. Nutritional quality of foods at and away from home. *Food Review*, 20:33–40, 1997.

[22] B.H-. Lin, E. Frazão, and J. Guthrie. Away-from-home foods increasingly important to quality of American diet. *Agriculture Information Bulletin No. 749*, Economic Research Service, U.S. Department of Agriculture, January 1999.

[23] M. McCrory, P. Fuss, N. Hays, A. Vinken, A. Greenberg, and S. Roberts. Overeating in America: association between restaurant food consumption and body fatness in healthy adult men and women ages 19 to 80. *Obesity Research*, 7(6):564–571, November 1999.

[24] U.S. Department of Health and Human Services. NHANES web tutorial. http://www.cdc.gov/nchs/tutorials/nhanes/, 2009.

[25] U.S. Department of Health, Human Services, and U.S. Department of Agriculture. Dietary giudelines for Americans, 2005. January 2005.

[26] C. Ogden, M. Carroll, M. McDowell, and K. Flegal. Obesity among adults in the Unites States - no statistically significant change since 2003-2005. Technical report, U.S. Department of Health and Human Services, 2007.

[27] T. Philipson and R. Posner. The long-run growth in obesity as a function of technological change. *Perspectives in Biology and Medicine*, 46(3):87S–107S, 2003.

[28] L. Powell and F. Chaloupka. Food prices and obesity: Evidence and policy implications for taxes and subsidies. *The Milbank Quarterly*, 87(1):229–257, 2009.

[29] A. J. Reed, W. Levedahl, and C. Hallahan. The generalized composite commodity theorem and food demand elasticity. *American Journal of Agricultural Economics*, 87(1):28–37, February 2005.

[30] L. Young and M. Nestle. The contribution of expanding portion sizes to the US obesity epidemic. *American Journal of Public Health*, 92(2):246–249, February 2002.

Appendix A: Who Is Eating Away From Home

The average body-mass index (BMI) of American men and women increased considerably in the past thirty-five years and a large fraction of Americans are now classified as either medically overweight or obese. In 1971, the average BMI of men and women between age 20 and 74 was equal to 25.6 and 25.0, respectively, implying that adult men and women had either a normal weight or were slightly overweight. In 2006, the average BMI increased to 28.7, implying that both men and women are overweight.

During the same period of time, Americans changed their eating habits dramatically, expanding net daily calorie intake and eating out more frequently. In 1971, 24 percent of total daily calories was consumed away from home compared to 40 percent in 2006. Since food away from home typically contains more added fat and added sugars than food prepared at home, some researchers have claimed that the increase in food away from home is one key factor that contributed to the obesity epidemic in the United

States (e.g., McCrory, Fuss, Hays, Vinken, Greenberg, and Roberts (1999), Binkley, Eales, and Jekanowski (2000), Young and Nestle (2002), or Kant and Graubard (2004)). In addition, given the possible link between obesity and increased consumption of food away from home, there has been a growing pressure on elected representatives to come up with policies aimed at curbing food intake away from home. For example, in July 2008, the Los Angeles City Council unanimously voted to put a one-year ban on new fast-food restaurants in one of the city's poorest areas.

In this paper, we use data from the National Health and Nutritional Examination Survey (NHANES) between 1971 and 2006 to analyze the relationship between BMI and the percentage of calories consumed away from home for different demographic groups. When considering the entire period between 1971 and 2006, the average BMI and the percentage of calories away from home are positively correlated. However, this relationship is not robust when examined over different time periods or more disaggregated data. First, BMI increased steadily between 1971 and 2006, while the fraction of calories consumed away from home is flat after 1988. Second, changes in BMI and the fraction of calories consumed away from home are negatively related for many demographic subgroups. Finally, results from a simple regression model show that the impact of calories consumed away from home on BMI is not statistically significant. Altogether, our results suggest that the relationship between BMI and food away from home is more complex than previously documented. Consequently, we believe that more research is needed before sound public heath policy recommendations can be made and implemented.

