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ABSTRACT

Americans have become considerably more obese over the past 25 years. This increase is primarily the result of consuming more calories. The increase in food consumption is itself the result of technological innovations which made it possible for food to be mass prepared far from the point of consumption, and consumed with lower time costs of preparation and cleaning. Price changes are normally beneficial, but may not be if people have self-control problems. This applies to some, but not most, of the population.

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I. Introduction

In the early 1960s, the average American male weighed 168 pounds. Today, he weighs nearly 180 pounds. Over the same time period, the average female weight rose from 142 pounds to 152 pounds. The trends in very high weight are even more striking. In the early 1970s, 14 percent of the population was classified as medically obese. Today, obesity rates are two times higher.

Weights have been rising in the US throughout the 20th century, but the rise in obesity since 1980 is fundamentally different from past changes. For most of the 20th century, weights were below levels recommended for maximum longevity (Fogel, 1994), and the increase in weight represented an increase in health, not a decrease. Today, Americans are fatter than medical science recommends, and weights are still increasing. While many other countries have experienced significant increases in obesity (the UK is a prime example), no other developed country is quite as heavy as the U.S.

What explains this growth in obesity? Why is obesity higher in the U.S. than in any other developed country? As an accounting statement, people gain weight if there is an increase in calories taken in or a decrease in calories expended.[1] As such, we begin by examining whether increased obesity results from decreases in exercise or increases in food consumption. Although we cannot be absolutely certain of the split, the evidence suggests increased caloric intake is far more important than reduced caloric expenditure in explaining recent increases in obesity. Calories expended have not changed significantly since 1980, while calories consumed have risen markedly.

But this just pushes the puzzle back a step: why has there been an increase in calories consumed? We propose a theory based on the division of labor in food preparation. In the 1960s, the bulk of food preparation was done by the family. People cooked their own food and ate it at home. Since then, there has been a revolution in the mass preparation of food that is roughly comparable to the mass production revolution in manufactured goods that happened a century ago. Technological innovations, including vacuum packing, improved preservatives, deep

[1] Recent developments in dietetic science emphasize that in many cases other variables, such as the fat or carbohydrate composition of food, may also influence weight patterns. Given the lack of scientific consensus, we ignore these issues in this paper.

freezing, artificial flavors, and microwaves, have enabled food manufacturers to cook food centrally and ship it to consumers for rapid consumption. In 1965, a married women who didn't work spent over two hours per day cooking and cleaning up from meals. In 1995, the same tasks take less than half the time. The switch from individual to mass preparation lowered the time price of food consumption and led to increased quantity and variety of foods consumed.

Our theory is perhaps best illustrated by the potato. Before World War II, Americans ate massive amounts of potatoes, largely baked, boiled or mashed. They were generally consumed at home. French fries were rare, both at home and in restaurants, because the preparation of French fries requires a significant amount of peeling, cutting and cooking. Without expensive machinery, these activities take a lot of time. In the post-war period, a number of innovations allowed the centralization of French fry production. French fries are now typically peeled, cut and cooked in a few central locations using sophisticated new technologies. They are then frozen at -40 degrees and shipped to the point of consumption, where they are quickly re-heated either in a deep fryer (in a fast food restaurant), in an oven or recently a microwave (at home). Today, the French fry is the dominant form of potato and America's favorite vegetable. This change shows up in consumption data. From 1977 to 1995, total potato consumption increased by about 30 percent, accounted for almost exclusively by increased consumption of potato chips and French fries.

The technical change theory has several implications, which we test and find support for empirically. First, we show that increased caloric intake is largely a result of consuming more meals rather than more calories per meal. This is consistent with lower fixed costs of food preparation. Second, we show that consumption of mass produced food has increased the most in the past two decades. Third, we show that groups in the population that have had the most ability to take advantage of the technological changes have had the biggest increases in weight. Married women spent a large amount of time preparing food in 1970, while single men spent little. Obesity increased much more among married women. Finally, we show that obesity across countries is correlated with access to new food technologies and to processed food. Food and its delivery systems are among the most regulated areas of the economy. Some regulations are explicit (for example, the European Union has taken a strong stance against genetically engineered food, Germany for many years had a Beer Purity Law), and others are cultural (Jose Bove's crusade against McDonalds' in France). Empirically, countries that are more regulatory and that support traditional agriculture and delivery systems have lower rates of obesity.

While the medical profession deplores the increase in obesity, the standard economic view is the opposite. Lower prices for any good – either monetary or time costs – expand the budget set and make people better off. But self-control issues complicate this interpretation. If people have difficulty controlling how much they eat, lowering the time costs of food consumption may exacerbate these problems. Certainly, the $30-$50 billion spent annually on diets testifies to the self-control problems that many people face. In the last part of the paper, we consider the welfare implication of lower food production costs in a model where individuals have self-control problems. Such a model helps explain why the increases in weight have been biggest at the upper end of the weight distribution, where self-control problems are the most severe. For the vast majority of people, however, price reductions lead to welfare increases.

In the next section, we discuss the basic facts about obesity and its rise over time. Section III shows the calculus between calories in and out and weight gain, and argues that caloric intake is the major factor in increased obesity Section IV discusses the technological changes we hypothesize to be important and documents their likely effects. We test the implications of our model empirically in Section V. Section VI takes up the welfare economics of obesity. The last section concludes.

II. Trends in Obesity

We start by reviewing trends in obesity, putting the recent increase in context historically and internationally. It is not always known historically what average heights and weights were. In older times, these data were not kept regularly. Some sporadic historical evidence exists, though, and has been compiled by Dora Costa and Richard Steckel (1997). We supplement their data with information from the National Health and Nutrition Examination Surveys (NHANES) were conducted in 1959-62, 1971-75, 1976-80, 1988-94, and 1999-2001. All but the last survey have been released in micro data form. We present data through 1999 where we can, but conduct most of our detailed analysis using data through 1994.

The NHANES surveys measure height and weight directly, using mobile research vans, so obesity calculations are exact. This is increasingly important as more people are overweight and embarrassed to admit it. We use the NHANES data extensively in our analysis.

The primary measure of obesity is Body Mass Index, or BMI.[2] BMI is measured as weight in kilograms divided by height in meters squared. Optimal BMI levels are generally believed to lie between 20 and 25. BMI below 20 is considered thin, BMI between 25 and 30 is overweight, and BMI above 30 is obese.[3] The medical evidence shows increasingly high rates of disease and death as BMI increases above 25.

Figure 1 shows average BMI over the 20th century for young and prime age males. Early in the century, BMI was either optimal medically, or too low, depending on the country (Fogel, 1994). Between 1894 and 1961, average BMI for men in their 40s increased from 23.6 to 26.0, with a somewhat smaller, but comparable, increase for men in their 30s. The increase for men in their 40s corresponds to roughly 16 pounds for a typical American male (five feet, nine inches tall). Fogel (1994) shows that increases in BMI over the past few centuries were a major source of improved health.

Since 1960, BMI has increased by another .7. While this continues the previous trend, the more recent trend is different in that weight increases in the more recent period are substantially less healthy than in the earlier time period. An average BMI above 25 places a large share of people in the medically overweight category. Figure 2 shows overweight and obesity rates over the past four decades. The share of the population that is either overweight or obese increased from 45 to 61 percent. The share of people that are obese increased from 13 percent to 27 percent, more than doubling. Obesity has increased for both men and women. For both men and women,

[2] BMI is a better measure of obesity than weight alone because it corrects for changes in height.

[3] These distinctions are based on the medical literature which shows increasingly high rates of disease and death for levels of BMI above 25 (see e.g. World Health Organization, 2000; Sturm et al., 2002).

most of this increase is in the 1980s and 1990s (after the 1976-80 survey). We thus restrict much of our subsequent analysis to the 1971-75 and 1988-94 NHANES, spanning the period of the large increase.

Not only is average weight increasing, but the right tail of the distribution is expanding particularly rapidly. Figure 3 shows the BMI distribution in detail. Median BMI increased by .9 between the 1971-75 and 1988-94 surveys. The 75th percentile increased by 1.5 and the 95th percentile increased by 2.7. There has been a global increase in weight, but that has been particularly true at the upper tail of the distribution. In contrast, there has been little change in the left tail of the distribution – people at very low weights. While eating disorders, such as anorexia nervosa, are believed to have increased over the past 30 years (Hsu 1996), the prevalence of this disease is still very low.[4]

Table 1 shows data on obesity for adults. The left columns report average BMI; the right columns report the share of the population that is obese. The average increase in BMI between the 1970s and the 1990s, shown in the first row, is 1.9. There are some differential increases in obesity by demographic group, which we examine later in the paper. In particular, married women and women with exactly 12 years of schooling have had the largest increases in average BMI. These groups traditionally spent a lot of time preparing meals at home, and spend less time now.

Table 1 shows some first evidence that increased obesity is not a result of ore women working. Less than 10 percent of increased obesity is because more men are in families where women work, or because the women themselves are working.[5]

The bottom panels show changes in obesity by education group, separately for men and women. Obesity for women is strongly negatively associated with education. This was true in the early

[4] The Surgeon General estimates an incidence of around 0.1 percent, or that about 300,000 people suffer from anorexia nervosa (U.S. Department of Health and Human Services, 1999). We do not find a significant increase in the population with very low weight even among younger women.

[5] This statement is based on a shift-share analysis that examines the impact of more men having working spouses and more women being workers compared to non-workers.

1970s and continues to be true today. But obesity has increased for all education groups. For men, obesity is relatively independent of education, and has been for the past few decades. These trends belie an obvious income-based explanation for increasing obesity.[6] Higher incomes, at least as reflected in increased education, would actually lower obesity

Table 2 presents this in a regression framework. We regress BMI or obesity on a dummy variable for the 1988-94 survey, and, in the even columns, a number of demographic variables. All told, trends in education, age, race, marital status, employment, occupation, and the employment status of the spouse of the head of the household explain at most 10% of the increase in BMI or obesity over this time period. Explanations of the rise in obesity that are based solely on demographic change are unlikely to be correct.

Figure 4 puts the US in international perspective, showing data on obesity in OECD countries. The U.S. is a clear outlier, but other countries are heavy as well. Obesity levels in several former Warsaw Pact countries are nearly as high as they are in the U.S. Obesity in England is also extremely high. France, Italy and Sweden rank much lower in their obesity levels, and the Japanese are quite thin.

Data on changes in obesity across countries are harder to find. Some countries have scattered information, which is shown in Appendix Table 1. The increase in obesity in the UK is similar to that of the US, although it starts from a lower level. Australia has also seen a rise, although not as large. Canada, a country which one might think would parallel the US, had much more modest increases in obesity for men and a decrease in obesity for women between 1978 and 1988. Obesity has increased since then, however (Katzmarzyk, 2002). A good theory of the changes in obesity should be able to explain why obesity has risen so much in some countries and so little in others.

III. Calories In vs. Calories Out

[6] They also reject theories of obesity based on more frequent participation in the marriage market.

Arithmetically, people get heavier if they consume more calories or expend fewer calories. On average, about 3,500 calories is one pound. Any increase in calorie consumption or reduction in caloric expenditure of that amount increases weight by one pound for a typical person.[7] In this section, we evaluate which of these factors explains changes in obesity.

We start with some basic energy accounting. People burn calories in three ways. The first is through basal metabolism – the energy cost associated with keeping the body alive and at rest. Basal metabolism represents the bulk of energy utilization for most people – about 60 percent. The energy cost of basal metabolism depends on weight. The more a person weighs, the more energy is required to sustain basic bodily functions. The most recent estimates (Schofield, Schofield and James, 1985) express the basic metabolic rate (BMR) as a linear function of weight: $BMR = \alpha + \beta * Weight$.[8] A 70 kilogram (155 pound) man burns on average about 1800 calories before he does any activity. A 60 kilogram woman (132 pounds) burns about 1400 calories.

The second source of energy expenditure is the thermic effect of food. Processing food requires energy. On average, the thermic effect is about 10 percent of the amount of calories consumed.[9] This is relatively low; only about 10 percent of total energy expenditures during a day come from the thermic effect of food.

Finally, calories are burned by physical activity. The caloric needs of a given amount of physical activity is proportional to weight: $Energy = \eta \bullet Weight \bullet Time$, where η varies with the activity done. η_a is typically grouped into categories such as light activity (walking, light housework),

[7] There are differences in metabolisms across human beings, and it is also possible that different caloric expenditures may have different impacts on the amount of weight gained or lost. But, these statements are true on average. We also focus on total caloric intake, and not the composition across macronutrients (protein, carbohydrates, and fats). Substantial recent attention has focused on this division of caloric intake, and its implications for weight gain (Atkins, 2000). According to aggregate production data, consumption of carbohydrates has increased by 28 percent in the past two decades, protein consumption has increased by 18 percent, and fat consumption has increased by only 9 percent. Whether this change in food mix has led to increased weight is a subject for future research.

[8] The appendix discusses the units and presents specific values for α and β.

[9] Of course, this differs by type of food. As with all of our calculations in this section, we present only averages.

moderate activity (fast walking, gardening) and heavy activity (strenuous exercise, farm work). Summing across activities, we denote an exercise index $E = \Sigma_a \eta_a Time_a$, reflecting total physical activity in a period of time.

