

Impatience, Incentives, and Obesity^{*}

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Abstract

This paper explores the relationship between time preference, food prices, and body mass index (BMI). We present a model predicting that impatient individuals should both weigh more than patient individuals and experience sharper increases in weight in response to falling food prices. We then provide evidence to support these predictions using data from the National Longitudinal Survey of Youth matched with local food prices from the Council for Community and Economic Research. Our findings suggest that the interaction of changing economic incentives with impatience can help to explain the shift to the right and thickening of the tails of the BMI distribution. Interestingly, we find no evidence of a relationship between time preference and weight loss attempts, suggesting that the observed effect on BMI represents rational intertemporal substitution rather than self-control problems.

Keywords: Obesity, weight, body mass index, discount factor, discount rate, time preference, food prices

JEL Classification: I10, D9

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1 Introduction

The US obesity rate has skyrocketed in recent decades, rising from 13% in 1960 to 34% in 2006 (Flegal et al., 1998; National Center of Health Statistics, 2008). Obesity, defined as a body mass index (BMI) of at least 30, is both a public health and public finance concern.¹ Adverse health conditions attributed to obesity, which include heart disease, diabetes, high blood pressure, and stroke, lead to an estimated 112,000 deaths per year (Strum, 2002; Flegal et al., 2005). Treating obesity-related conditions costs an estimated \$117 billion annually, with about half of these expenditures financed by Medicare and Medicaid (US Department of Health and Human Services, 2001; Finkelstein et al., 2003).

A growing literature argues that changes in economic incentives over time have decreased the opportunity cost of eating and raised the opportunity cost of physical activity, leading to an increase in population weight. Economic factors linked to obesity include food, cigarette, and gasoline prices; the availability of restaurants, grocery stores, and Walmart Supercenters; technological innovations in food processing and preservation; work hours; on-the-job physical activity; health insurance coverage; the minimum wage; and the unemployment rate.² Less is known, however, about the role individuals' underlying preferences play in influencing weight and altering the BMI distribution over time. We contribute by providing evidence that a stronger preference for present over future consumption increases BMI, that the relationship between food prices and BMI strengthens with greater impatience, and that the link between impatience and BMI is not accompanied by more frequent weight loss attempts.

¹BMI = weight in kilograms divided by height in meters squared.

²A full review of this expansive literature is beyond the scope of this paper. For examples of the different factors mentioned, see Anderson and Matsa (forthcoming), Baum (2008), Bhattacharya et al. (2010), Chou et al. (2004), Chou et al. (2006), Courtemanche (2009a, 2009b, forthcoming), Courtemanche and Carden (forthcoming), Currie et al. (2010), Cutler et al. (2003), Dunn (2008), Eid et al. (2008), Ewing et al. (2003), Frank et al. (2004), Giles-Corti et al. (2003), Goldman et al. (2010), Gruber and Frakes (2006), Lakdawalla and Philipson (2002), Lakdawalla et al. (2005), Meltzer and Chen (2010), Nonnemaker et al. (2008), Philipson and Posner (2003), Plantinga and Bernell (2007), Rashad (2006), Rashad et al. (2006), Ruhm (2000 and 2005); Satia et al. (2004), Zhao and Kaestner (2010). Related literatures have also examined the economic determinants of childhood obesity, the economic consequences of obesity, the effects of various public policies on obesity, and the economic determinants of eating and exercise.

Limited research addresses the link between time preference and BMI.³ Komlos et al. (2004) hypothesize that people may have become less patient over time, contributing to the rise in obesity. They support this theory by illustrating a time-series relationship between obesity and both the savings rate and debt-to-income ratio in the US, and also by demonstrating that countries with low savings rates have higher obesity rates. Smith et al. (2005) proxy for time preferences with savings behavior and find some evidence of a connection to BMI using data from the National Longitudinal Survey of Youth (NLSY). Zhang and Rashad (2007) estimate a link between time preference and BMI in two datasets, the small Roper Center Obesity survey and the larger Behavioral Risk Factor Surveillance System. Their proxies for time preference are self-reported willpower in the former and desire but no effort to lose weight in the latter. Chabris et al. (2008) find a relationship between impatience and BMI using a more direct measure of time preference, the discount rate computed from answers to questions on intertemporal trade-offs administered in a laboratory setting to 126 subjects from the Boston area.

Even if time preference and BMI are related, if people have not become less patient over time, then time preferences alone cannot explain trends in BMI. Borghans and Golsteyn (2006) consider a number of proxies for time preference available in a Dutch dataset and find that the extent to which time preference and BMI are related depends heavily on the choice of proxy. They examine trends in some of their proxies and find no evidence that the rate of time preference has changed over time. In a meta-analysis of experimental and field studies on time preferences published from 1978-2002, Percoco and Nijkamp (2009) find no evidence of changing time preferences over the sample period. In a longitudinal field experiment, Meier and Sprenger (2010) find a high degree of stability for measured time preferences, suggesting that time preference is relatively stable over an individual's lifetime, similar to other personality constructs.