A.1 Data Set and Variables

In the next sections, we use data from the National Health and Nutritional Examination Survey (NHANES) for four distinct time periods (NHANES I for years between 1971 and 1975, NHANES III for years between 1988 and 1994, NHANES 1999-2000, and NHANES 2005-2006) to document changes in BMI and the fraction of calories consumed away from home between 1971 and 2006 for different subgroups of the population. Specifically, we look at BMI and food away from home by gender, age, race, education, family income, and marital status.

Race: We have three categories for races: white, black, and other, since this was the only classification offered in NHANES I. In NHANES III we included Mexican-American of unknown race under category other. For NHANES 1999-2000 and 2007-06 we used "Non-Hispanic White" as white, "Non-Hispanic Black" as black and all other categories (Mexican American, Other Hispanic, Other Race including multiracial) are clustered under category other.

Education: We consider four education levels: less than a high school degree, high school degree, some college, and college graduate or above. Individuals that are in the category "less than a high school degree" have not completed twelve years of primary education. Those in the high school degree category have finished 12th grade but decided not to attend college or obtain an associate degree. Individuals with some college education have either an associate degree from a technical college or enrolled in a 4-year college or university but did not obtain their degree. Finally, the highest category includes individuals with at least a bachelor degree, and possibly higher degrees such as masters, Ph.D., or professional degrees.

Family Income: In NHANES, family income is expresses in nominal terms and is top coded. Top codes for NHANES I, NHANES III, and NHANES 1999-2000 and NHANES 2005-06 are $15,999, $44,999, and $75,000, respectively. Using information on the consumer price index (CPI) published by the Bureau of Labor Statistics, we adjust family income for inflation and express it in 2005 constant dollars. In this way, family income is directly comparable across surveys. We also create four distinct income brackets: $0-24,999; 25,000-44,999; 45,000-74,999; 75,000 and above.

Marital Status: We constructed four categories for marital status; Married, Living with Partner, Other, and Never Married. The category other includes widowed, divorced, and separated. The category Living with partner is not available for NHANES I. In NHANES III we combined category "Married-spouse in household" and "Married-spouse not in household" into Married category.

A.2 Descriptive Analysis

A.2.1 Changes in BMI and Calories by Age and Gender

In Tables A.1 and A.2, we present changes in BMI and the percentage of calories away from home for adult males and females between age 20 to 74 for the periods 1971-75, 1988-94, 1999-2000, and 2005-2006.

The average BMI for men and women increase by 11.9 and 14.4 percent, respectively, between 1971 and 2006. In 1971, men and women were either slightly overweight or had a healthy weight as their BMI was equal to 25.56 and 25.05, respectively. In 2006, both men and women were overweight and had BMI equal to 28.60 and 28.65, respectively.[1] Over the same period of time, the fraction of calories consumed away from home increased by 36.7 and 72.5 percent for men and women, respectively.[2] As a result, BMI and the fraction of calories consumed are positively correlated between 1971 and 2006.

Further analysis of the relationship casts some doubt about causality, however. First, the increase in BMI is steady between 1971 and 2006, while most of the increase in the fraction of calories consumed away from home occurs between 1971 and 1994. For example, the fraction of calories eaten

[1]Note that men and women are slightly taller in 2006 compared to 1091, which everything else equal reduces BMI.

[2]In our data we also observe that on average men tend to consume more calories away from home, relative to women and that this fact is robust for the entire 35-year-period. Lin and Frazao (1997) reported similar result for year 1995 using Continuing Survey of Food Intakes by Individuals (CSFII).

away from home for men increase from 28.6 to 37.9 percent between 1971 and 1994.[3] However, between 1999 and 2006, the same fraction increased only from 38.7 to 39.1. For women, the decoupling between BMI and the fraction of calories eaten away from home is even stronger as the fraction of calories away from home for women declined between 1999 and 2006, while BMI increased.

Second, the percentage increase in the fraction of calories consumed away from home is the largest for men and women over 50. However, the BMI for men and women over 50 is not significantly higher compared to men and women below 50.

Finally, in all four samples, the fraction of calories consumed away from home declines with age, while BMI tends to increase first and then declines with age.[4] Several physiologic and economic factors influence the desire of people to eat out, including age, income, etc. What our analysis shows, however, is that the relationship between BMI and the fraction of food consumed away from home is complex and requires further analysis. In the next sections, we look at the relationship between BMI and fraction of calories consumed away from home by race, education, marital status, and income.