In steady-state, calories in equal calories out. Denoting K as daily calories consumed, this implies a weight equation of the form:

$$(1)\quad K = \alpha + (\beta + E) * Weight + .1 * K\ ,$$

Using estimates of β and E from the literature (Schofield, Schofield, and James, 1985; Whitney and Cataldo, 1983), equation (1) can be inverted to form the net caloric imbalance associated with a given increase in weight. The 10 to 12 point increase in median weight we observe in the past two decades requires a net caloric imbalance of about 100 to 150 calories per day.[10]

These calorie numbers are strikingly small. One hundred and fifty calories per day is three Oreo cookies or one can of Pepsi. It is about a mile and a half of walking. Given the small size of this change, it is obviously difficult, if not impossible, to determine exactly what explains it. We would have to know about dietary habits and activities in extreme detail to be able to do that. We do not have high quality data that is that detailed. Accordingly, we use a more indirect measures to infer the causes of rising weight. We discuss evidence on changing intake first, and then turn to energy expenditure.

Evidence on Caloric Intake

We begin with the change in calories consumed. There are two sources of data on food intake: food diaries and agricultural sales data. Food diaries are kept by respondents, who detail everything they eat over some time period (usually three days). Detailed food diaries are available for 1977-78 and 1994-96 from the Continuing Surveys of Food Intake by Individuals,

[10] These calculations are subject to a certain amount of error. However even under relatively conservative assumptions about calculation error, the message is clear: very little change in caloric intake is required to explain the observed change in BMI.

conducted by the U.S. Department of Agriculture.[11] In principle, all food consumption is recorded. In practice, however, consumption is surely understated. People do not record everything they eat, and the act of keeping a diary lowers consumption for some people. Evidence on this underreporting is seen in average caloric intake recorded in these surveys. The average male in 1994-96 reports consuming 2347 calories – corresponding to roughly 106 lbs in steady state. The average female reports caloric intake of 1658 calories, consistent with a steady-state weight of 64 lbs. Underreporting is not necessarily a problem for our analysis, if it is constant over time. As surveys have improved, underreporting has likely fallen. This difficulty explains why we look at aggregate production data as well.

Table 3 shows changes in food consumption between the mid-1970s and the mid-1990s for males and females. The top row in each panel reports overall caloric intake. Reported consumption increased by 268 calories for men and 143 calories for women between the two surveys. This increase is more than enough to explain the increase in steady-state weight.

The rows of the table show the distribution of those calories by meal. Somewhat surprisingly, most of the increase in calories is from calories consumed during snacks. Dinnertime calories have actually fallen somewhat. Americans are not just eating more; they are spreading their consumption out over the day. Consistent with this, the increase in caloric intake is because of greater frequency of eating, not eating more at any one sitting.

The finding that increased caloric intake is from more snacks rules out two obvious accounting explanations for increased obesity. The first is that obesity is a result of increased portion sizes in restaurants (Young and Nestle, 2002). If this theory were true, calories at main meals, particularly dinner, would have increased. Similarly, the evidence also rules out the view that fattening meals at fast food restaurants have made America obese.

Table 4 shows more detail on where calories are consumed. Fast food has certainly increased, from about 60 calories per day to over 200 calories per day. But this increase is largely at formal

[11] Consistent with other researchers, we use consumption information from only the first day, although these too are believed to be underreported (Enns, Goldman and Cook 1997).

meals, where it has been offset by reduced home consumption. The increase in snacks, in contrast, is largely concentrated in snacks consumed at home, and to a lesser extent in snacks purchased in stores and restaurants.

Because of the substantial underreporting in the food diaries, we also examine agricultural data on food sales. The Department of Agriculture publishes data on total calories available for consumption. The data are from production sources and are adjusted for exports, imports, and feed stock. In recent years, the data have also been adjusted for wastage, although this is less precise.

Figure 5 shows agricultural production data since 1909. Food supply declined relatively steadily between 1909 and 1950. There were significant downturns during World War I and the Great Depression, and moderate declines in other periods. This decline is almost certainly related to reduced need for food, as people moved off of farms and into cities. The decline in food consumption explains why obesity increased only mildly during this earlier time period, despite a large reduction in energy expenditures.

Since 1965, however, food supply has increased markedly, particularly in the last two decades. In 1978, food supply was 3200 calories per person. By 1999, food supply was 3900 calories per person, 700 calories higher. Adjusted for wastage, the increase is 418 calories. This is three to four times the increase that is needed to explain the increase in average obesity over the time period.

Evidence on Energy Expenditure

We examine two components of energy expenditure: voluntary exercise, and involuntary energy expenditure associated with employment. Data on voluntary exercise come from time diary studies. Like food consumption data, time diaries are in principle an ideal way to learn about daily activities. In practice, however, time diaries have several problems. As with food diaries, the very act of keeping the diaries induces some people to alter their behavior. Moreover, some of the data is retrospective and there are natural memory problems. People may lie as well. Still, it is not clear that these problems bias trends in time allocation, which is our concern.

Table 5 displays information on time usage in 1965, 1975, 1985 and 1995. The data from the first three time periods is taken from Robinson and Godbey (1997); the data from 1995 is from our calculations. Timeu se has been remarkably stable they are. The biggest change occurred between 1965 and 1975 when television watching increased by 40 minutes. Some of the increase in TV time appears to have come out of other forms of socializing (see Putnam, 2000, for more discussion) and a decline in meal cleanup activities. Using our energy expenditure equation above, we calculate that a 40 minute change from light household activity to sedentary activity would lead to a four-pound increase in steady-state weight for the average male (see the Appendix).

Since 1975 television viewing has increased by 22 minutes, half of the increase in the previous decade. Furthermore, this has been offset by a decline in other passive categories such as sleeping and an increase in more active categories such as sports or walking have increased. At the bottom of table 5, we calculate values of E – the energy expenditure index – for the different time periods. The estimated value of E fell between 1965 and 1975, but has been quite stable since then. We cannot explain changes in obesity in the past two decades on that basis.

The second component of energy expenditure is energy spent on the job and commuting to work. Philipson and Posner (1999) stress this hypothesis in explaining the increase in obesity over time. This view is certainly true over the longer run. Between 1910 and 1970, the share of people employed in jobs that are highly active (farm workers, laborers, etc.) fell from 68 to 49 percent. Since then, the change has been more modest. Between 1980 and 1990, the share of the population in highly active occupations declined by a mere 3 percent, from 45 to 42 percent. As Table 2 showed, occupation changes are not a major cause of the recent increase in obesity.

Changes in transportation to work are another possible source of reduced energy expenditure – driving a car instead of walking or using public transportation. Over the longer time period, cars have replaced walking and public transportation as means of commuting. But this change had largely run its course by 1980. In 1980, 84 percent of people drove to work, 6 percent walked and 6 percent used public transportation. In 2000, 87 percent drove to work, 3 percent walked, and 5 percent used public transportation. Changes of this minor magnitude are much too small to explain the trend in obesity.[12]

A final piece of evidence on the importance of energy expenditure comes from examining population subgroups. Children and the elderly do not work now, and they did not work in 1980. However, Figure 5 shows large increases in obesity among children and adolescents.[13] Further, the elderly may be more active now than in 1980, yet they are also more obese now than in 1980. One needs a richer story than just changes in energy expenditure to explain why people are heavier.

In sum, our results suggest that increased caloric intake explains the rise in obesity, not reduced caloric expenditure. While we cannot be certain that this explanation is right, or that it is the entire explanation for the rise in obesity, that explanation is the most plausible. Accepting this conclusion, we turn next to theories of why caloric consumption has increased so greatly.

IV. Technology, The Division of Labor, and Obesity

There are several possible theories that could potentially explain the increase in caloric intake over the past 25 years. Price and income changes are one explanation. As people get richer, they will demand more food. Relative price declines for food would also explain increased consumption. Changes in the monetary costs of food have not been great, however. From 1970 to 1999, the consumer price index for food items increased only 3 percent slower than the CPI for non-food items. Similarly, income changes cannot explain our results. Income and obesity are negatively associated today, at least for women. Furthermore, for much of the period real

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[12] For a 70 kilogram man with a typical commute time of around 22 minutes, this change would lead to an increase of less than .4 pounds in steady state.

[13] Anderson, Butcher and Levine (2002) offer evidence that children of working mothers are more likely to be overweight than children of nonworking mothers, although this effect explains only a small portion of the total increase in child overweight in the last thirty years.

incomes were not increasing greatly at the bottom of the income distribution, but obesity for those groups still increased.

We also reject a theory of obesity based on increased numbers of women at work, and thus more demand for eating out. This theory has drawn much support, and the unhealthiness of fast food has drawn wide critique. We showed above, however, that increased female Furthermore, it is not clear that eating out by itself should increase caloric intake. Restaurants can cook low calorie food just as easily as high calorie food. Indeed, substitution of dinners from home-cooked to eaten out seems not to have increased caloric intake at dinner.

The income and labor force participation theories are not right in their simple framework, but we believe there is some truth in them. We propose a new theory of increased obesity that has as its premise reductions in the time cost of food. This has allowed more frequent food consumption of greater variety, and thus higher weights.[14]

The Rise of Mass Preparation

Traditionally, consumers took raw agricultural products and transformed them into edible food. This preparation involved significant amounts of time. As late as the 1960s, 57 percent of the total costs of food were preparation and cleanup time.[15] The primary cost of food may well have been the time spent in the household preparing that food. Over the past 30 years, the range of foods available has barely changed at all, but the time involved in preparing food has fallen substantially.

People could always make almost any form of food that is currently available, if they were willing to spend the time to do so. Cream-filled cakes could be made by ambitious cooks, for example, but it took time. Technological innovations since 1970 mean that preparation can now

[14] As a sidelight, it may also explain why more women have chosen to go to work (Greenwood, Seshandri and Yorukoglu, 2001), although we do not explore this path.

[15] In 1960, the average family spent $15 per day on purchased food (in 1990 dollars). The time involved in preparation was 130 minutes. At the average wage of women, this is perhaps $20, or 57 percent of total costs.

be done in restaurants and factories, exploiting technology and returns to scale. Cream cakes are now available widely for less than a dollar. This time savings is a key aspect of our theory.

In order to produce food in one location that will be nearly ready for consumption in another location, one must surmount five main technological obstacles (Kelsey, 1989): controlling the atmosphere; preventing spoilage due to microorganisms; preserving flavor; preserving moisture; and controlling temperature. Innovations in food processing and packaging over the last three decades have improved food manufacturers' ability to address each of these issues.

Controlled atmosphere processing (CAP) and, more recently, modified atmosphere processing (MAP), allow food manufacturers to control the gaseous environment in which their foods are stored. In the case of fruits, vegetables, and other foods with living cells, these technologies allow the control of the food's respiration, to slow down ripening and prevent spoilage. For recently introduced packaged goods such as fresh pasta, prepared salads, and cooked chicken, control of the atmosphere inside the package can greatly lengthen shelf life (Testin, 1995). Hydrogen-peroxide sterilization (approved for use in 1981) and stretch-wrap films (introduced in 1976) have improved food producers' ability to kill and seal out harmful microorganisms. Since the 1970s, there have also been significant advances in food irradiation technology, although the diffusion of this technology has been slowed by the FDA.

A persistent problem in food processing and packaging is that the packaging and packaging process can adversely affect food flavor. This is especially troublesome for food products that attempt to replicate a homemade or "like mom used to make" flavor. The 1980s saw huge advances in "flavor barrier" technology, which involves the use of barrier materials specially tailored to the food in question. These barriers prevent migration of flavor-related chemicals to and from the food. Complementary to advances in flavor barriers, the food industry has increasingly made use of chemists as flavor specialists to design food flavors to suit consumers' tastes (Schlosser, 2002). These chemists hone in on exactly what makes certain foods desirable and synthesize it in the laboratory. These artificial flavors can then be added to make pre-prepared food more appealing.

Temperature and moisture pose a particular problem in the case of frozen foods. If moisture is allowed to build up in the package, ice crystals can form, which separate ingredients and alter the food's texture (Kelsey, 1989). In addition, moisture can sublimate in the freezer, leading to dehydration of the food and resulting "freezer-burn." Advances in materials technology such as polyethylene plastics have improved control over the internal moisture of food packages and limited many of these problems, thus extending the freezer/shelf life of many foods and improving end-use flavor.

Other technologies are available at the user end. Microwave ovens allow for rapid heating of frozen and pre-prepared foods. Microwaves were developed in the 1940s as an outgrowth of radar technology, and became available for a reasonable consumer in the 1970s.[16] As late as 1978, only 8 percent of American households had microwaves. By 1999, 83 percent of American households had microwave ovens. Other kitchen appliances, such as refrigerators, have also improved.

These technologies did not impact all foods or all places equally. For example, controlled atmosphere processing was available for use in the bulk storage of produce decades before modified atmosphere processing, a related technology, was applied to retail foods in the late 1980s. Generally, foods that are consumed in more-or-less the same form that they leave the farm (e.g. fruit) stand to gain less from advances in packaging and processing. Foods that involve significant amounts of preparation have been able to benefit most from the new technologies.

American technological leadership and the large size of the American market meant that many of the most important innovations were first developed in the U.S. Other countries have often limited the incursions of American food products or food retailers (such as fast food outlets). Moreover, as food is one of the most regulated areas of the economy, highly regulated economies have generally put substantial roadblocks to the incorporation of new food

[16] As early the 1950s, prototypes for home use were available, but these were extremely expensive and as large as dishwashers.

technologies. The examples of genetically altered food and Germany's Beer Purity Law were noted above.[17]

Perhaps the most telling evidence for the revolution in time costs of food production has been the reduction in the time spent cooking and cleaning. Table 6 shows food preparation times for different subgroups of the population in 1965 and 1995. The food preparation and clean-up times for both working and non-working women fell by about 50 percent. These changes hold work status constant. They reflect technology, not labor force participation.