We build on the obesity literature in three ways. First, we utilize a large national dataset,

³A related literature examines the link between risk preference and BMI; see, for instance, Anderson and Mellor (2008).

the 2006 NLSY, which includes not only questions on body weight and hypothetical intertemporal trade-offs but also a rich array of other individual information. These data allow us to push further than prior research toward establishing that the estimated association between time preference and BMI is a *ceteris paribus* relationship rather than a spurious correlation. We do this both by controlling for potential confounders and conducting falsification tests. Building up from a simple regression to a model that includes demographic characteristics, IQ, education, income, net worth, work hours, and risk preference demonstrates that greater impatience consistently increases BMI and that the coefficient estimate is stable across specifications. The effects are strongest for white males and are accompanied by related effects on the probabilities of being obese and severely obese. Falsification tests find no evidence of a link between time preference and either height or health conditions that are less directly tied to eating and exercise.

Second, we examine, both theoretically and empirically, whether impatience and incentives interact in determining BMI. Even if underlying rates of time preference have not changed over time, impatience can still help to explain changes in the BMI distribution if patient and impatient people respond differently to changing economic incentives. Individuals who are highly concerned about future health might never develop unhealthy eating habits regardless of how cheap and available food becomes, whereas those who are less interested in the future might be more responsive. We find evidence to support this hypothesis by matching the NLSY to local food price data from the Council for Community and Economic Research (C2ER). The interaction between impatience and incentives might help to explain why the BMI distribution has become more spread out over time (as shown in Figure 1), as opposed to merely shifting to the right.

Finally, we provide a preliminary attempt to disentangle whether the observed relationship between time preference and BMI represents rational intertemporal substitution or self-control problems, a distinction that has critical implications for policy. If people make eating and exercise decisions via time-inconsistent preferences, then lower food prices could actually de-

crease welfare, providing a justification for policies designed to alter these decisions (Cutler et al., 2003). If instead individuals make these decisions by rationally trading off current and future consumption in a way that maximizes lifetime expected utility, then policies that alter eating and exercise could be socially wasteful even if they reduce population weight. Following Ruhm's (2010) treatment of weight loss attempts as an admission of past "mistakes" due to self-control problems, we test whether such attempts vary systematically with patience. We find no evidence of a relationship between time preference and probability of trying to lose weight, suggesting that, at least in this context, the results are more consistent with rational intertemporal substitution than impulsive behavior.

2 Theoretical Model

We present a simple theoretical model to highlight the interaction of impatience and incentives in weight accumulation. We demonstrate that more impatient individuals should display a greater response to decreasing food prices than patient individuals. We consider a modified version of the Philipson and Posner (2003) and Lakdawalla and Philipson (2009) model of food choice and weight accumulation. Our novel extension is to model weight gain as non-instantaneous; instead, food intake increases weight after a time lag. Modeling food intake as conferring immediate hedonic benefits but delayed health costs implies that a consumer's optimal weight choice is a function of time preferences as well as utility preferences.

Utility U depends on Weight (W), food intake (f), and other consumption goods (c). Assume there exists an ideal weight W^* , and utility is decreasing from deviations in either direction from this ideal weight. This implies that $\frac{\partial U}{\partial W}(W^*) = 0$ with $\frac{\partial^2 U}{\partial W^2} < 0$. Let subscripts denote time periods. Food and consumption goods provide instantaneous utility, $\frac{\partial U}{\partial f}, \frac{\partial U}{\partial c} > 0$ with $\frac{\partial^2 U}{\partial f^2}, \frac{\partial^2 U}{\partial c^2} < 0$. Assume that food increases weight in the *subsequent* period, so that future weight is an increasing function of current weight and current food intake $W_{t+1}(W_t, f_t)$, with $\frac{\partial W_{t+1}}{\partial W_t}, \frac{\partial W_{t+1}}{\partial f_t} > 0$. Note that assuming that food increases weight instantaneously as

well as in the future period would not change our key comparative static result that more impatient individuals place less emphasis on future weight gain, and hence a greater sensitivity to declining food prices.

Consider an infinitely lived consumer in discrete time with additively separable and stationary utility. Normalize the price of consumption to 1 and let p_t denote the relative price of food in period t . A consumer begins with initial wealth I_0 , which he can save at market interest rate r . Let δ denote the per-period discount factor, with $0 \leq \delta \leq 1$. A consumer chooses food f and other consumption c to maximize:

$$\max_{f,c} \sum_{t=0}^{\infty} \delta^t U_t(W_t, f_t, c_t) \quad \text{s.t.} \quad \frac{\sum p_t f_t}{(1+r)^t} + \frac{\sum c_t}{(1+r)^t} = I_0 \quad (1)$$

Alternatively, the value function V is given by:

$$\begin{aligned} V_t(W_t, I_t) &= U_t(W_t, f_t, c_t) + \delta V_{t+1}(W_{t+1}, f_{t+1}, c_{t+1}) \\ \text{s. t.} \quad &: \quad W_{t+1} = W_t - p_t f_t - c_t \\ I_{t+1} &= (I_t - p_t f_t - c_t)(1+r). \end{aligned} \quad (2)$$

Substituting in the wealth and weight transition equations yields the following Bellman equation:

$$V_t(W_t, I_t) = \max_{f_t, c_t} U_t(W_t, f_t, c_t) + \delta V_{t+1}[W_{t+1}; I_{t+1}] \quad (3)$$