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[3] Very similar result was reported by Guthrie, Lin, and Frazão (2002) for the period between 1977-78 and 1994-95 using the Nationwide Food Consumption Survey (NFCS). They report that during this period the contribution of away food to the total diet rose from 18 percent to 32 percent.

[4] The fact that seniors ate the fewest share of their meals away from home was already observed by Lin and Frazao (1997).

Tab. A.1: Change in body-mass index and percentage of calories consumed away from home by age for men (s.d.)

	BMI				% calories away from home			
Year	1971-1975	1988-1994	1999-2000	2005-2006	1971-1975	1988-1994	1999-2000	2005-2006
All (20-74)	25.56	26.58	27.67	28.60	28.58	37.92	38.68	39.07
	(0.08)	(0.11)	(0.24)	(0.27)	(0.61)	(0.64)	(1.05)	(1.11)
20-29	24.52	25.15	26.44	26.98	35.69	45.56	47.74	41.19
	(0.15)	(0.16)	(0.31)	(0.48)	(1.27)	(1.52)	(2.84)	(1.93)
30-39	26.08	26.45	27.41	28.47	34.77	41.77	40.97	44.31
	(0.20)	(0.23)	(0.39)	(0.31)	(1.25)	(1.38)	(2.75)	(1.87)
40-49	26.19	27.26	27.89	29.67	30.55	40.22	40.18	42.53
	(0.16)	(0.21)	(0.37)	(0.36)	(1.34)	(1.47)	(1.40)	(1.90)
50-59	25.99	27.74	28.67	29.01	22.70	34.60	37.22	38.20
	(0.18)	(0.19)	(0.57)	(0.39)	(1.29)	(1.87)	(1.55)	(2.20)
60-69	25.48	27.32	28.83	28.97	15.14	22.15	22.92	28.09
	(0.14)	(0.19)	(0.29)	(0.40)	(1.30)	(1.49)	(1.36)	(2.35)
70-74	25.30	26.74	27.83	28.48	11.03	14.51	18.69	21.50
	(0.16)	(0.26)	(0.45)	(0.38)	(1.05)	(1.31)	(2.47)	(3.54)

Tab. A.2: Change in body-mass index and percentage of calories consumed away from home by age for women (s.d.)

	BMI				% calories away from home			
Year	1971-1975	1988-1994	1999-2000	2005-2006	1971-1975	1988-1994	1999-2000	2005-2006
All (20-74)	25.05	26.44	0.28	28.65	19.86	32.36	35.51	34.26
	(0.10)	(0.17)	(0.23)	(0.30)	(0.54)	(0.80)	(1.02)	(1.01)
20-29	23.08	24.44	26.59	26.73	27.09	37.71	41.23	40.74
	(0.13)	(0.23)	(0.38)	(0.49)	(0.94)	(1.69)	(2.96)	(2.09)
30-39	24.74	26.20	28.41	28.21	21.03	36.08	40.55	36.91
	(0.17)	(0.30)	(0.49)	(0.48)	(0.91)	(1.42)	(1.62)	(3.57)
40-49	25.67	26.97	28.36	29.17	19.09	36.00	37.09	35.03
	(0.25)	(0.34)	(0.72)	(0.47)	(0.99)	(1.31)	(2.67)	(1.34)
50-59	26.17	28.31	29.59	29.81	17.01	29.32	34.41	36.56
	(0.23)	(0.28)	(0.64)	(0.58)	(1.24)	(1.48)	(2.43)	(2.54)
60-69	26.50	27.46	29.40	29.94	13.30	19.89	21.47	22.26
	(0.18)	(0.20)	(0.43)	(0.58)	(1.02)	(1.19)	(1.96)	(1.49)
70-74	26.32	27.10	27.64	28.18	8.25	15.38	16.55	20.94
	(0.25)	(0.28)	(0.64)	(0.97)	(0.95)	(1.52)	(2.65)	(2.96)

A.2.2 ... By Race and Gender

In Table A.3, we present changes in BMI and the percentage of calories away from home for adult males and females between age 20 to 74 by race. BMI for white and black men increase by 11.7 and 12.8 percent between 1971-2006, respectively. During the same period, the percentage of calories consumed away from home increased by 41.3 percent for white men and by 13.8 for black. In other words, both white and black men gained similar amount of weight, while white men increase their consumption of food away from home significantly more compared to black men. In addition, BMI for black men increase the most between 1999-2006 (by 5.4 percent), while their consumption of food away from home actually decrease by 3.1 percent.