The trend towards increased levels of commercial preparation also appears in data on the distribution of food payments. In 1972, 44 percent of the cost of food went to farmers. By 1997, only 23 percent of the cost of food represented the input of farmers. The rest is input from the retail sector. This is not just a statement about the restaurant sector. Eighty percent of the cost of food eaten at home is now spent non-farm related expenses. Labor in the supermarket and the factory has replaced labor in the home, and this has been associated with dramatic time savings within the home.

Implications of Technological Change

Food preparation involves both fixed and variable costs. The peeling and cutting of French fries is a marginal time cost, while deep frying is generally a fixed cost (up to the point where the fryer is full). Mass preparation means that the fixed time component can be shared over a wide range of consumers. This is the first benefit from improvements in technology. In addition, mass preparation reduces the marginal cost of preparing food, by substituting capital for labor. Finally, mass preparation exploits the division of labor. Food professionals now prepare food instead of everyday people, reducing both fixed and marginal costs.

Reductions in the time cost of food preparation should lead to an increase in the amount of food consumed. This increase can occur through several channels: (1) increased variety of foods consumed, (2) increased frequency of food consumption, (3) a switch to high calorie/high flavor

[17] The Beer Purity Law was eventually struck down by the EU as a trade barrier.

prepared foods which had previously been unavailable, or (4) an increase in the overall consumption of each individual food item. As fixed costs decline, we would expect most of the increase in calories to come from increased variety of foods and frequency of food consumption, rather than more food during each meal. Indeed, reductions in time costs have an ambiguous effect on calories per food item. If the quantity of meals and food at each meal are substitutes (for example, as people become sated), the calories at any given meal will decline.[18]

There are four empirical implications of the mass preparation theory. First, the lower costs of food preparation mean that individuals should consume a wider range of products at more times during the day. Second, the increase in food consumption should come mostly in foods that had an improvement in mass preparation technology (and complements to those foods). We will test this implication by looking at changes in food consumption across food groups. Third, individuals who have taken the most advantage of the new technologies should have had the biggest increase in obesity. We test this empirically by correlating the time spent by different demographic groups in food preparation in the 1960s and the change in time spent in food preparation with the increase in BMI. Finally, we examine whether obesity rates are higher in countries with greater access to technological changes in food consumption.

V. Testing the Implications of the Theory

Implication 1: Changes in Food Type, Composition, and Timing

The first implication of the theory concerns the change in the nature and composition of food consumption. The theory predicts that people will consume a greater variety of foods now than in the past, and at more times during the day. We already noted the evidence for this above (table 3). Snacks are where a significant portion of the changes in food production have occurred. Snacks are also largely pre-prepared.

[18] These predictions follow from a standard quantity-quality model of food consumption. See Becker and Lewis (1973) for the structure.

Implication 2: Calories From Different Food Products

A second prediction of our model is that consumption should have increased most for food items that have experienced the most technological change. The best measure of the degree of mass preparation is the USDA's measure of the share of costs going to farmers instead of other food preparers (the farm value share). Food items with a great deal of mass preparation have low farm values. The USDA has calculated this for some, but not all, food categories. The farm value share varies greatly, from over 60 percent for eggs to near 10 percent for grains.

Figure 7 shows the relationship between farm value share and caloric growth across thirteen food categories. Consistent with the model, there is a statistically significant negative relationship between the two: food items with large amounts of commercial preparation have increased in consumption, and food items with less commercial preparation have fallen. The correlation is -.68, which is relatively large.

Because the farm value share is not calculated for all products, we also test this theory in a second way – by looking at consumption of food categories that are more and less branded. Branded foods are more pre-processed than unbranded foods (potato chips vs. raw potatoes, for example), so the prediction is that consumption of branded food groups should rise relative to consumption of unbranded food groups. Figure 8 shows this to be the case. The correlation between the degree of branding and the rise in calories is .51 across food categories, which is significant at the 5 percent level.

Implication 3: Changes in Obesity Across Demographic Groups

Our third prediction is across groups: obesity should increase the most among groups for whom the costs of production fell the most. One natural demarcation of these groups is by the percentage of food consumption that was formerly produced at home. Groups that have traditionally cooked at home were more limited in the type of foods they could consume because of the fixed costs of production. Groups that ate out more, in contrast, were not as constrained. Thus, the theory predicts that obesity should increase the most among groups who formerly made most of their food in the house, and should have increased the least among groups that ate out more.

To test this prediction, we relate changes in obesity across demographic groups to the amount of time spent preparing food in 1965, and to changes in the amount of time spent preparing food between 1965 and 1995. We divide the adult population into the 8 demographic groups shown in Table 6. An important issue is whether the time costs should be for the person or the family. Under the assumption of joint household decision-making, it is the total time usage that matters, not the individual time spent. In other models, the time that each person spends in food preparation would matter. For example, if men eat at work in ways their wives cannot control, we would not expect reduced time costs for wives to have much effect on weight of married men.

Figures 9 and 10 show the relationship between the initial time spent preparing food and the change in BMI. Figure 9 shows the relationship where time spent in food preparation is person-specific. In figure 10, the time is for the family as a whole. There is a positive relationship between time costs and obesity changes in Figure 9, but less so in Figure 10. Basically, women spend less time preparing food now than they used to, and they are much more obese than they used to be. The difference between the two may be related to the fact that variety has increased the most for women (men already ate out more), or to lack of joint decision-making. The data in figure 9 indicate that each ½ hour of initial food preparation time is associated with an increase in BMI of nearly .5. This does not explain all of the increase in obesity – the constant is statistically significantly positive – but it explains a good share.

Figure 11 shows the correlation between the change in BMI and the change in the time spent preparing food, using person-specific time costs. The results are similar: groups that saw a large reduction in the time spent preparing food also had large increases in BMI.

Implication 4: Obesity Across Countries

The final implication of the theory is that obesity should increase more in countries where technological innovations are more encouraged. All of the technologies we describe can in principle be used in any country. But the extent to which they are used varies across countries, driven in part by differential public policies. Many countries have explicit or implicit restrictions on the ability of food producers or consumers to have access to such technologies. We examine whether such restrictions are related to obesity.

For data reasons, our sample is OECD countries.[19] Table 7 shows the results. In all of our regressions, we control for female labor force participation rates and GDP per capita, to test these theories of obesity. The first column includes just female labor force participation rates and income. Neither is significantly related to obesity (nor are they related when other variables are included). Ideally, we would have data directly on food industry regulation. Such data are not always available, however. We use a number of proxies. The second column includes the frequency of price controls in the economy as a whole. This variable is an average of the 1989 and 1994 *Economic Freedom of the World* index of price controls (Gwartney, Lawson, and Block 1995). The index ranges from 0 to 10. We have normalized it to have a mean of 0 and a standard deviation of 1. People in countries with more price controls are much less obese than people in countries without price controls. A one standard deviation increase in price controls is associated with about 3.7 percentage points less obesity. As figure 12 shows, this effect is not driven by any individual country.

The third column looks at the relation between producer protection – measured as the ratio of agricultural prices in the country to and worldwide prices – and obesity. The measure captures tariff and non-tariff barriers to agriculture, but is only available for 9 countries. Figure 13 shows a strong relation between relative food prices (normalized in the same way) and obesity not driven by any one country. A one standard deviation increase in domestic prices above world prices reduces obesity by a statistically significant 4.5 percentage points (the third column of the

[19] Appendix Table 3 shows the countries included in each regression.

table).[20] The fourth column includes a simple count of the number of food laws listed in nine countries, taken from Kellan and Guanino (2000).[21] The mean country for which data are available has 26 food laws. The few observations still suggest a pattern. Countries with more food laws have lower levels of obesity.

Recent research has highlighted the link between regulation and the structure of the legal system (La Porta, Lopez-de-Silanes, Shleifer, and Vishny, 1999). Countries with a common law legal origin (the British model) are much less regulated than are countries with a civil law origin (the French model). The fifth column includes a measure of civil law legal origin to capture the overall prevalence of regulation. More regulated countries are 7 percent less obese than are less regulated countries.

One way that regulation works is to stop new technology. To measure the ease of technology importation, the sixth column relates obesity to the Djankov et al. (2002) measure of the time required in days to open a new business (in days). Countries with greater time delays to opening new businesses are less obese than countries with shorter times.

The last column relates obesity to the price of a Big Mac, taken from the *Economist*. Although not necessarily exogenous (Big Mac prices will depend on demand as well as supply[22]), Big Mac prices are an approximate measure of relative food costs in different countries. Countries in which Big Macs cost more are less obese than countries in which they cost less.

While our international results are not definitive, they are strongly consistent with the theory. People in more regulated countries, and particularly countries with a more regulated agricultural

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[20] One concern is that this relationship is driven by pure price effects – higher prices would lead to lower consumption – but the strong correlation between our measure of protectionism and our other measures of regulation suggests that price effects are not the whole story.

[21] These laws include factors such as packaging and labeling requirements, preservative tolerances, and pesticide regulations.

[22] In defense of this measure, we note that if variation in Big Mac prices were due to demand differences across countries, we would expect to see lower prices associated with lower obesity.

sector, are less obese. Female labor force participation rates and real income are unrelated to obesity.

VI. Obesity and Self-Control

Lower time costs of food preparation may affect consumption through two channels. The first is a standard price mechanism. The cost of food consumption includes time and money costs. As time costs fall, one would expect a standard demand response to price (assuming demand is downward sloping).

This effect could be large enough to explain the increase in consumption we observe. Reductions in the time required to prepare food reduced the per calorie cost of food by 29 percent from 1965 to 1995.[23] If the elasticity of caloric intake with respect to price is -.7, this could explain the increase in caloric intake. An elasticity of -.7 is possible, but probably on the high side. Typical food price elasticities are on the order of -.6 (Blundell, Browning, and Meghir, 1994). The elasticity of caloric intake with respect to price is likely smaller than this, however, since the food spending elasticity includes increased quality of food in addition to quantity. We do not know how much smaller, however.

We suspect, however, that this is not the only reason why lower time costs lead to increased consumption. Rather, self-control issues are likely to be important as well. The standard model of consumption involves rational individuals – people decide how much to consume on the basis of price and income, fully accounting for the future health consequences of their actions. But at least some food consumption is almost certainly not rational. People continue to overeat, despite substantial evidence that they want to be thinner and try to lose weight (there is a $30 to $50 billion annual diet industry). Food is addictive and brings immediate gratification, while health costs of overconsumption occur only in the future. Maintaining a diet is also very difficult. People on diets frequently yo-yo; their weight rises and falls as they start and stop dieting.

[23] In the early 1960s, time costs accounted for 57 percent of food costs. Preparation and cleanup time fell by about 50 percent since then, from 130 minutes to 62 minutes per day. At the same time, caloric intake increased. On a per calorie basis, this represents a 29 percent reduction in cost.

Survey evidence confirms this difficulty. Figure 14 shows the relation between current weight and the person's self-described optimal weight. In general, desired weight rises only slightly with actual weight, particularly for obese individuals. One might argue that these desired weights only reflect desired weights if moving to that weight were costless, when in fact it is not. But the caloric reduction required to lose weight is so low that we suspect many obese people would be willing to make that sort of tradeoff, if they could do it.

As a result, people with self-control problems may find themselves overconsuming food, particularly when the time costs of food preparation fall. In this situation, lower time costs of food preparation may be a welfare loss.[24] In this section, we present a framework for self-control problems and evaluate the welfare implications of technical change in such a situation.

A Model of Self-Control Problems

Consider an individual who discounts all times in the future at a rater higher than the pure time discount rate, but trades off consumption in future states at the time discount rate. Such an individual will always want to begin a diet tomorrow (because the long-term benefits justify the lost utility tomorrow) but not today (because the immediate gratification from food is high). Reductions in the time cost of food preparation may significantly reduce the welfare of this person, by increasing the immediate consumption value of food relative to the long-term health costs.

The logic of this argument can be illustrated by thinking about a hungry worker and a vending machine filled with cookies. If the vending machine is 10 feet away, a person might each mid-afternoon cookies, even if he is on a diet (the diet can always start tomorrow). The same person, however, might not be willing to walk 10 minutes to and from the store to get cookies, or to spend a half-hour baking cookies (if at home). The benefits 10 minutes or one-half hour down the road are too far away to justify it. It is a common feature of many behavioral change

[24] Increased food consumption might be a welfare loss for another reason as well – the external costs of individual weight for medical and disability programs. As with smoking, however, we suspect that such external costs are relatively small (Gruber, 2001).

programs – smoking and drinking cessation, weight loss – that they encourage keeping the offending items as far away as possible. Raising time costs is believed to reduce consumption.

We model this formally using the hyperbolic discounting framework of Laibson (1997) and Harris and Laibson (2001). At each point in time, people receive utility from consumption of a durable composite commodity (C) and food (represented by caloric intake, K) and lose utility from being overweight. To eliminate income effects, we assume utility is linear in composite consumption. The instantaneous utility function is therefore

(2) $$Utility_t = C_t + U(K_t) - h \bullet Weight_t,$$

The cost of food is P, including both time and money costs. Thus, $C_t = Y - PK_t$, where Y is income.

A rational consumer will consume food until the marginal consumption benefit is equal to the marginal cost. The consumption benefit at the time of consumption is $U'(K_t)$. We assume that food decisions made today are only implemented τ units of time in the future; it takes that long to prepare or shop for the food. Thus, the benefits of consumption are discounted by that interval. Following Harris and Laibson, we assume that people discount the future in two ways. The first is standard exponential utility: for a period of time "t" periods in the future, people get $e^{-\rho t}$ units of utility. In addition, people also make a distinction between the "current self" and the "future self." This distinction is the essence of the hyperbolic model.[25] People discount the future self's utility with parameter $0 \leq \gamma \leq 1$. If γ=1, the future is considered the same as today; if γ=0, the future is ignored. With hazard rate λ, people switch from being "current" selves to being "future" selves.