The steady-state first-order conditions are thus:

$$\frac{\partial V_t}{\partial f_t} = \frac{\partial U_t}{\partial f_t} + \delta \frac{\partial V_{t+1}}{\partial W_{t+1}} \frac{\partial W_{t+1}}{\partial f_t} - \delta \frac{\partial V_{t+1}}{\partial I_{t+1}} \frac{\partial I_{t+1}}{\partial f_t} = 0 \quad (4)$$

$$\frac{\partial V_t}{\partial c_t} = \frac{\partial U_t}{\partial c_t} - \delta \frac{\partial V_{t+1}}{\partial I_{t+1}} \frac{\partial I_{t+1}}{\partial c_t} = 0 \quad (5)$$

which implies that at the optimum:

$$\frac{\partial U_t}{\partial f_t} + \delta \frac{\partial V_{t+1}}{\partial W_{t+1}} \frac{\partial W_{t+1}}{\partial f_t} = p_t \frac{\partial U_t}{\partial c_t}. \quad (6)$$

Note that if a person is underweight, $\frac{\partial V_{t+1}}{\partial W_{t+1}}$ is positive, which could happen at sufficiently high food prices. However, individuals in our modern U.S. sample are presumably either at or above their ideal weight and therefore $\frac{\partial V_{t+1}}{\partial W_{t+1}} < 0$. Our comparative static results focus on the cases in which $\frac{\partial V_{t+1}}{\partial W_{t+1}} < 0$. Equation (6) implies that a consumer should eat food until its benefits and weight costs are equalized with the per-dollar utility of other consumption goods. Food yields immediate benefits $\frac{\partial U_t}{\partial f_t}$, with explicit financial cost p and implicit weight cost $\frac{\partial V_{t+1}}{\partial W_{t+1}}$; however, the weight cost of food occurs in the future and is therefore discounted by δ .

We now consider the relationship between patience, food consumption, and weight. Our first result is that more patient individuals consume less food and will have a lower weight. That is, for a given p , if $\frac{\partial V_{t+1}}{\partial W_{t+1}} < 0$, then as $\delta \rightarrow 1$, f_t declines. Greater patience has two effects. First, in equation (6), as δ approaches 1, the negative $\frac{\partial V_{t+1}}{\partial W_{t+1}}$ term carries a greater impact. To maintain equality with the $p_t \frac{\partial U_t}{\partial c_t}$ term requires more patient individuals to increase $\frac{\partial U_t}{\partial f_t}$, i.e. to reduce food consumption f_t . Since the weight-gain cost occurs in the future, impatient individuals discount this cost and effectively face a lower total price of food than do more patient individuals. Further, as patience increases the present value of all future consumption increases, necessitating a reduction in present food consumption in favor of greater future wealth.

Our second result reveals the interaction between time preferences and food prices. We demonstrate that more patient individuals should display a smaller response to changes in food prices. If $\frac{\partial V_{t+1}}{\partial W_{t+1}} < 0$, then as $\delta \rightarrow 1$, $\frac{\partial f}{\partial p}$ increases and becomes less negative. Consider a decrease in food price p . The left-hand side of equation (6) must decrease to preserve equality, so the individual should eat more food in response to falling food prices and $\frac{\partial U_t}{\partial f_t}$ will decline.

As the individual increases food consumption, he also incurs future weight gains through the negative $\frac{\partial V_{t+1}}{\partial W_{t+1}}$ term, further helping to decrease the left-hand side term. However, the negative weight-gain effects $\delta \frac{\partial V_{t+1}}{\partial W_{t+1}}$ are more pronounced for more patient individuals than for impatient individuals. As such, more patient individuals will purchase less additional food after a decrease in food prices than will impatient individuals, $\frac{\partial f}{\partial p \partial \delta} > 0$. The greater emphasis on future weight effects causes patient individuals to display a dampened increase in food consumption in response to cheaper food compared to impatient individuals; alternatively, more impatient individuals should be more responsive to changes in food prices. Our data analysis tests these theoretical predictions.

3 Data

To test these theoretical predictions, we use data from the 2006 wave of the NLSY, a panel from the US Bureau of Labor Statistics that follows 12,686 individuals from 1979 to 2008. The respondents were between 14 and 22 years old in 1979, and were interviewed annually until 1994 and biennially thereafter. The sample consists of 6,111 randomly selected individuals, 5,295 minority and economically disadvantaged youths, and 1,280 military youths. The respondents report their weight in all survey years except 1987 and 1991 and their height in 1981, 1982, and 1985, after which point they are assumed to have reached their adult height. These variables allow for the construction of BMI and indicator variables for whether or not the respondent is overweight, Class I obese, or severely obese (with the omitted category reflecting BMI<25).⁴ Additionally, the NLSY includes an indicator variable for whether the respondent is currently trying to lose weight, which we use as the dependent variable in Section 4.3. We also construct a set of control variables using the NLSY's information on age, race, gender,

⁴Measurement error is a concern with self-reported weight and height as people may underreport their weight or exaggerate their height. Cawley (1999) proposes a correction that uses the NHANES, which includes both actual and self-reported weight and height, to estimate actual BMI as a function of self-reported BMI and a variety of demographic characteristics. The correlation between actual and self-reported BMI is very high, though, and employing the correction does not typically significantly alter coefficient estimates (Cawley, 1999; Lakdawalla and Philipson, 2002). We therefore do not employ the correction in this paper.

marital status, education, income, and work hours. As dependent variables in falsification tests, we utilize binary variables reflecting whether the respondents have arthritis, asthma, anemia, chronic kidney or bladder problems, chronic stomach problems, frequent colds, or frequent headaches.