The fact that white men tend to eat more away from home compared to black men perhaps reflects differences in the level and growth rates of family income. However, it is not evident that eating away from home automatically translates into higher BMI levels. More rigorous empirical analysis is needed to assess the impact of eating out after controlling for many demographic characteristics.

In 1971, black women consumed more calories away from home relative to white women. This trend reversed in 1988 and today white women consume more calories away from home. Between 1971-2006, BMI for white and black women increase by 11.7 and 12.8 percent, respectively. On the other hand, the consumption of food away from home increase by 41.3

percent for white women and only by 13.8 percent for black women. As in case of men, there is a decoupling between changes in BMI and the fraction of calories consumed away from home. In addition, note that black women decreased their consumption of food away from home by 15.2 percent between 1999-2006, while their BMI still increased (by 0.5 percent).

What about lagged effects? Between 1971 and 1988 white women increase their consumption of calories away from home by 67.5 percent, while black women increase their calories by 43.1 percent. If eating away is really an important determinant for BMI but has a lagged effect on weight (it takes some time to gain weight), we would expect to see the weight increase for white women to be higher than for black women in the next period. However, during the period 1988-1999, white women increased their BMI by 6.1 percent, while black women increase it by 10.2 percent. Similarly, between 1988 and 1999 white women increase their food away from home by 6.8 percent while black women increase it by 9.3 percent. Again, we would expect black women to gain more weight between 1999 and 2005. However, white women increased their BMI by 2.1 percent while black women increase it by only 0.5 percent.

A.2.3 ... By Education and Gender

In Tables A.4 and A.5, we present changes in BMI and the percentage of calories away from home for adult males and females with different education levels. Less educated men, those with high school diploma or less,

Tab. A.3: Change in body-mass index and percentage of calories consumed away from home by race and gender (s.d.)

	BMI				% calories away from home			
Year	1971-1975	1988-1994	1999-2000	2005-2006	1971-1975	1988-1994	1999-2000	2005-2006
Men:								
White	25.58	26.70	27.70	28.58	28.60	38.57	38.93	40.40
	(0.09)	(0.13)	(0.26)	(0.26)	(0.66)	(0.64)	(1.03)	(1.30)
Black	25.69	26.49	27.48	28.98	28.26	33.80	33.19	32.17
	(0.31)	(0.13)	(0.29)	(0.36)	(1.78)	(0.87)	(1.97)	(1.68)
Other	22.87	24.62	27.53	28.03	30.17	35.47	45.94	32.66
	(0.64)	(0.30)	(0.84)	(0.90)	(7.43)	(3.82)	(6.37)	(5.01)
Women:								
White	24.80	26.19	27.79	28.38	19.54	32.73	34.97	35.12
	(0.11)	(0.20)	(0.32)	(0.30)	(0.57)	(0.89)	(1.17)	(1.09)
Black	27.34	28.66	31.59	31.74	21.93	31.37	34.28	29.06
	(0.28)	(0.23)	(0.42)	(0.36)	(1.26)	(0.76)	(2.01)	(1.07)
Other	23.34	24.72	28.51	25.90	26.62	27.57	49.43	33.36
	(0.44)	(0.63)	(1.68)	(0.73)	(4.94)	(2.85)	(5.29)	(4.24)

tend to eat more at home compared to men that have some college or above. However, the percentage of calories consumed away from home between 1971-2006 increased for all men, regardless of their education, with the highest increase for men with less than high school diploma and the least for the college graduate and above. During the same period all men, regardless of their education gained weight and their BMI increased. However, the biggest increase in the BMI did not happen to men with less than high school diploma, but rather to those with some college education. Moreover, men with some college or above have lower BMI in any given period, compared to men with high school diploma or less. More educate men, however, eat significantly more calories away from home compared to less educated men.