[25] Changes in the time cost of food preparation will affect people with self-control problems in two ways. First, since time costs must be aid before one gets to eat, these costs will be particularly salient for people who are very present oriented. Second, time costs delay consumption, which mean that food consumption is more likely to be enjoyed by the future, rather than current, self.

Individuals have perfect knowledge about all of the parameters of the system (they are sophisticated hyperbolic agents), but they don't know when they will switch to being a "future self." Thus, the value of future consumption is probabilistic. With probability $e^{-\lambda t}$, the future utility remains connected to the current self and with probability 1- $e^{-\lambda t}$, the future utility is associated with the future self and is worth only γ as much. Putting this together, the marginal utility from food consumed τ units of time in the future equals $\left(e^{-\rho\tau}(e^{-\lambda\tau}+(1-e^{-\lambda\tau})\gamma\right)U'(K)$. For a typical food consumption decision, the standard discounting effect is small (time costs are on the order of 10 minutes to a few hours). Thus, $\rho\tau$ is approximately 0, and the utility of food consumed τ units of time in the future is just the hyperbolic term.

Food consumption carries two costs – the dollar value of foregone consumption (the *C* not consumed), and the health and social costs of increased weight. Consider the foregone consumption first. If the composite commodity is durable, consumption is given by the differential equation $\dot{C}_t = -\delta C_t + I_t$, where $I_t = Y - PK_t$ is spending at time t. With both standard and hyperbolic discounting**,** spending one unit of income on the durable composite commodity generates welfare benefits of:

$$\text{(3)}\quad \textit{Utility from Durable} = \int_{t>0} e^{-(\rho+\delta)t}\left(e^{-\lambda t}+(1-e^{-\lambda t})\gamma\right)dt = \left(\frac{1-\gamma}{\lambda+\rho+\delta}+\frac{\gamma}{\rho+\delta}\right)$$

The hyperbolic discounting literature (Frederick, Lowenstein, and O'Donoghue, 2002) suggests that people switch from current selves to future selves over the course of a day, and quite possibly over a matter of hours, which implies a very high value of λ (i.e. 1,000 or more). As such, the marginal value of an extra unit of the future commodity is well approximated by $\frac{\gamma}{\rho+\delta}$. The value of foregone consumption from consuming one more unit of food is *P* times this amount.

The health and social consequences of being heavier are the second cost of food consumption. We assume these costs are linear with slope *h*. Following the discussion of Section II, weight evolves according to the differential equation $\dot{W}_t = -\tilde{\alpha} - \mu W_t + wK_t$. Integrating this equation and using the same approximations as above, the health costs of current consumption approximately equal $\frac{wh\gamma}{\rho+\mu}$.

In equilibrium, therefore, the consumer will choose K so that:

$$(4) \qquad \frac{P\gamma}{\rho+\delta} + \frac{wh\gamma}{\rho+\mu} = \left(e^{-\lambda\tau} + \gamma(1-e^{-\lambda\tau})\right)U'(K).$$

The benefit from food consumption, which will be enjoyed by the current self, or, with lower value, the future self, is on the right hand side of the equation. This is weighed against the costs from lost income (the first term on the left-hand side), and lower health (the second term on the left-hand side). These other costs are born almost entirely by future selves.

One can show several points about this optimization. First, as long as hyperbolic concerns are real (λ is large), the level of food consumed will decrease with increases in γ and reductions in λ. Increases in γ make consumers more forward looking and so lead to less present-oriented consumption. Increases in λ, on the other hand, make the value of consumption more likely to benefit a future self, and thus lead to lower consumption.

Second, a reduction in the price of food will lead to increased food consumption and higher steady-state weights. Technological innovation that allows mass preparation of food will impact consumption through two variables: the price P, and the delay before consumption τ.[26] Importantly, the weight gain from a reduction in time delay will be particularly important for

[26] Differentiating equation (4) shows that

$$d\ln(K) = \left(\frac{1}{\sigma}\right)\left\{\left(\frac{P\gamma/\delta}{P\gamma/\delta + wh\gamma/\mu}\right)d\ln(P) - d\ln(e^{-\lambda\tau} + (1-e^{-\lambda\tau})\gamma)\right\}$$, where $\sigma = KU''/U'$, the elasticity of substitution of utility. The first term is the price effect, weighted by the price component of the cost of food consumption; the second term is the time effect.

more hyperbolic people -- more hyperbolic people will gain more weight than less hyperbolic people from a reduction in time cost.[27] This result is intuitive – people with self-control problems respond more to the ready availability of food than people without such problems.

This result helps explains one of the most striking facts about the recent rise in obesity -- the dramatic increase at the upper tail of the weight distribution. People with self-control problems (lower levels of γ) are more likely to have high initial weight levels and are more likely to gain more weight with further improvements in food technology. This result also helps explain why reductions in the time cost of food might have a much larger impact on the level of obesity than reductions in the monetary cost of food. Because reduced time costs affect both the price of the food and the delay before consumption, hyperbolic consumers will be very sensitive to changes in time delay, even if they are not very price sensitive.

Welfare Implications of Lower Time Costs

To simplify the welfare analysis, we abstract from non-hyperbolic discounting, i.e. we assume that $\rho = 0$. This implies that in the absence of self-control problems, the individual's choice of calories will maximize steady state consumption. We will focus on steady-state utility, which equals:

(5) $$\textit{State-state Utility} = (Y - PK^*)/\delta - hwK^*/\mu + U(K^*).$$

The impact on welfare of a change in a parameter that impacts both K* and P equals

(6) $$\Delta Utility = -\Delta P \bullet \frac{K^*}{\delta} + \Delta K \bullet \left(-\frac{1}{\delta} P - \frac{hw}{\mu} + U'(K^*) \right).$$

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[27] From footnote (2), τ affects consumption in two ways. The first is by changing the price of food. This effect is independent of γ (γ cancels from the ratio multiplying the change in price). The second effect is through the time cost. Differentiating the second term in footnote (2) shows that $d\ln(K) = \left(\frac{1}{\sigma}\right)\left(\frac{\lambda e^{-\lambda\tau}(1-\gamma)}{e^{-\lambda\tau} + (1-e^{-\lambda\tau})\gamma}\right) d\tau$. If γ=1, this term is zero.

$$= -\Delta P \bullet \frac{K^*}{\delta} - \Delta K \bullet \left(\frac{1-\gamma}{1-\gamma+\gamma e^{\lambda\tau}}\right) \bullet \left(\frac{P\gamma}{\delta}\right) - \Delta K \bullet \left(\frac{1-\gamma}{1-\gamma+\gamma e^{\lambda\tau}}\right) \bullet \left(\frac{wh\gamma}{\mu}\right)$$

where the latter equation comes from substituting the first order condition in (4). The first term is the direct impact on price. Because prices are falling (the time component, if not the money component), this term is positive. The second term is the reduction in other goods consumption resulting from the fact that people spend more on food, weighted by the extent to which preferences are not rational. We suspect that this term is small; the chief harm from people overconsuming food is not the fact that they are immiserized, but the health costs of increased weight. The third term is the health cost. It is the product of the weight gained and the health costs of additional weight,[28] again weighted by the non-rational degree of discounting. If preferences were rational ($\gamma = 1$), the second and third terms would disappear; individuals are maximizing long run utility and the increase in calories cannot cause a utility loss. With hyperbolic preferences, however, individuals overconsume food, and a further increase in calories adversely affects welfare.

In particular, equation (6) implies that a necessary condition for welfare will fall with a reduction in time costs is:[29]

(7’) $\frac{1-\gamma}{1-\gamma+\gamma e^{\lambda\tau}} * \text{Change in Weight} * \text{Cost of Weight} > \text{Change in Costs of Food}$,

People are worse off if the weight consequences of excessive obesity are greater than the value of less time spent preparing food. To compare these terms, we need to express everything in the same units. It is easiest to evaluate them in units of time. We do not know the monetary willingness to pay for lower weight, but we can use exercise technology to figure out a rough estimate of the time cost. In terms of time costs, people are worse off if:

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[28] $w\Delta K$ is the change in weight, and $\frac{h\gamma}{\mu}$ is the utility cost of increased weight.

[29] This ignores the second term in equation (6), the lost utility from having less income to spend on other goods.

(7'') $\frac{1-\gamma}{1-\gamma+\gamma e^{\lambda\tau}}$ *Time Costs of Losing the Weight Gained > Reduction in Time Costs of Food

On average in the U.S., there has been a reduction in time costs of food preparation of about 20 minutes.[30] The 10 lb weight gain that corresponds to this time reduction represents about 100 calories per day, or about 1 mile of daily exercise. If it takes 15 minutes to walk or jog a mile, the time cost of the 10 lbs gained is about 15 minutes per day. [31] This is less than the 20 minutes of time savings that resulted in the weight increase.

It is clear that the typical person cannot be made worse off by the reduction in time costs. To put it simply, people have an additional 20 minutes per day in free time. They could spend 15 of those minutes exercising, lose the weight gained, and still have 5 minutes left over.

The only way people might be made worse off is if they are particularly impatient and as a result would be willing to forgo more than 15 minutes per day to lose 10 pounds in steady state, but cannot seem to do so. For example a person who always vows to exercise but never starts can be viewed conceptually as someone willing to pay more than 15 minutes per day to lose 10 lbs. Consider a person who is willing to spend 30 minutes per day to lose ten pounds. In that case, they will have lost utility if $\frac{1-\gamma}{1-\gamma+\gamma e^{\lambda\tau}}$ is less than two-thirds. Assuming a value of $e^{\lambda\tau}$ of 2 (there is a fifty percent chance of changing into a future self by the time the food is prepared), then they will have lost utility if $\gamma<.2$. Extremely hyperbolic individuals can be hurt by the change in technology, but people without extreme self-control problems will be better off. While there is no evidence on the distribution of γ in the population, we suspect that most – but certainly not all -- people are better off by the technological advance.

[30] This 20 minute saving does not include the larger time savings in cleaning up which is also, in part, due to changes in food technology.

[31] This is the time cost for people who exercise. Standard economic logic suggests that the people who don't exercise probably value losing weight by less than 15 minutes a day. Of course, hyperbolic concerns can complicate this picture. We consider higher values of the willingness to forgo time for weight in some cases, to reflect this.

VII. Conclusion

Over the past 25 years, there has been a startling increase in the rate of obesity in the United States. Weights have increased for all demographic groups, and have done so particularly at the upper end of the weight distribution. In this paper, we argue that this increase is primarily a result of increased food consumption, rather than reduced exercise. Since 1975, Americans have been eating a lot more.

The increase in food consumption itself appears to be related to a host of technological innovations in food production and transportation. Technology has made it increasingly possible for firms to mass prepare food and ship it to consumers for ready consumption, thereby taking advantages of scale economies in food preparation. This situation is similar to the one that occurred a century ago, when manufacturers used mass production to bring about the widespread distribution of manufactured goods. The result of this change has been a significant reduction in the time costs of food. These lower time costs have led to increased food consumption, and ultimately increased weights.

Several facts are consistent with this theory. First, food variety has increased significantly in recent decades, and people eat many more times during the day. Both of these are implications of declining prices for mass produced goods. Indeed, the increase in food consumption has occurred largely in prepared foods. Foods that involve significant home production have not had major increases in caloric consumption. Looking across demographic groups, people who were most constrained in their food choices a few decades ago had the largest increases in obesity. Finally, countries with significant regulation, especially of the food industry, have had less of an increase in obesity.

The usual economic logic suggests that this time cost savings and the corresponding increase in consumption represent pure economic benefit. However, the presence of self-control problems make it possible that the changes have been welfare reducing. Eliminating the time cost of food preparation disproportionately increases consumption for hyperbolic discounters, because time delay is a particularly important mechanism for discouraging those individuals from consuming.

Our model shows that some people were likely hurt by the improved technology, although most have surely benefited. Thus, while the rise in obesity has significant health costs, those costs are likely offset by the dramatic savings in time of food preparation.

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Table 1: Increase in Weight by Population Group

	Average BMI (kg/m^2)			Percent Obese (BMI≥30)		
	1971-75	1988-94	Change	1971-75	1988-94	Change
Average	25.4	27.3	1.9	16%	30%	13%
Adults						
All	25.0	27.1	2.1	15	28	14
Single male	24.4	25.5	1.1	9	18	8
Married male, non-working spouse	25.6	27.1	1.5	13	26	13
Married male, working spouse	25.7	27.3	1.6	11	24	13
Single female	24.9	27.4	2.5	18	32	14
Married female, working	24.3	27.4	3.1	13	33	21
Married female, not working	24.9	28.0	3.1	16	36	19
Elderly						
All	26.1	27.6	1.5	19	32	12
Male	25.4	27.0	1.6	13	28	15
Female	26.7	28.2	1.5	25	36	12
Women Aged 20+, By Education Group						
<High School	26.3	28.4	2.1	24	38	14
High School	24.2	27.5	3.3	13	33	19
College or More	22.8	25.4	2.6	7	20	13
Men Aged 20+, By Education Group						
<High School	25.6	26.5	0.9	15	23	8
High School	25.7	26.7	1.0	13	24	11
College or More	25.2	26.4	1.2	8	21	13

Note: Data are from the National Health and Nutrition Examination Survey (NHANES). BMI is measured in kg/m^2.