We restrict our analysis to the 2006 wave of the NLSY – by which point only 6592 individuals remained in the panel – as in that year the survey includes two questions on hypothetical intertemporal trade-offs that allow for the computation of discount factors. The first is,

"Suppose you have won a prize of \$1000, which you can claim immediately. However you have the alternative of waiting one year to claim the prize. If you do wait, you will receive more than \$1000. What is the smallest amount of money in addition to the \$1000 you would have to receive one year from now to convince you to wait rather than claim the prize now?"

We compute respondents' discount factors – which we name "Discount Factor 1" ($DF1$) – from their answers ($amount1$) as follows:

$$DF1 = \frac{1000}{1000 + amount1}. \quad (7)$$

The second question is:

"Suppose you have won a prize of \$1000, which you can claim immediately. However, you can choose to wait one month to claim the prize. If you do wait, you will receive more than \$1000. What is the smallest amount of money in addition to the \$1000 you would have to receive one month from now to convince you to wait rather than claim the prize now?"

We use these answers ($amount2$) to compute annualized (via simple multiplication) dis-

count factors – named "Discount Factor 2" ($DF2$) – through the following formula:

$$DF2 = \frac{1}{12 / \frac{1000}{1000 + amount2} - 11}. \quad (8)$$

Discount factor 1 is our preferred measure, as the question uses a one year delay and does not require annualizing from a shorter period. As robustness checks, we explore the sensitivity of the results to the use of discount factor 2 or an average of discount factors 1 and 2. In unreported regressions, we also verified that the conclusions reached are similar using discount rates instead of factors.

Some economists object that hypothetical questions, such as the ones above, provide no incentive for respondents to carefully assess the intertemporal trade-off and thus may not be representative of individuals' true preferences. However, at least in the domain of time preferences, several studies have demonstrated no difference in responses between real and hypothetical decisions (Johnson and Bickel, 2002; Madden et al., 2003). Of studies demonstrating a difference between real versus hypothetical time discounting decisions, Kirby and Marakovic (1995) found that subjects discounted real amounts more impatiently, whereas Collier and Williams (1999) found that respondents discounted real amounts more patiently. Taken together, these studies suggest that there is no systematic bias between the temporal discounting of real versus hypothetical amounts.

We also utilize the answer to a 2006 NLSY question on risk preference as a control in order to address the possible concern that time and risk preference are correlated. This question is:

"Suppose you have been given an item that is either worth nothing or worth \$10,000. Tomorrow you will learn what it is worth. There is a 50-50 chance it will be worth \$10,000 and a 50-50 chance it will be worth nothing. You can wait to find out how much the item is worth, or you can sell it before its value is determined. What is the lowest price that would lead you to sell the item now

rather than waiting to see what it is worth?"

We match these individual-level data to local price information from the second quarter of 2006 taken from the C2ER's American Chamber of Commerce Researchers Association Cost of Living Index (ACCRA COLI). The second quarter 2006 ACCRA COLI computes prices for a wide range of grocery, energy, transportation, housing, health care, and other items in 311 local markets throughout the US. Most of these local markets are single cities, but some are multiple cities (i.e. Bloomington-Normal, IL) while others are entire counties (i.e. Dare County, NC). We use the county identifiers from the restricted version of the NLSY to match each respondent to the closest ACCRA COLI market. This leads to measurement error in the price variables that increases with distance from the nearest ACCRA COLI market. To mitigate potential attenuation bias in the coefficient estimators for the price variables, we drop the 919 respondents living in counties greater than 50 miles from the closest ACCRA COLI area. The conclusions reached are similar using 30, 40, 60, and 70 mile distance cutoffs. Our food price variable is the average price of the 19 reported food items, weighted by their share as given by the ACCRA COLI. Table 1 lists these items while giving their average prices and weights. We also construct a non-food price variable by taking the weighted averages of the price indices for housing, utilities, transportation, health care, and miscellaneous goods and services.

Tables 2 and 3 report the names, descriptions, means, and standard deviations of the variables used in the empirical analysis. Although the NLSY is not a random sample, it provides sampling weights that we use both in computing the summary statistics and in all regressions. Since the respondents were between 14 and 22 years old at the start of the panel, they are between 41 and 49 years old in our sample. The average BMI is 27.8; 40% of the sample is overweight but not obese, 19% is class I obese, and 10% is severely obese. 47% of respondents report currently attempting to lose weight. The mean discount factor is 0.6 using the annual delay question and 0.4 using the monthly delay question, corresponding to a 66% and 150% annual interest rate. Though this degree of financial impatience may appear

implausibly high, note that the NLSY questions explicitly establish receiving money immediately as the status quo. Measuring patience via this willingness to delay methodology yields greater elicited impatience than methods which do not impose an immediate intertemporal reference point (Loewenstein, 1988; Shelley, 1993; McAlvanah, 2010). Since higher discount factors indicate greater patience, the average respondent is more patient over longer delays, supportive of hyperbolic discounting or diminishing impatience.