Similar result hold for women. Less educated women tend to eat more at home compared to more educated women. The percentage of calories consumed away from home increase for all women, regardless of their education, with the highest increase for women with less than high school diploma. All women also gained weight during this period. However, the second smallest increase in BMI was observed by women with less than high school diploma - same women who increased their consumption of food away from home the most.

Tab. A.4: Change in body-mass index and percentage of calories consumed away from home by education for men (s.d.)

	BMI				% calories away from home			
Year	1971-1975	1988-1994	1999-2000	2005-2006	1971-1975	1988-1994	1999-2000	2005-2006
Less than HS	25.47	26.79	28.01	28.40	21.94	30.92	31.24	35.68
	(0.10)	(0.18)	(0.44)	(0.54)	(0.73)	(1.12)	(2.29)	(1.89)
HS	25.89	26.85	28.25	29.16	30.83	39.49	38.91	38.28
	(0.14)	(0.20)	(0.30)	(0.41)	(1.32)	(1.38)	(2.20)	(1.81)
Some College	25.45	26.62	27.42	28.81	32.46	41.55	44.26	40.76
	(0.22)	(0.20)	(0.49)	(0.32)	(1.44)	(1.86)	(2.20)	(2.07)
Collge+	25.22	26.02	27.08	27.92	33.75	39.79	39.84	39.87
	(0.17)	(0.23)	(0.37)	(0.37)	(1.56)	(1.60)	(1.68)	(1.59)

Tab. A.5: Change in body-mass index and percentage of calories consumed away from home by education for women (s.d.)

	BMI				% calories away from home			
Year	1971-1975	1988-1994	1999-2000	2005-2006	1971-1975	1988-1994	1999-2000	2005-2006
Less than HS	26.64	27.62	29.11	29.26	15.66	24.27	26.79	28.17
	(0.17)	(0.24)	(0.45)	(0.36)	(0.63)	(1.03)	(1.23)	(1.97)
HS	24.64	27.10	28.67	29.41	20.26	33.78	31.26	33.38
	(0.12)	(0.29)	(0.34)	(0.35)	(0.75)	(1.05)	(1.50)	(2.15)
Some College	23.69	25.70	28.78	29.34	25.18	35.37	41.83	36.56
	(0.23)	(0.26)	(0.25)	(0.46)	(1.16)	(1.59)	(2.61)	(1.84)
Collge+	23.30	24.54	26.26	26.88	24.97	35.72	40.98	35.81
	(0.20)	(0.21)	(0.51)	(0.48)	(1.40)	(1.34)	(2.28)	(1.81)

A.2.4 ... By Family Income and Gender

In Tables A.6 and A.7, we present changes in BMI and the percentage of calories away from home for adult males and females between age 20 to 74 by income. For the entire period between 1971 and 2006, BMI and the fraction of calories eaten away from home are positively correlated for both men and women. However, a few comments are in order. First, note that the fraction of calories eaten away from home increases with income for both men and women. There is no clear mimicking pattern for BMI, however. Looking at the data for men in 1971-75, income and BMI are clearly positively related. This, however, is no longer true in 1988-94 and after, where men with the highest income obtain the biggest share of their calories from the food away from home, but do not have the highest BMI. The highest BMI is recorded for the men in the income group $45,000-74,999 who obtain less of calories away from home compared to the high income earners. In other words, the middle-income men have the highest BMI, but do not eat the largest share of their calories away from home. The lowest BMI is recorded for the low-income men, who have experienced the biggest increase in the consumption of food away from home, and for the high-income earnenrs, who obtain the largest share of their calories from the food away from home.

Second, the increase of BMI is the same for men in the $0-24,999 and $75,000+ income bracket (11.0 and 11.2 percent respectively). However, the increase in the fraction of calories away from home is much larger for men in the $0-24,999 income bracket (59.2 percent) compared to men in the $75,000+ income bracket (24.2 percent).