Table 2: Correlates of BMI and Obesity

	BMI (kg/m^2)				Dummy for Obesity (BMI≥30)			
	Men		Women		Men		Women	
Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dummy for 1988-94	1.19	1.46	2.32	2.04	0.088	0.095	0.126	0.109
	(0.08)	(0.10)	(0.09)	(0.10)	(0.006)	(0.008)	(0.006)	(0.007)
12-15 years education		0.32		-1.16		0.004		-0.059
		(0.09)		(0.10)		(0.007)		(0.007)
16+ years education		-0.13		-2.65		-0.030		-0.140
		(0.14)		(0.17)		(0.012)		(0.012)
Age (years)		0.24		0.37		0.011		0.019
		(0.02)		(0.02)		(0.001)		(0.001)
Age squared		-0.0023		-0.0034		-0.0001		-0.0002
		(0.0002)		(0.0002)		(0.0000)		(0.0000)
black (dummy)		0.59		2.52		0.034		0.121
		(0.25)		(0.31)		(0.020)		(0.022)
married (dummy)		0.91		-0.06		0.040		-0.016
		(0.10)		(0.10)		(0.008)		(0.007)
white (dummy)		0.77		0.57		0.024		0.014
		(0.24)		(0.30)		(0.020)		(0.021)
spouse of household head working (dummy)		0.12		---		-0.009		---
		(0.16)				(0.013)		
employed (dummy)		0.13		-0.45		0.007		-0.025
		(0.10)		(0.12)		(0.008)		(0.008)
Occupation dummies	NO	YES	NO	YES	NO	YES	NO	YES
Constant	25.4	18.3	25.2	16.6	0.118	-0.177	0.175	-0.216
	(0.05)	(0.38)	(0.06)	(0.45)	(0.005)	(0.031)	(0.004)	(0.031)
Observations	13,765	13,765	18,256	18,256	13,765	13,765	18,256	18,256
R-squared	0.017	0.076	0.034	0.129	0.014	0.034	0.022	0.074

Note: Standard errors are in parentheses. The data are from the National Health and Nutrition Examination Surveys.

Table 3: Changes in Food Consumption, 1977-78 to 1994-1996

	Meal	Calories* 1977-78	Calories* 1994-96	Change	Percent of total change
Male	TOTAL	2080	2347	268	100%
	Breakfast	384	420	36	13
	Lunch	517	567	50	19
	Dinner	918	859	-59	-22
	Snacks	261	501	241	90
	Calories per meal	573	566	-7	
	Meals per day	3.92	4.53	.61	
Female	TOTAL	1515	1658	143	100%
	Breakfast	286	312	26	18
	Lunch	368	398	31	22
	Dinner	676	602	-74	-52
	Snacks	186	346	160	112
	Calories per meal	422	408	-14	
	Meals per day	3.86	4.44	.58	

Note: Data are from the Continuing Survey of Food Intake 1977-78 and 1994-96.
* Average calories except for the row reporting average meals per day.

Table 4: Distribution of Calories by Meal and Location

		Men			Women		
Meal	Location	1977-78	1994-96	Change	1977-78	1994-96	Change
Breakfast	Home	350	328	-23	271	260	-12
	Store	3	14	11	0	7	6
	Restaurant	13	26	13	4	13	8
	Fast food	5	26	21	2	12	11
	Work / school	8	14	7	5	11	6
	Other	6	12	6	4	10	6
Lunch	Home	331	296	-35	258	239	-19
	Store	5	26	21	2	10	8
	Restaurant	45	51	6	23	36	14
	Fast food	30	103	73	18	46	28
	Work / school	78	61	-16	52	40	-12
	Other	28	30	2	14	26	12
Dinner	Home	800	630	-170	597	451	-146
	Store	0	15	14	0	9	9
	Restaurant	48	88	40	29	61	32
	Fast food	21	60	40	13	33	20
	Work / school	10	10	0	5	7	2
	Other	40	56	16	31	40	10
Snacks	Home	199	358	160	146	258	112
	Store	7	38	31	5	19	14
	Restaurant	7	27	20	4	11	8
	Fast food	10	18	8	5	11	6
	Work / school	16	19	4	9	14	6
	Other	22	41	19	17	32	16

Note: Data are from the Continuing Survey of Food Intake.

Table 5: Time use, 1965-1995
[Minutes per day, age 18-64]

Activity	1965	1975	1985	1995
Paid work	290	258	259	266
Eating on the job	11	8	8	--
Breaks	8	4	3	1
Household work	146	128	124	102
Food preparation	44	41	39	27
Meal cleanup	21	12	10	4
Child care	37	31	31	18
Obtaining goods and services	51	45	53	49
Personal needs and care	622	644	634	632
Meals at home	58	54	50	65
Meals out	11	19	19	(meals at home & out)
Sleeping/napping	473	496	479	495
Education and training	12	16	18	23
Organizational activities	20	24	18	17
Entertainment / Social	78	65	65	72
Recreation	27	37	43	47
Active sports	5	4	10	13
Outdoor	1	7	5	6
Walking/hiking/exercise	1	2	4	5
Communication	158	191	195	212
TV	89	129	129	151
TOTAL	1440	1440	1440	1440
Kcal per minute per kilogram	1.69	1.57	1.62	1.53
“E” for 70 kilogram man	16.4	13.5	14.7	12.6
“E” for 60 kilogram woman	15.1	12.3	13.5	11.3

Note: Time use data from Robinson and Godbey (1997) and authors' calculations from 1995 time diary. Energy expenditure data from authors’ calculations based on Compendium of Physical Activities.

Table 6: Time costs by demographic group
[minutes]

	1965		1995	
	Meal Prep.	Meal Prep. + Cleanup	Meal Prep.	Meal Prep. + Cleanup
Adults				
Single male	13.6	18.1	15.5	17.3
Married male, non-working spouse	6.5	9.4	13.2	14.4
Married male, working spouse	8.1	11.9	13.2	14.4
Single female	38.1	60.1	28.9	33.1
Married female, working	58.3	84.8	35.7	41.4
Married female, not working	94.2	137.7	57.7	68.8
Elderly				
Male	16.6	26.3	18.5	20.2
Female	65.9	10.4	50.1	60.3

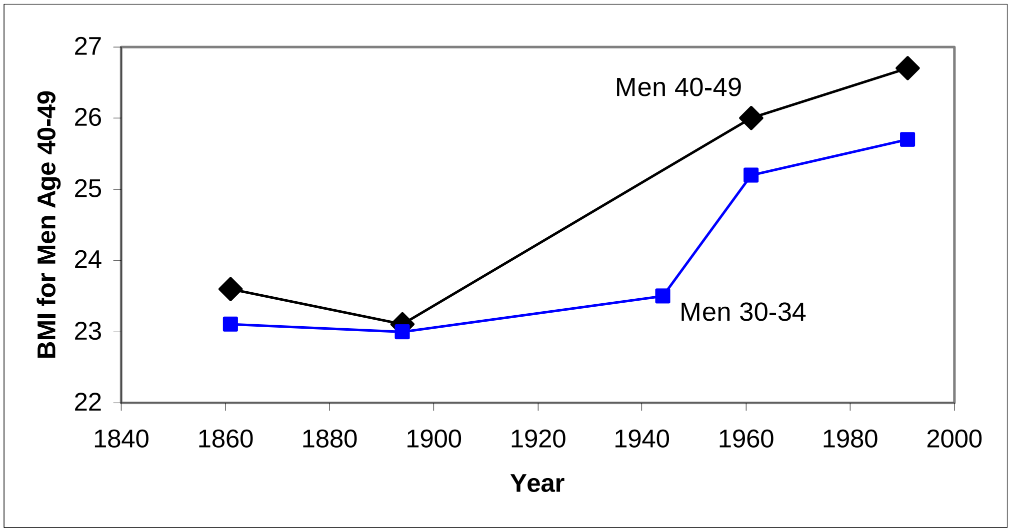
Source: Authors' calculations from Americans' Use of Time Survey Archives, 1965 and 1995.

Table 7: International Regressions
[Dependent Variable: Percent of Adult Population That is Obese]

Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
frequency of price controls*		-3.7					
		(1.3)					
producer protection*			-4.5				
			(1.7)				
number of food statutes*				-7.4			
				(2.2)			
Civil law origin					-7.5		
					(2.2)		
log(time to open business)						-2.6	
						(1.1)	
cost of a Big Mac (US2000$)*							-4.7
							(2.3)
log(GDP per capita), 1998	0.68	-4.63	6.78	5.10	-1.58	-4.72	10.65
	(4.57)	(4.25)	(4.59)	(3.76)	(3.72)	(4.56)	(6.80)
% females in labor force, 1992	0.24	0.04	0.81	0.69	0.26	-0.15	0.46
	(0.31)	(0.27)	(0.66)	(0.41)	(0.25)	(0.31)	(0.47)
Constant	-0.35	22.73	-42.96	-31.42	11.15	39.75	-39.30
	(19.27)	(17.98)	(33.38)	(22.05)	(15.82)	(23.15)	(31.83)
Observations	22	21	9	9	22	21	13
Adjusted R-squared	-0.072	0.204	0.491	0.310	0.557	0.128	0.124

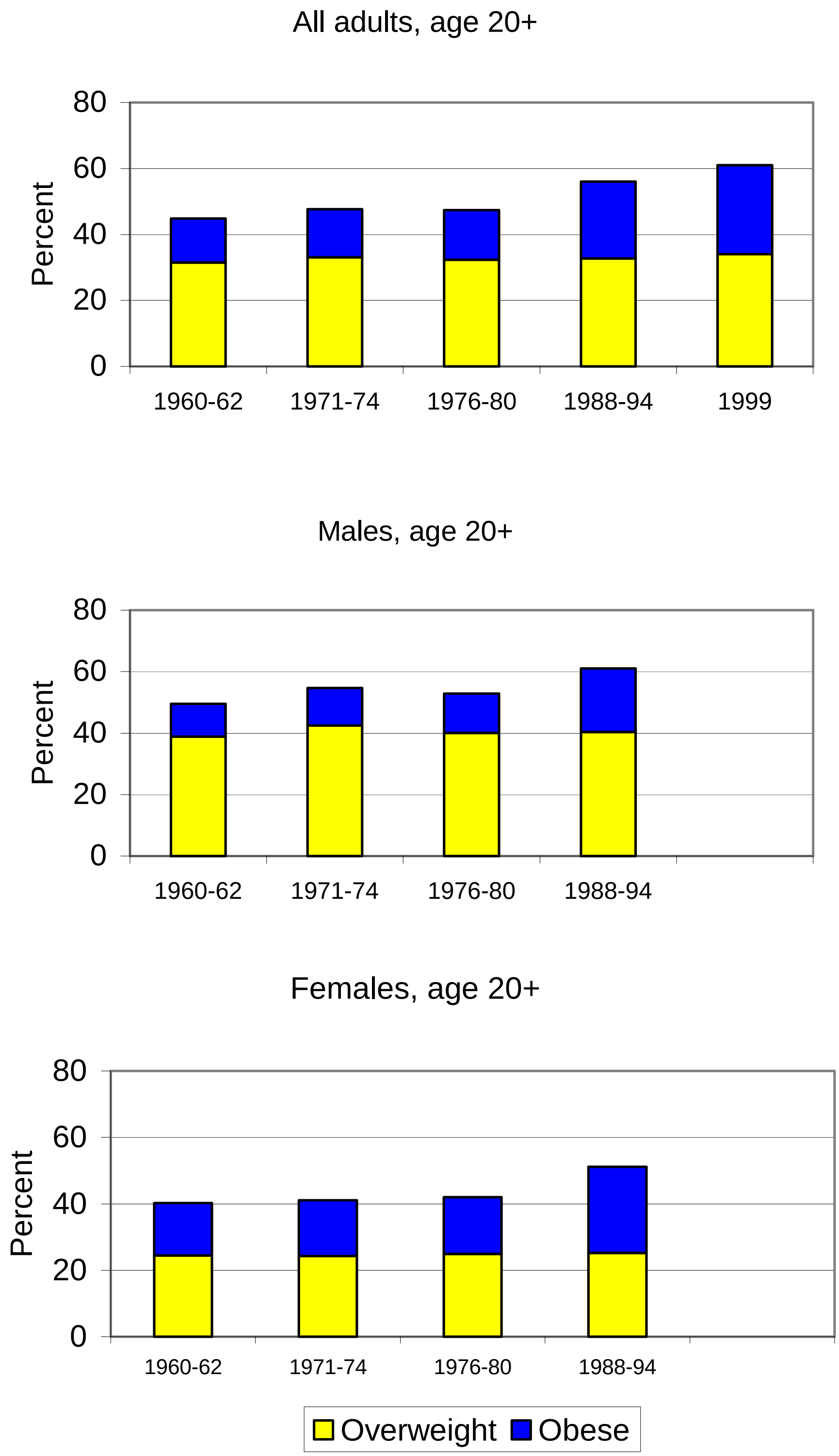
Note: Standard errors are in parentheses. Appendix Table 3 shows the available countries and source of data.
* Data are standardized to have a mean of 0 and standard deviation of 1.

Figure 1: Historical trends in BMI



Data are from Costa and Steckel (1997).

Figure 2: Overweight and obese, 1960-1999



Source: CDC (2001). Overweight is defined as 25<=BMI<=30. Obese is defined as BMI>=30. Data for 1999 are not available by gender.