4 Empirical Analysis

4.1 Discount Factor and BMI, Overweight, and Obesity

We begin the empirical analysis by estimating the association between discount factor and BMI. Our main regression equation is

$$BMI_i = \beta_0 + \beta_1 DF1_i + \beta_2 DEMO_i + \beta_3 HC_i + \beta_4 FIN_i + \beta_5 RISK_i + \varepsilon_i \quad (9)$$

where i indexes individuals. $DF1$ is the preferred discount factor measure described in Section 3. **DEMO** is a set of demographic controls including age and indicators for gender, race, and marital status. **HC** is a set of variables reflecting endowment of and investment in human capital; these include IQ (as measured by score on the Armed Forces Qualifying Test) and dummies for educational attainment. **FIN** is a set of controls relating to finances and labor market activity, including income, net worth, and work hours. We also include the square of income as prior research has documented an inverted U-shaped relationship between income and BMI (Lakdawalla and Philipson, 2002). Finally, $RISK$ is the measure of risk preference. We include the sets of control variables in an effort to isolate the ceteris paribus relationship between time preference and BMI. If levels of patience and BMI both differ systematically on the basis of age, gender, race, marital status, intelligence, education, income, net worth, time spent working, or risk preference, failing to adequately control for these variables may bias

the estimator of β_1 . Our model contains a much more detailed set of covariates than the two prior studies that examined the relationship between computed measures of time preference and BMI. Borghans and Golsteyn (2006) controlled for only age and sex, while Chabris et al. (2008) control for only age, sex, education, and depression symptoms. We begin with a simple regression of BMI on discount factor and then gradually add the sets of controls to build up to the full model (8). As robustness checks, we also estimate (8) replacing $DF1$ with $DF2$ and the average of $DF1$ and $DF2$.

Table 4 reports the results. Discount factor is statistically significant and negatively associated with BMI in all seven regressions. The magnitude of the effect remains similar across specifications, ranging from -0.7 to -1.0. All estimates are within a standard error of each other. The results imply that a one standard deviation increase in patience decreases BMI by an average of 0.22 to 0.31 units, or 1.39 to 1.97 pounds at the sample mean height of 67.3 inches. Though we are of course unable to control for every potential confounding factor, the fact that the results are not sensitive to the choice of covariates increases our confidence that our estimate reflects a *ceteris paribus* relationship between time preference and BMI, rather than a spurious relationship driven by omitted variables. The results for the control variables are generally consistent with prior research. Being male, black, or married, not having a college degree, having a lower net worth, and working longer hours all increase BMI. Additional income decreases BMI but at a diminishing rate. We do not find a statistically significant association between age, IQ, or risk preference and BMI conditional on time preference and the other regressors. The lack of an effect for age likely reflects the limited age range in the sample.

Table 5 displays the estimates of β_1 splitting the sample by gender and race, using discount factor 1 and the full set of control variables. The effect of discount factor on BMI is strong and significant for men, and still negative but smaller and insignificant for women. When stratifying by race, discount factor's impact is strong and significant for whites but small and insignificant for non-whites.

We next estimate the association between discount factor and probability of being overweight, Class I obese, or severely obese using an ordered probit model. Since an increase in BMI is not harmful to health throughout the entire distribution and actually improves health at the far left tail, it is important to verify that weight gain caused by impatience is accompanied by increased odds of becoming overweight or obese. We estimate

$$P(CATEGORY_i = j) = \Phi(\alpha_j - (\gamma_0 + \gamma_1 DF1_i + \gamma_2 \mathbf{DEMO}_i + \gamma_3 \mathbf{HC}_i + \gamma_4 \mathbf{FIN}_i + \gamma_5 \mathbf{RISK}_i + \mu_i)) \quad (10)$$

where

$$CATEGORY = \begin{cases} 0 & \text{if } BMI < 25 \\ 1 & \text{if } 25 \leq BMI < 30 \\ 2 & \text{if } 30 \leq BMI < 35 \\ 3 & \text{if } BMI \geq 35 \end{cases}$$

and Φ is the cumulative distribution function for the standard normal distribution. Table 6 reports the estimate of γ_1 as well as the marginal effects of discount factor on the probabilities of being overweight, obese, or severely obese. Discount factor is statistically significant at the 5% level and its coefficient estimate is negative, indicating that greater patience is associated with a lower BMI category. The marginal effect of discount factor on $P(\text{Overweight})$ is a modest -0.002 and is only marginally significant. The marginal effects on $P(\text{Class I Obese})$ and $P(\text{Severely Obese})$, however, are -0.026 and -0.024 and are significant at the 5% level. These effects are sizeable, representing 14% and 25% of the sample Class I obesity and severe obesity rates.

We close this section with a series of falsification tests. First, we re-estimate (8) using height in inches instead of BMI as the dependent variable. Since it is implausible that impatience affects BMI by making people shorter rather than increasing their weight, such a finding would call into question the validity of the identification strategy. We then utilize as dependent variables chronic health conditions that are less directly the result of intertemporal

choices than BMI. These conditions include arthritis or rheumatism; asthma; kidney or bladder problems; stomach, liver, intestinal, or gall bladder problems; anemia; frequent colds, sinus problems, hay fever, or allergies; and frequent or severe headaches, dizziness, or fainting spells. We also consider a dependent variable representing the total number of these conditions reported. These health problems are less clearly tied to eating and exercise than obesity, so any meaningful "effect" of discount factor likely reflects a mis-specified model rather than a causal effect. We estimate linear models for height, probit models for the individual health conditions, and a Poisson model for the total number of conditions. Table 7 reports the marginal effects. Discount factor is never significant at the 5% level and is only significant at the 10% level in one of the nine regressions. These results increase our confidence that the findings for BMI are not the artifact of omitted variables correlated with patience and either health or stature. The falsification tests also help alleviate concerns about reverse causality, as having a high BMI might decrease an individual's life expectancy and thereby cause her to optimize over a shorter time horizon. If this were the case, discount factor should be correlated with all health problems regardless of whether they are the direct result of behaviors.