For women, BMI and percentage of calories eaten away from home move in completely opposite direction. Notice that women with the highest incomes obtain the biggest share of their calories from the food away from home. These women, however, have the lowest BMI. For example, in 2005-06, women in the income group $75,000+ obtained 38 percent of their calories away from home and they had a BMI of 27.40. Women in the lowest income group $ 0-24,999 obtained the smallest share of their calories from the food away from home (28.15 percent) but had the highest BMI equal to 29.71. In other words, poorer women tend to obtain fewer calories way from home, but have the highest BMI. On the other hand, the richest women, obtain the biggest share of their calories away from home, but have the lowest BMI. This fact, is robust for the entire 35-year-period.

A.2.5 ... By Marital Status and Gender

In Tables A.8 and A.9, we present changes in BMI and the percentage of calories away from home for adult males and females between age 20 to 74 by marital status. First, men and women in the never married category eat out the most, while their BMI is the lowest. One possible explanation for this finding is that never married individuals are young and young people tend to be slimmer and go out more frequently. Second, married men have the highest BMI but obtain the smallest share of their calories

Tab. A.6: Change in body-mass index and percentage of calories consumed away from home by income for men (s.d.)

	BMI				% calories away from home			
Year	1971-1975	1988-1994	1999-2000	2005-2006	1971-1975	1988-1994	1999-2000	2005-2006
0-24,999	24.82	26.19	27.44	27.55	21.92	29.49	35.56	34.90
	(0.15)	(0.20)	(0.34)	(0.45)	(1.73)	(1.26)	(2.63)	(1.94)
25,000-44,999	25.42	26.42	28.08	28.25	26.06	36.70	38.72	36.59
	(0.12)	(0.24)	(0.43)	(0.39)	(0.98)	(1.32)	(1.45)	(1.77)
45,000-74,999	25.88	26.99	27.97	29.28	31.27	38.54	40.62	42.27
	(0.17)	(0.19)	(0.44)	(0.48)	(1.00)	(1.27)	(1.89)	(2.26)
75,000+	26.07	26.71	27.68	28.99	33.61	43.52	44.14	41.73
	(0.18)	(0.19)	(0.42)	(0.25)	(1.17)	(1.29)	(2.26)	(2.25)

Tab. A.7: Change in body-mass index and percentage of calories consumed away from home by income for women (s.d.)

	BMI				% calories away from home			
Year	1971-1975	1988-1994	1999-2000	2005-2006	1971-1975	1988-1994	1999-2000	2005-2006
0-24,999	26.30	27.59	29.00	29.71	17.34	26.25	33.51	28.15
	(0.20)	(0.26)	(0.34)	(0.51)	(1.09)	(1.48)	(1.84)	(1.59)
25,000-44,999	25.21	26.38	29.40	28.59	19.45	33.55	38.57	33.21
	(0.16)	(0.26)	(0.50)	(0.40)	(0.77)	(1.07)	(2.02)	(2.25)
45,000-74,999	24.46	26.26	27.10	29.22	20.53	32.50	35.01	36.83
	(0.20)	(0.28)	(0.38)	(0.54)	(0.98)	(1.35)	(2.85)	(2.11)
75,000+	24.10	25.57	26.83	27.40	23.23	37.76	41.33	37.90
	(0.18)	(0.26)	(0.81)	(0.41)	(1.14)	(1.41)	(2.15)	(2.00)

from the food away from home. This fact is robust for the entire 35-year-period. The heaviest group of women are those that are divorced, separated, or widowed, with the highest BMI - in 2005-06 the average women in this category was actually obese. These women, however, do not eat out as much as never married women and women living with a partner, and only slightly more compared to married women. Finally, notice that the fraction of calories eaten away from home increased the most for married women (it almost doubled with the increase of 86 percent over the 35-year-period), while BMI of married women changed the least (it went up by only 13 percent, compared to an increase of 21 percent experienced by never married women). The increase in calories eaten away from home can possibly relate to more women joining the labor force.

Tab. A.8: Change in body-mass index and percentage of calories consumed away from home by marital status for men (s.d.)