Figure 3: Distribution of BMI, 1971-75 and 1988-94

Figure 3a: Males, age 20-55

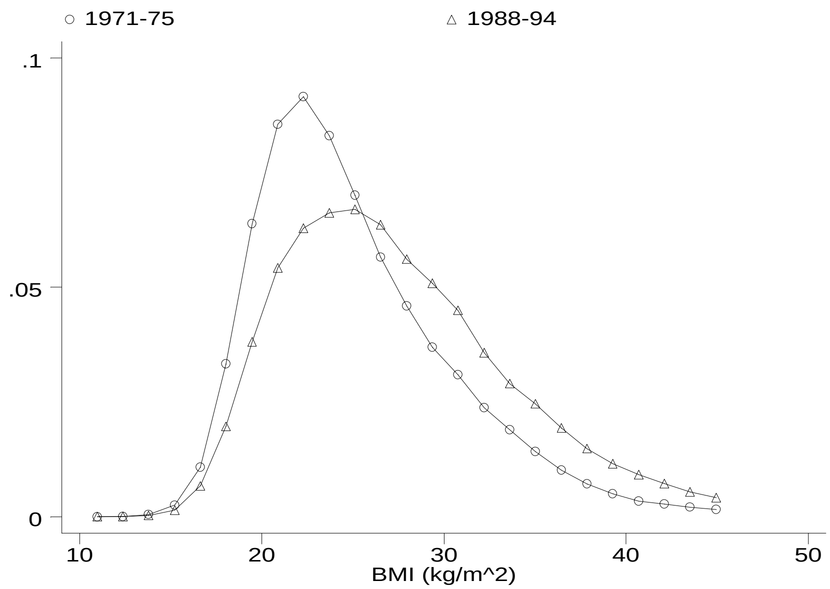
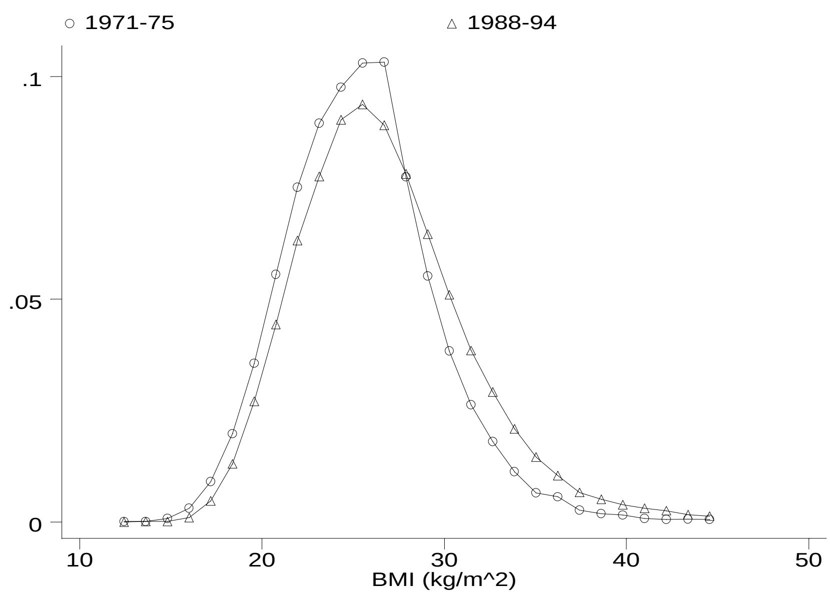
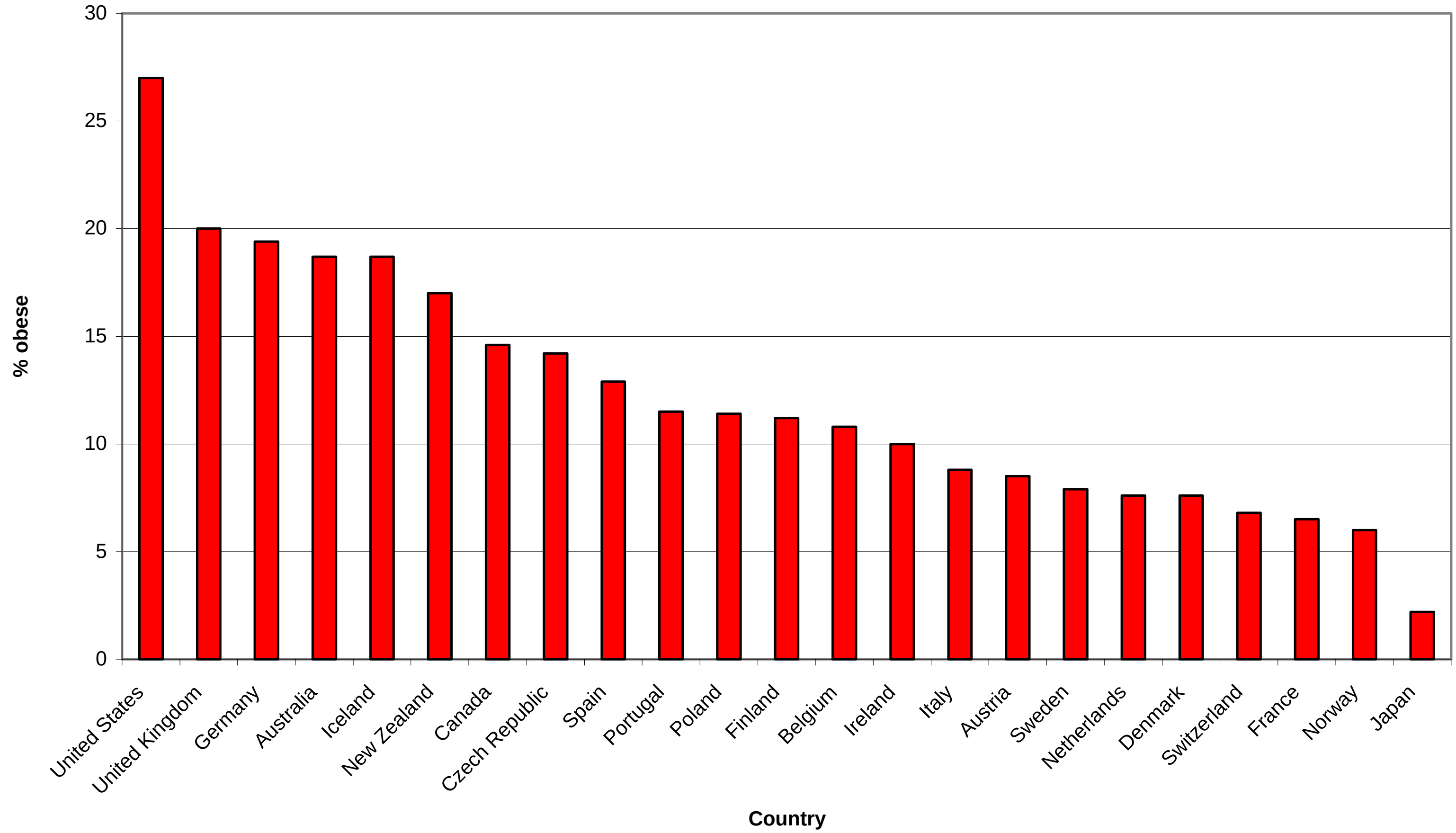


Figure 3b: Females, age 20-55



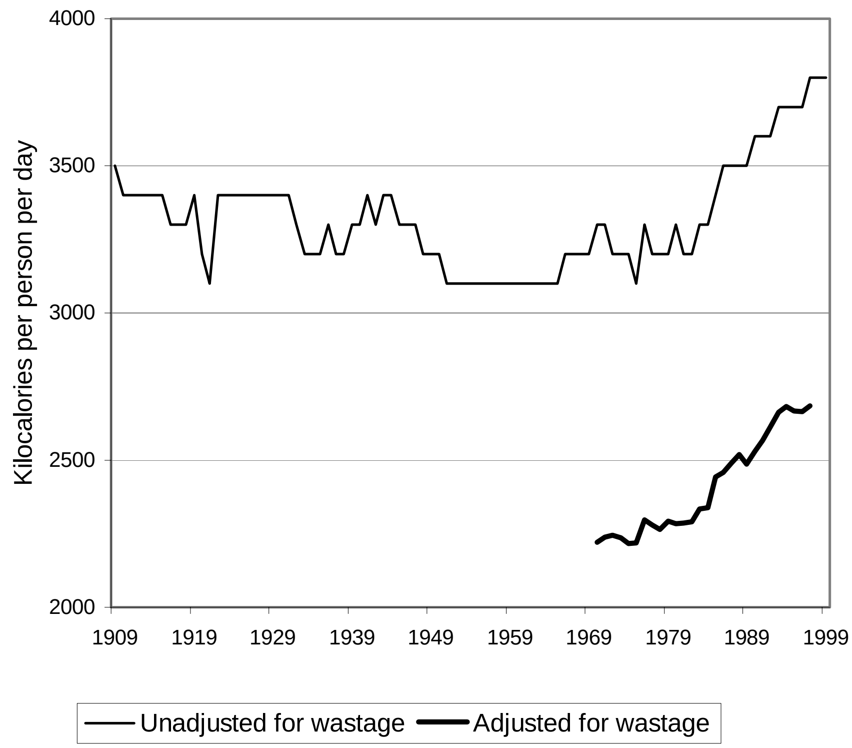
Source: National Health and Nutrition Examination Surveys

Figure 4: Obesity in International Perspective



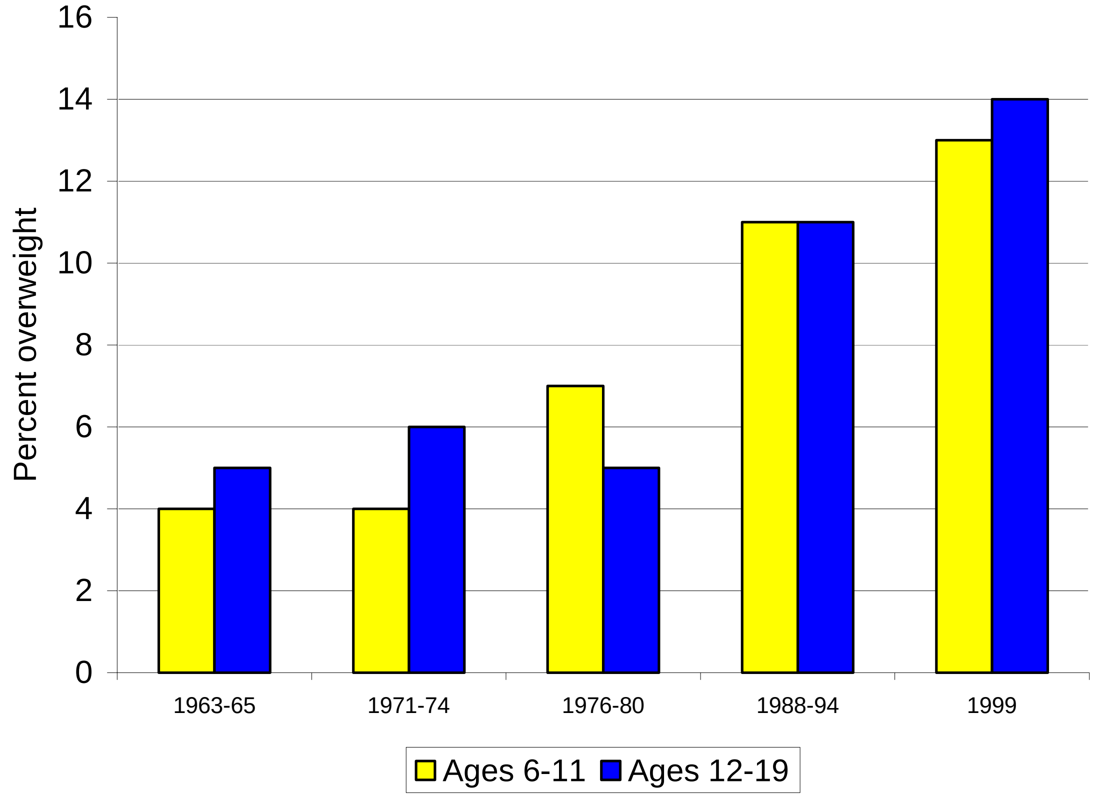
Source: OECD Health Statistics (2000)

Figure 5: Trends in the Food Supply, 1909-1999



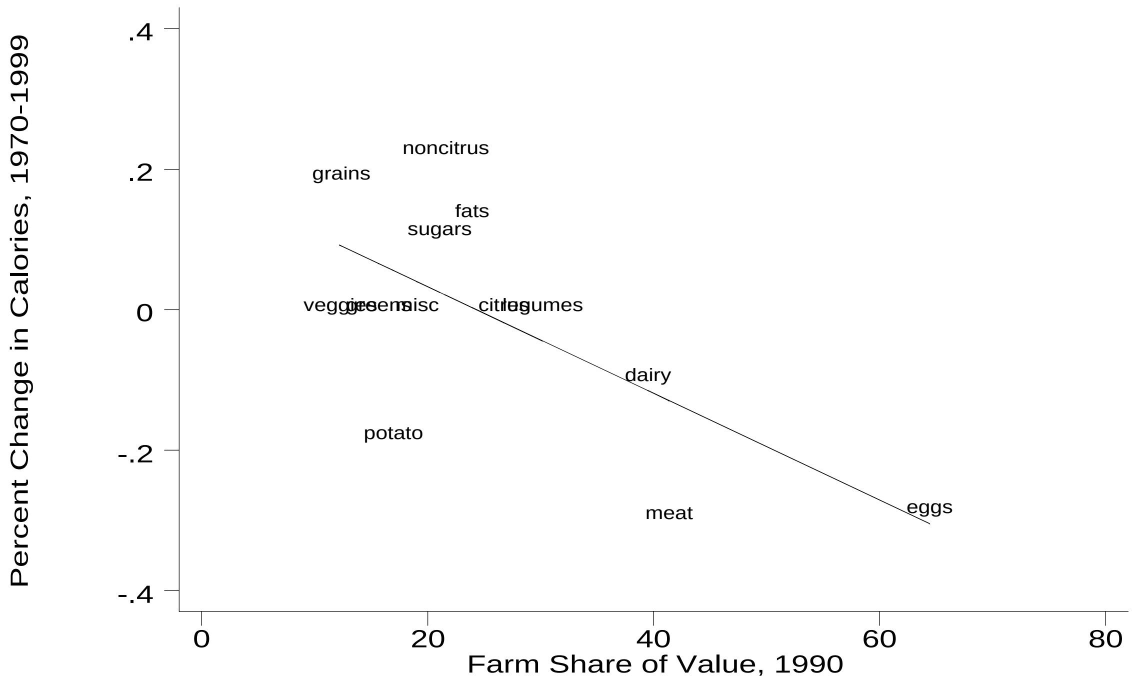
Source: USDA, Economic Research Service.