4.2 Interaction of Discount Factor and Food Prices

We next test the second prediction of the theoretical model and examine heterogeneity in the effect of local food prices on BMI on the basis of discount factor. The decline in real food prices in recent decades is generally regarded as a contributing factor to the rising obesity rate (Lakdawalla and Philipson, 2002; Chou et al., 2004). Changing economic incentives such as falling food prices may explain the increase in the mean of the BMI distribution, but do not explain why the variance of the distribution has also increased. We hypothesize that changing incentives have interacted with individuals' levels of patience to both shift the BMI distribution to the right and thicken its tails. Testing for an effect of the interaction of discount factor and food prices provides a preliminary test of this theory.

The regression equation is similar to (8) but adds local food prices ($PFOOD$), non-food prices (PNF), and the interaction of food prices with discount factor:

$$\begin{aligned}
BMI_{ic} = & \beta_0 + \beta_1 DF1_{ic} + \beta_2 \mathbf{DEMO}_i + \beta_3 \mathbf{HC}_i + \beta_4 \mathbf{FIN}_i + \beta_5 \mathbf{RISK}_i + \beta_6 PFOOD_c \\
& + \beta_7 (DF1_{ic} * PFOOD_c) + \beta_8 PNF_c + \varepsilon_i
\end{aligned} \tag{11}$$

where c indexes counties.⁵ Controlling for non-food prices helps ensure that the estimated effects of food prices are not simply capturing a more general price effect. The endogeneity of food prices is a natural concern. However, note that the regressor of interest in equation (10) is the interaction of food price with discount factor, not food price itself. Even if the coefficient estimator for food price is biased by unobservable market-level factors affecting both food prices and weight, the estimator for the interaction term would only be biased if the effect of these unobservables differs systematically for people with different discount factors. It is not obvious why this would be the case.⁶

Table 8 displays the results, starting with a model with no controls and gradually building up to the full specification in column (5). Columns (6) and (7) again experiment with the alternative discount factor measures. One potential concern with all of these models is that the food basket used to compute market prices contains both healthy and unhealthy items, whereas the rise in obesity may be the result of cheaper junk food rather than lower across-the-board food prices. In columns (8) and (9) we therefore experiment with dropping the (arguably) healthier items from the food basket in an attempt to isolate the price of unhealthy food. Column (8) excludes the fruits and vegetables (lettuce, bananas, potatoes, peas, peaches, and corn). Column (9) also excludes the meats (steak, beef, chicken, sausage, eggs, tuna, and chicken frozen dinner), meaning that food prices represent the weighted average prices of only

⁵In unreported regressions, we verified that the standard errors remain virtually identically clustering by county.

⁶In unreported regressions, we also attempted a panel data specification using the variation in city food prices over time. Due to the limited sample size, the fixed effects specification did not permit meaningful precision.

white bread, cereal, potato chips, and the three restaurant meals.⁷

The coefficient estimate for food price is negative across all specifications, consistent with results from the literature (i.e. Chou et al., 2004). The interaction term is significant in all regressions and positively associated with BMI, supporting the prediction that more patient people respond less strongly than impatient people to changes in food prices. Importantly, the estimates from columns (8) and (9) are very similar to those from column (5), so our results are not sensitive to the use of alternative food baskets.

Figure 2 uses the estimates from the full model in column (5) to show how the marginal effect of food price on BMI changes across the discount factor distribution. The solid line shows the marginal effect, while the dashed lines represent the endpoints of the 95% confidence interval. A \$1 increase in food price (30% of the sample mean) decreases the BMIs of the most impatient individuals by almost 2 units, or 13 pounds at the sample mean height. This effect steadily weakens with additional patience, reaching zero at a discount factor of 0.67. Though the sign flips to positive after that point, at no point in the distribution is the marginal effect positive and significant.

Figures 3-5 illustrate how this heterogeneity in the food price effect can affect the variance of the BMI distribution. We perform an approximate median split and define "impatient" individuals as those with discount factors below 0.5 and "patient" individuals as those with discount factors above 0.5. We use the regression results from column (5) to plot the predicted BMI distributions for the two groups at the sample mean food price of \$3.35, as well as at \$0.40 above and below the mean. We choose \$0.40 above and below the mean because, according to Consumer Price Index (CPI) data from the Bureau of Labor Statistics, the real price of food at home fell by 12% during the 50 years preceding the survey year 2006, and

⁷In an unreported regression we included separate variables for the prices of fruits/vegetables, meats, and other (unhealthy) foods, along with interactions of these three food prices with discount factor. The coefficient estimates for price and the interaction of price and discount factor were both much larger for "other" foods than for fruits/vegetables and meats, suggesting that consumers' BMIs – and the BMIs of impatient consumers in particular – are most responsive to the prices of unhealthy foods. However, multicollinearity among the price variables prevented any of the price variables or interaction terms from being statistically significant. We therefore consider these findings speculative and do not present them in the paper.