	BMI				% calories away from home			
Year	1971-1975	1988-1994	1999-2000	2005-2006	1971-1975	1988-1994	1999-2000	2005-2006
Married	25.83	27.07	28.26	29.18	27.20	36.44	35.35	38.66
	(0.08)	(0.13)	(0.27)	(0.33)	(0.60)	(0.73)	(1.33)	(1.67)
With Partner	NA	25.75	27.07	27.86	NA	36.98	46.90	39.52
	NA	(0.43)	(0.66)	(0.63)	NA	(2.89)	(4.46)	(3.39)
Other	24.93	26.36	27.29	28.65	33.10	35.45	40.18	37.60
	(0.27)	(0.30)	(0.67)	(0.49)	(1.99)	(2.29)	(3.74)	(2.25)
Never Married	24.26	25.22	26.67	26.97	34.36	44.41	45.67	41.30
	(0.22)	(0.16)	(0.49)	(0.49)	(1.93)	(1.83)	(2.75)	(2.41)

Tab. A.9: Change in body-mass index and percentage of calories consumed away from home by marital status for women (s.d.)

	BMI				% calories away from home			
Year	1971-1975	1988-1994	1999-2000	2005-2006	1971-1975	1988-1994	1999-2000	2005-2006
Married	25.02	26.43	27.98	28.27	17.68	30.13	34.15	32.93
	(0.12)	(0.16)	(0.37)	(0.23)	(0.52)	(0.85)	(1.54)	(1.38)
With Partner	NA	26.24	27.66	27.11	NA	35.99	36.66	37.86
	NA	(0.47)	(0.74)	(0.59)	NA	(2.53)	(5.27)	(3.57)
Other	25.81	27.24	28.97	30.34	21.05	31.97	32.31	31.08
	(0.21)	(0.25)	(0.50)	(0.61)	(0.96)	(1.30)	(1.91)	(1.32)
Never Married	23.80	25.30	28.36	28.75	32.96	41.08	43.93	41.71
	(0.24)	(0.34)	(0.61)	(0.63)	(1.67)	(1.86)	(2.55)	(2.88)

Appendix B: Per Calorie Food Prices

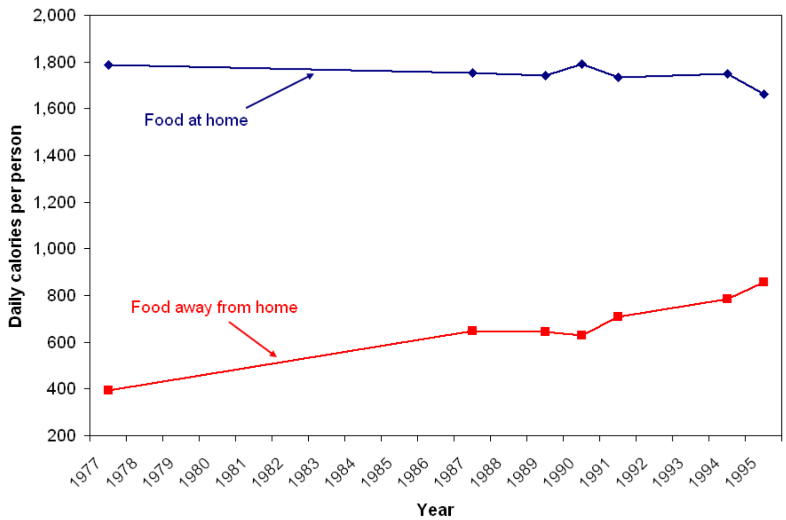
In this section, we introduce a new method to measure food prices that adjusts for changes in calories consumed over time. Using household expenditures share data for different food categories, we calculate the *price per calorie* as household expenditures on food divided by calories consumed. Our research is related to the work of Drewnowski, Darmon, and Briend (2005) who study the energy cost of adults' diets in France in 1989. There are important differences between our work and theirs, however. First, we measure food prices in terms of dollars per calories consumed, while Drewnowski et al. use euros per joules. Second, we look at changes in per calorie food prices over time from 1977 to 1996, while their measure is only for one year. Finally, we consider changes in per calorie food prices for broadly defined food categories, while their basket includes prices for fifty-seven food items. The increase in calories consumed away from home and larger portions at restaurants are often blamed for the weight gain of

Americans. Between 1977 and 1995, calories from food away from home increased from eighteen to thirty-three percent of total daily calories consumed (Guthrie, Lin, and Frazão (2002)). Moreover, food portions are larger today than they were in the past. According to Young and Nestle (2002), "in the mid-1950s, McDonald's offered only one size of french fries; that size is now considered small and is one third the weight of the largest size available in 2001" (p.248).