Figure 6: Overweight Among Children and Adolescents



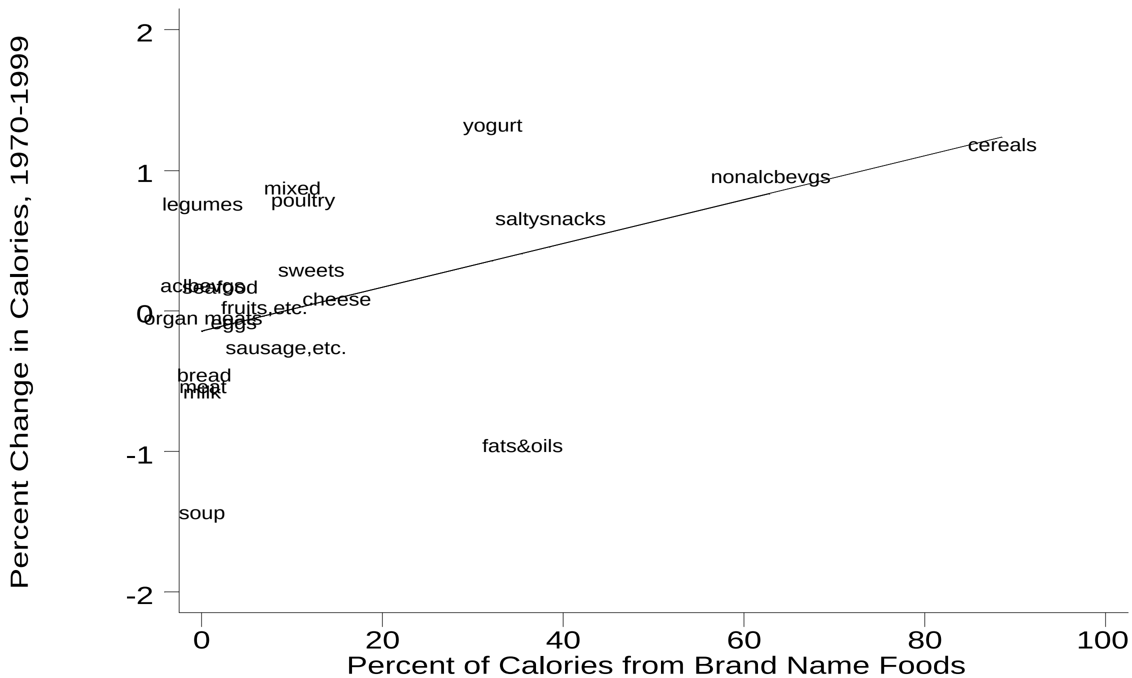
Source: National Health and Nutrition Examination Surveys

Figure 7: Food Preparation and Changes in Intake



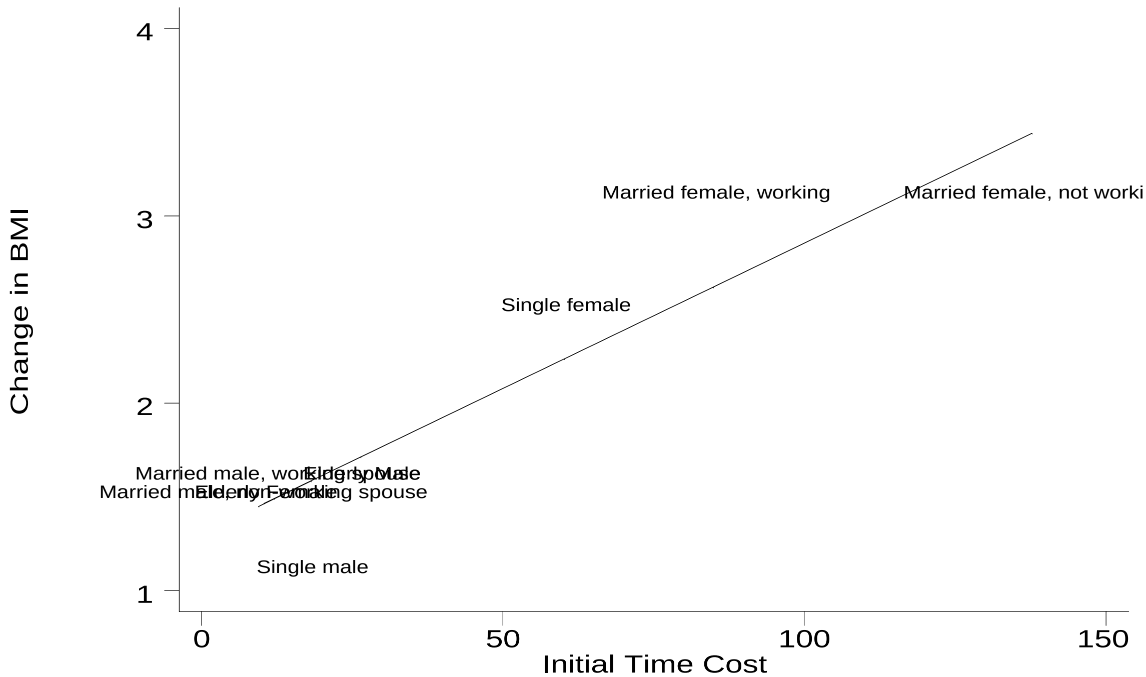
Notes: Data on calories for each food group are from the Per Capita Food Consumption Data System (2002). Data on farm share of value were obtained by personal correspondence with Howard Elitzak of United States Department of Agriculture, Economic Research Service. The regression equation is: Δln(cals, 1970-1999) = 0.185 (.075) - 0.008 (.003) * farm share of value, 1990 ; N=13, Adj. R^2=0.409

Figure 8: Brand Name Foods and Changes in Calories



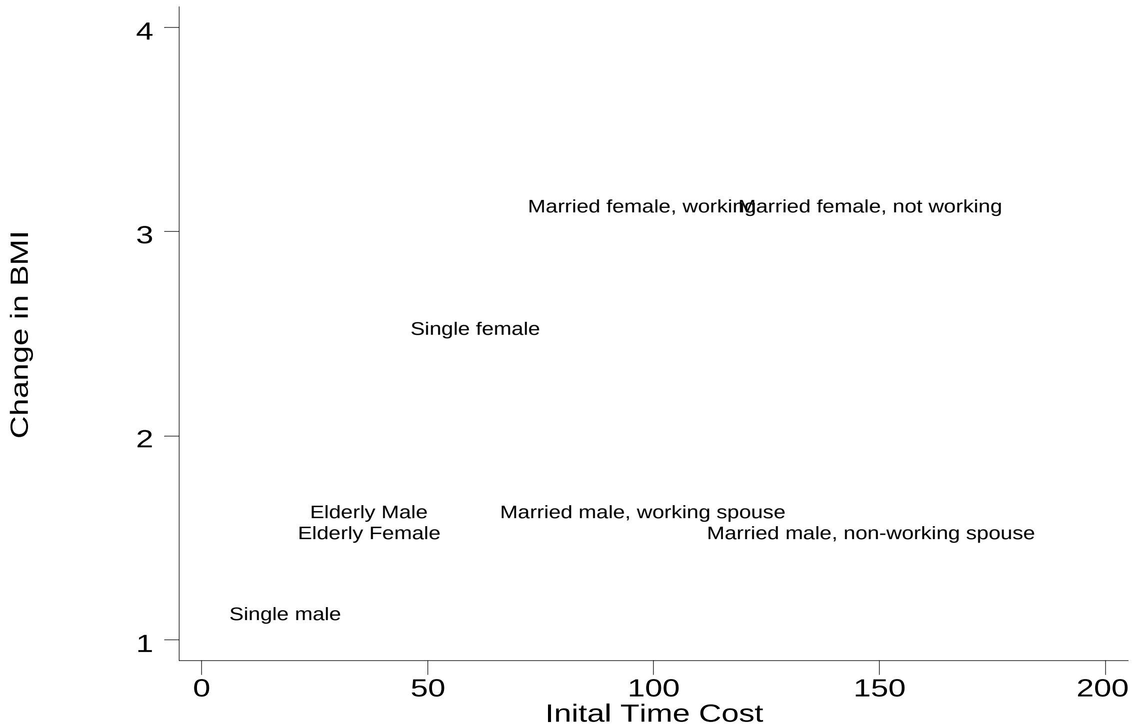
Notes: The table plots the percent change in caloric intake from 1971-75 to 1988-94 against the percent of calories in 1988-94 coming from brand name foods. The calculations are restricted to home consumption of males aged 20-55. The regression equation is: $\Delta\ln$(cals, 1971-75 to 1988-94) = -0.145 (.175) + 0.016 (.006) * (% of calories from brand name foods, 1988-94); N=20, Adj. R^2=0.223.

Figure 9: Time Costs and Changes in BMI
Using Sex-Specific Time



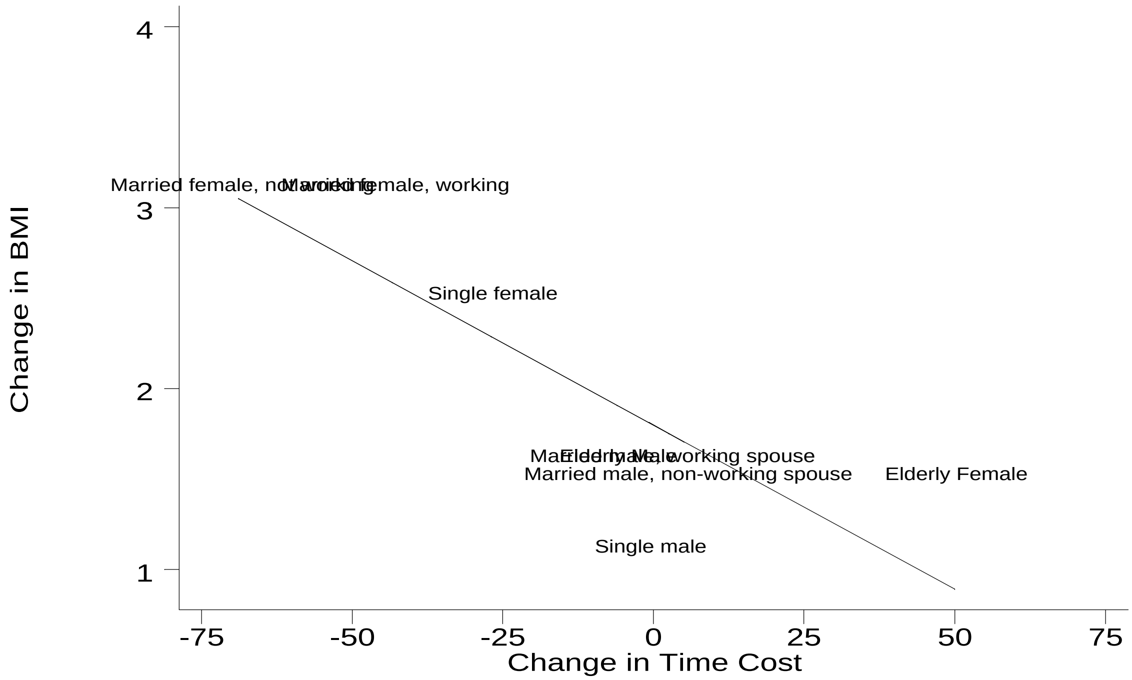
Note: The change in BMI is from the NHANES surveys of 1971-75 to 1988-94. The initial time cost is from 1965, computed as time spent preparing and cleaning up after meals. The data are from the Americans Use of Time Survey Archive. The regression line is: ΔBMI (1971-75 to 1988-94) = 0.06 (0.19) + 1.30 (0.17) * Initial Time Cost; N=8, Adj. R^2=0.816

Figure 10: Time Costs and Changes in BMI
Using Total Household Time



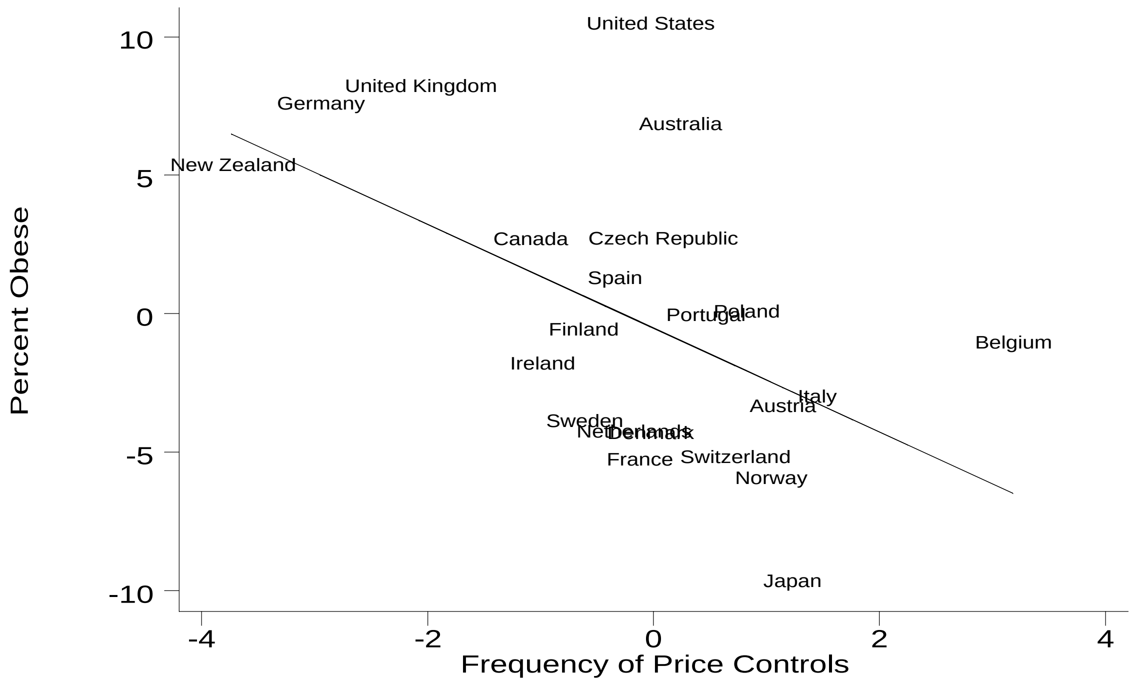
Note: The change in BMI is from the NHANES surveys of 1971-75 to 1988-94. The initial time cost is from 1965, computed as time spent preparing and cleaning up after meals. The data are from the Americans Use of Time Survey Archive.