12% of our sample mean food price is \$0.40.⁸ Figure 3 therefore represents the predicted BMI distributions of patient and impatient individuals at 1956 food prices, Figure 4 shows the distributions at 2006 prices, and Figure 5 presents the distributions if the price of the food basket falls by another \$0.40 in the future. Figure 3 shows that at 1956 food prices the predicted BMI distributions of impatient and patient people are virtually on top of each other. As food prices fall to 2006 levels in Figure 4, a difference between the two distributions emerges and impatient individuals have higher predicted BMIs than patient ones. Figure 5 projects that if real food prices fall further in the future the gap between the two groups will widen even more.

4.3 Discount Factor and Trying to Lose Weight

We close the empirical analysis by providing a preliminary attempt to determine whether the observed relationship between time preference and BMI reflects rational intertemporal substitution or self-control problems, a distinction that holds critical policy implications as discussed in the introduction. Although the data do not allow for a direct test, we perform an indirect test motivated by the literature. Ruhm (2010) considers attempts to lose weight as an admission of past mistakes in optimization resulting from impulsive choices. An individual may weigh more than the medical optimum but not more than the utility-maximizing optimum if her weight is the result of rational trade-offs between food consumption and health. We would not expect such an individual to be attempting to lose weight, barring a sudden shift in preferences or budget. Following this logic, if the estimated effect of time preference on BMI is not accompanied by an effect on weight loss attempts, it would be consistent with the rational utility-maximization model presented in Section 2. If impatient people do have more frequent weight loss attempts, then impulsive behavior is likely at work and a model featuring time-inconsistent discounting may be more appropriate.

We estimate the relationship between time preference and the probability an individual is

⁸After adjusting for changes in the overall CPI, the CPI for food at home dropped from 219.4 to 193.1 between 1956 and 2006, a decline of 12%.

attempting to lose weight (*ATT*) with the following probit model:

$$P(ATT_i = 1) = \Phi(\theta_0 + \theta_1 DF1_i + \theta_2 \mathbf{DEMO}_i + \theta_3 \mathbf{HC}_i + \theta_4 \mathbf{FIN}_i + \theta_5 \mathbf{RISK}_i + \nu_i) \quad (12)$$

along with models experimenting with the different subsets of control variables and alternative measures of time preference. We also consider a specification that controls for BMI and therefore tests whether patient and impatient individuals with the same weight differ in their frequency of weight loss attempts. Table 9 reports the marginal effects. We find no evidence in any regression of a link between discount factor and weight loss attempts, consistent with the rational model.

In addition, we constructed an index of time-inconsistency utilizing the ratio of discount factors elicited over a monthly versus yearly interval, $\frac{DF1}{DF2}$. If individuals are time-consistent, then the (annualized) monthly discount factor should be identical to that of the annual discount factor. If, however, individuals exhibit hyperbolic discounting or decreasing impatience, then the discount factor over a yearly interval will be larger than the discount factor over a monthly interval and $\frac{DF1}{DF2} > 1$. In unreported regressions, we included this index of time-inconsistency in the BMI regressions and the above probit regressions on attempting to lose weight. Though the index of time-inconsistency had the expected sign, with more time-inconsistent individuals reporting more frequent weight loss attempts, it was never statistically significant.

It is critical to point out that these results do not suggest that self-control problems play no role in determining body weight, only that any self-control problems that do exist are not captured by surveyed rates of time preference such as those of the NLSY. Put differently, our findings suggest that some overweight and obesity is rational, not necessarily that all of it is rational. Ruhm (2010) models eating decisions as driven by conflicts between two parts of the brain: a rational "deliberative system" and an impulsive "affective system". One can therefore interpret our results as simply showing that the deliberative system is in control

when respondents answer questions on hypothetical intertemporal trade-offs.

5 Conclusion

This study investigates the connection between time preference, food prices, and BMI. We present a theoretical model predicting that greater impatience should both increase BMI and that impatient people should be more responsive to falling food prices. We then test these predictions using the 2006 NLSY matched with local price data from C2ER. Time preference is significantly associated with BMI and the probabilities of being overweight and obese. The effects are robust to specification changes and strongest for white males. Patience and food prices interact in the predicted manner, suggesting that impatient individuals are primarily responsive to food prices whereas patient individuals are responsive to both food prices and health effects. Our results potentially help to explain the rightward shift in the BMI distribution in recent decades as well as the most dramatic increase in the right tail. Finally, we show that the link between time preference and BMI is not accompanied by a corresponding impact on weight loss attempts, suggesting that the observed relationship reflects rational intertemporal substitution rather than impulsive behavior. Future research should investigate whether other economic incentives besides food prices might also interact with individuals' rates of time preference in determining weight. Additional research should continue to focus on the influence of self-control problems on weight and the corresponding policy implications.