In Figure B.1, we present changes in daily calories consumed away and at home between 1977 and 1955. Food away from home includes full and limited service meals and snacks, food at employee sites and schools, food from vending machines and mobile vendors, and other food away from home. Food at home includes all the food prepared at home. We use calorie shares from Lin, Frazão, Guthrie (1999) as well as data on total daily calories from the US Department of Agriculture to calculate changes over time in total calories consumed at and away from home. Calories away from (at) home are equal to total daily calories times the fraction of calories consumed away from (at) home. Between 1977 and 1995, calories away from home increased by hundred and eighteen percent, while calories consumed at home slightly decreased by seven percent.

In Figure B.2, we present changes in the relative price of food at home and away from home between 1977 and 1995. We consider two measures for changes in the relative price. The first one uses data from the Bureau of Labor Statistics (BLS) and does not adjust for changes in calories consumed

Fig. B.1: Daily calorie intake for food at home and food away from home



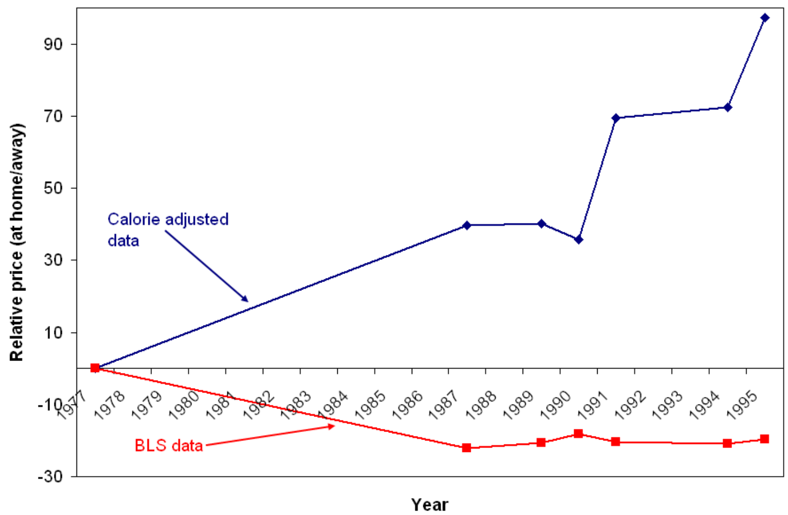
over time. The second one uses data on household expenditure shares published in the BLS yearly bulletins. For each year between 1977 and 1995, the per calorie price of food away from home, $p_{A,t}$, and food at home, $p_{H,t}$, are equal to:

$$p_{A,t} = \frac{\alpha_{A,t} I_t}{\text{Calories}_{A,t}}, \quad p_{H,t} = \frac{\alpha_{H,t} I_t}{\text{Calories}_{H,t}} \tag{B.1}$$

where $\alpha_{A,t}$ and $\alpha_{H,t}$ denote the expenditure share on food away and at home, respectively, and I_t represents real income in period t. The relative price of food at home versus food away from home is defined as $\frac{p_{H,t}}{p_{A,t}}$.

Looking at changes in food prices that are not adjusted for changes in calories consumed, we find that food away from home has become more expensive relative to food at home (see Figure B.2). Using basic economic

Fig. B.2: Percentage change in relative price over time



theory of supply and demand alone, we cannot reconcile changes in people's habits (calories consumed away from home doubled) and changes in relative food prices (food away from home became twenty percent more expensive). On the other hand, looking at changes in food prices that are adjusted for changes in calories consumed, the per calorie price of food away from home has become ninety percent cheaper compared to food at home (see Figure B.2). We conclude that changes in per calorie food prices can potentially explain the recent increase in calories consumed away from home, while simple food prices cannot. The main reason why food prices that are not adjusted for changes in calories fail to portray an accurate picture is due to the "quality change" bias. It is true that the prices of restaurant meals have been increasing. The food prices that are not adjusted for changes in calories captures this effect. However, during the same period, the portion size at restaurants have also been increasing. Hence, if we control for the increase in the portion size (calories) we see that the restaurant meals today are relatively cheaper.