Figure 11: Changes in Time Costs and Changes in BMI
Using Sex-Specific Time Costs



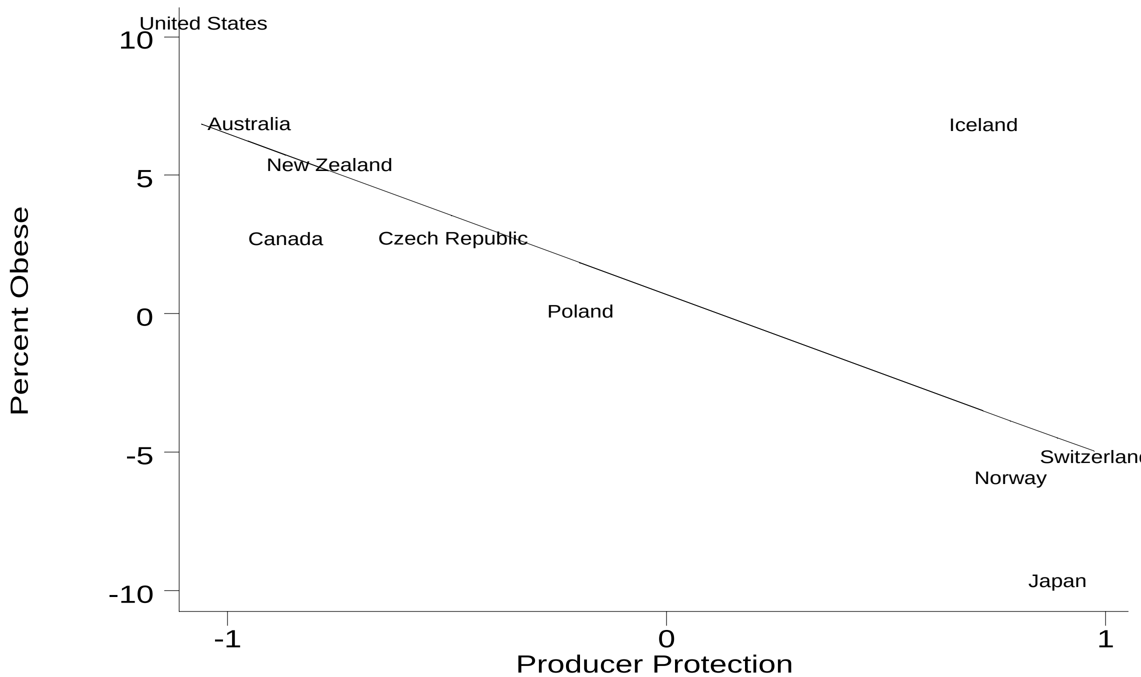
Note: The change in BMI is from the NHANES surveys of 1971-75 to 1988-94. The initial time cost is from 1965, computed as time spent preparing and cleaning up after meals. The data are from the Americans Use of Time Survey Archive. The regression line is: ΔBMI (1971-75 to 1988-94) = -0.02 (0.01) + 1.80 (0.18) * ΔTime Cost; N=8, Adj. R^2=0.634

Figure 12: Obesity and Price Controls



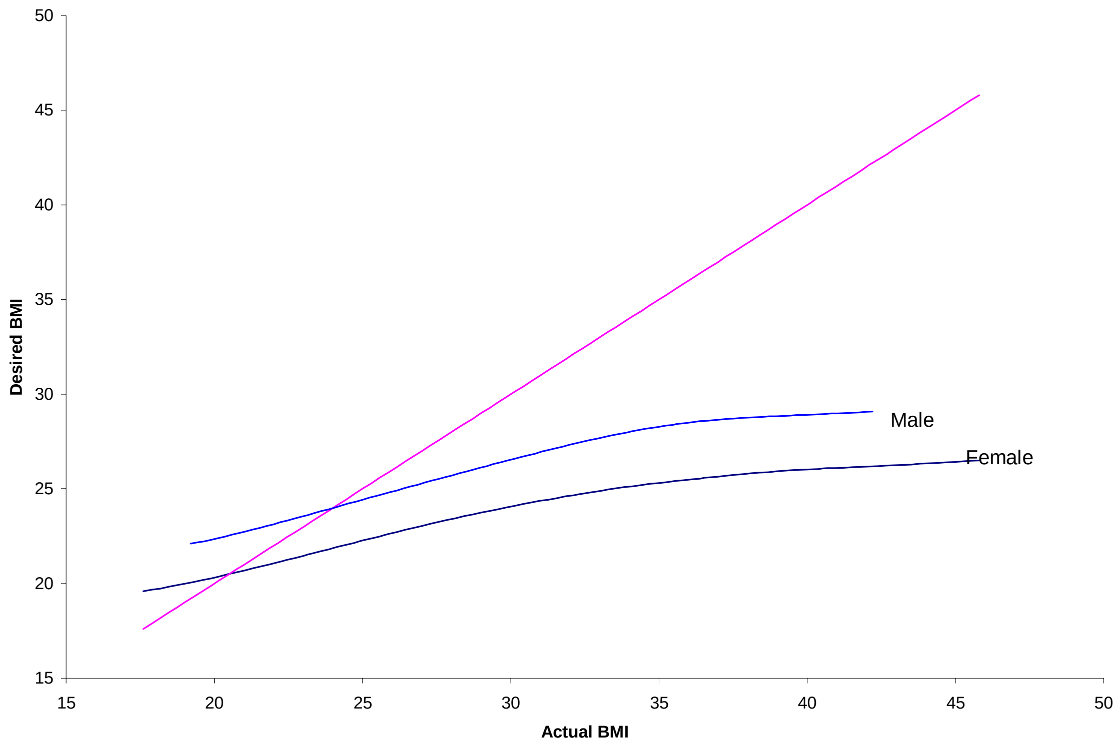
Note: Variables are partialled with respect to GDP per capita in 1998. Data on obesity are from OECD Health Statistics (2000). Data on price controls are from the Economic Freedom of the World.

Figure 13: Obesity and Producer Protection



Note: The variables are partialled with respect to GDP per capita in 1998. Data on obesity are from OECD Health Statistics (2000). Data on producer protection are from OECD Producer and Consumer Supports Database (2000).

Figure 14: Actual and Desired BMI



Notes: Calculated using data from Behavioral Risk Factor Surveillance Survey (BRFSS). Lines are based on a nonparametric Gaussian kernel regression with a bandwith of 2.

Appendix – Energy Accounting

In this appendix, we describe in more detail the components of energy accounting. As noted in the text, people expend energy in three ways. The first is basal metabolism – the energy cost of keeping the body alive and the organs functioning. Scientific evidence estimates that the basal metabolic rate (BMR) is proportional to weight:

$$BMR = \alpha + \beta * Weight$$

Schofield, Schofield, and James (1985) estimate that $\alpha = 879$ for men and 829 for women. They also estimate that $\beta = 11.6$ for men and 8.7 for women (where weight is measured in kilograms).

The second form of energy expenditure is the thermic effect of food. This is proportional to food intake, with the typical food costing about 10 percent of the energy it supplies to digest. Finally, people use energy engaging in physical activity. Energy use is proposal to how strenuous the exercise is, and to the person's weight. We summarize this energy cost as

$$Energy = \eta * Weight * Time$$

Ainsworth et al. (1993) classify activities into different categories. The categories are very detailed. In evaluating changes in time use, we group activities into these categories. The Compendium of Physical Activities reports the energy expenditure associated as a ratio of activity metabolic rate to resting metabolic rate. These units are referred to as METs. The table below shows a list of sample activities (the ten activities taking up the most time on average in 1995), their associated METs, and their corresponding activity descriptions in the time use diaries. A full list of time diary activities and their associated METs is available from the authors at jmshapir@fas.harvard.edu.

Compendium Description	Time Diary Description	METs
Sleeping	Sleeping/napping	0.9
Sitting-light office work	At work	1.5
Sitting quietly	Television watching	1.0
Eating (sitting)	Eating	1.5
Standing-talking or talking on the phone	Visiting	1.8
Cooking or food preparation	Food preparation	2.5
Cleaning, house or cabin, general	Cleaning house	3.5
Automobile or light truck driving	Travel to/from work	2.0
Walking-shopping (non-grocery shopping)	Shopping for clothes	2.3
Sitting quietly	Thinking/relaxing	1.0

Appendix Table 1: Trends in obesity in selected countries

Country	Age group	Year	Percent obese (men)	Percent obese (women)
USA	20-74	1976-80	12%	17%
		1988-94	20	25
Canada	20-70	1978	7	10
		1988	9	9
England	16-64	1980	6	8
		1991	13	15
Finland	20-75	1978-79	10	10
		1991-93	14	11
Sweden	16-84	1980-81	5	9
		1988-89	5	9
Australia	25-64	1980	9	8
		1989	12	13
Japan	20+	1976	1	3
		1993	2	3

Source: World Health Organization (2000).

Appendix Table 2: Changes in food variety, 1977-78 to 1994-96

	Food category	Variety Index 1977-78	Variety Index 1994-96	Change
Male	Dairy	0.222	0.238	0.016
	Meat, poultry and fish	0.302	0.281	-0.021
	Eggs	0.013	0.014	0.001
	Legumes	0.038	0.040	0.002
	Grains	0.475	0.505	0.031
	Fruits	0.196	0.222	0.027
	Vegetables	0.305	0.301	-0.004
	Fats and oils	0.114	0.108	-0.006
	Sweets	0.286	0.326	0.041
Female	Dairy	0.218	0.234	0.016
	Meat, poultry and fish	0.241	0.226	-0.014
	Eggs	0.012	0.015	0.002
	Legumes	0.035	0.040	0.005
	Grains	0.444	0.498	0.054
	Fruits	0.206	0.229	0.023
	Vegetables	0.287	0.314	0.027
	Fats and oils	0.104	0.107	0.003
	Sweets	0.281	0.310	0.029

Note: The data are from the Continuing Survey of Food Intake 1977-78 and 1994-96.

Appendix Table 3: International Data

Country	GDP per capita, 1998 ($PPP)	Percent females in labor force, 1992	Percent of adults obese, latest available	Price of a Big Mac in US$, 2000	Civil legal origin	Frequency of price controls (10=most), average 1989 and 1994	Ratio of farm prices to world prices, 1998	Number of food statutes (max=)	Time to open a business (days)
Australia	24181	42	18.7	1.54	0	3.5	1.03		2
Austria	23574	43	8.5		1	4.5		33	37
Belgium	23805	43	10.8		1	6.5			33
Canada	25293	47	14.6	1.94	0	2	1.15	28	2
Denmark	25702	48	7.6	3.08	1	3		36	3
Finland	21793	47	11.2		1	3			24
France	21785	45	6.5	2.62	1	3.5		44	53
Germany	22953	43	19.4	2.37	1	0.5		28	42
Iceland	25277	46	18.7		1	10	2.74		
Ireland	22710	36	10		0	2.5			16
Italy	22271	35	8.8	2.16	1	5		21	62
Japan	24102	38	2.2	2.78	1	4.5	2.87		26
Netherlands	24714	40	7.6		1	3			31
New Zealand	17745	43	17	1.69	0	0.5	1		3
Norway	26161	45	6		1	4	2.83		18
Poland	8181	46	11.4	1.28	1	6.5	1.26	25	58
Portugal	15696	43	11.5		1	5			76
Spain	17027	35	12.9		1	4			82
Sweden	21855	48	7.9	2.71	1	3			13
Switzerland	27336	43	6.8	3.48	1	3.5	3.06		16
United Kingdom	22119	44	20	3	0	1.5		17	4
United States	32299	45	22.6	2.51	0	2	1.19	20	4
Source	World Development Indicators	World Development Indicators	OECD Health Statistics	The Economist	La Porta et al	Economic Freedom of the World	OECD Producer and Consumer Supports Database	Kellam and Guarino	Djankov et al