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Table 1 – ACCRA COLI Food Items

Item	Average Price	Weight
1 oz white bread	1.175	0.0861
18 oz box of corn flakes; Kellogg's or Post	2.987	0.0399
Head of iceberg lettuce	1.219	0.0267
1 lb bananas	0.518	0.0555
10 lb sack potatoes	3.753	0.0264
15 oz can sweet peas; Del Monte or Green Giant	0.826	0.0110
29 oz halves or slices peaches; Hunts, Del Monte, or Libby's	1.805	0.0127
16 oz whole kernel frozen corn	1.240	0.0110
1 lb t-bone steak	8.383	0.0354
1 lb ground beef	2.539	0.0354
1 lb whole uncut chicken	1.057	0.0440
1 lb package sausage; Jimmy Dean or Owen	3.183	0.0454
Dozen large eggs; grade A or AA	1.150	0.0100
6 oz chunk of light tuna; Starkist or Chicken of the Sea	0.746	0.0378
8 to 10 oz frozen chicken entree; Healthy Choice or Lean Cuisine	2.538	0.0876
12 oz plain regular potato chips	2.419	0.0730
1/4 lb patty with cheese; McDonald's	2.549	0.1133
11" to 12" thin crust cheese pizza; Pizza Hut or Pizza Inn	10.250	0.1133
Thigh and drumstick of chicken; Kentucky Fried Chicken or Church's	2.863	0.1133

Table 2 – Summary Statistics for Body Weight and Time Preference Variables

Variable Name	Description	Mean (Std.Dev.)
BMI	Body mass index (kg/m ²)	27.810 (5.397)
Overweight	Binary variable equal to 1 if $25 \leq \text{BMI} < 30$	0.395 (0.489)
Obese (class I)	1 if $30 \leq \text{BMI} < 35$	0.188 (0.391)
Severely obese	1 if $\text{BMI} \geq 35$	0.097 (0.296)
Lose weight	1 if trying to lose weight	0.466 (0.499)
Discount factor 1	Computed from amount needed to wait a year to receive \$1000	0.595 (0.256)
Discount factor 2	Computed from amount needed to wait a month to receive \$1000	0.389 (0.307)

Notes: Observations are weighted using the NLSY sampling weights. All variables are from 2006 survey unless otherwise indicated.

Table 3 – Summary Statistics for Other Variables

Variable Name	Description	Mean (Std.Dev.)
Age	Age in years	44.880 (2.293)
Female	1 if female	0.481 (0.500)
Race: black	1 if race is black	0.135 (0.341)
Race: other	1 if race is neither black nor white	0.026 (0.158)
Married	1 if married	0.634 (0.482)
AFQT	Percentile score on armed forces qualifying test in 1985	48.735 (28.632)
High school	1 if highest grade completed=12	0.412 (0.492)
Some college	1 if 13≤highest grade completed≤15	0.233 (0.423)
College	1 if highest grade completed=16	0.280 (0.449)
Income	Total household income (units of \$10,000)	8.288 (8.405)
Net Worth	Household assets minus liabilities in 2004	25.772 (47.195)
Hours worked	Average hours worked per week in the preceding year	35.569 (19.657)
Risk	Amount needed to forego a 50% chance of \$10,000 or \$0	4797.196 (3277.271)
Arthritis	1 if ever had arthritis or rheumatism	0.121 (0.327)
Asthma	1 if asthmatic	0.070 (0.255)
Kidney/Bladder	1 if kidney or bladder problems	0.045 (0.208)
Stomach	1 if trouble with stomach, liver, intestines, or gall bladder	0.100 (0.300)
Anemia	1 if anemic	0.045 (0.207)
Colds	1 if frequent colds, sinus problems, hay fever, or allergies	0.254 (0.435)
Headaches	1 if frequent or severe headaches, dizziness, or fainting spells	0.106 (0.308)
Food price	Weighted average price of 19 food items	3.345 (0.293)
Non-food index	Weighted average price index of non-food price categories	105.636 (18.101)

See notes for Table 2.

Table 4 – Effect of Discount Factor on BMI

	Dependent Variable: BMI						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Discount factor	-0.998 (0.308)***	-0.885 (0.309)***	-0.693 (0.312)**	-0.696 (0.318)**	-0.815 (0.321)***	-0.773 (0.269)***	-0.997 (0.328)***
Age	-	0.026 (0.033)	0.030 (0.034)	0.033 (0.035)	0.037 (0.035)	0.034 (0.035)	0.037 (0.035)
Female	-	-1.144 (0.154)***	-1.115 (0.153)***	-0.949 (0.162)***	-0.954 (0.163)***	-0.945 (0.163)***	-0.953 (0.163)***
Race: black	-	1.921 (0.174)***	1.733 (0.196)***	1.681 (0.202)***	1.690 (0.203)***	1.675 (0.204)***	1.675 (0.203)***
Race: other	-	0.603 (0.405)	0.452 (0.409)	0.431 (0.412)	0.391 (0.418)	0.368 (0.415)	0.379 (0.416)
Married	-	-0.048 (0.166)	0.100 (0.170)	0.648 (0.198)***	0.660 (0.197)***	0.664 (0.197)***	0.663 (0.197)***
AFQT	-	-	-0.003 (0.004)	0.0004 (0.004)	0.001 (0.004)	0.001 (0.004)	0.001 (0.004)
High school	-	-	0.074 (0.326)	-0.006 (0.334)	0.044 (0.337)	0.027 (0.337)	0.034 (0.337)
Some college	-	-	-0.141 (0.360)	-0.148 (0.369)	-0.104 (0.373)	-0.117 (0.373)	-0.111 (0.373)
College	-	-	-1.211 (0.382)***	-0.809 (0.396)**	-0.738 (0.400)*	-0.763 (0.400)*	-0.747 (0.400)*
Income	-	-	-	-0.128 (0.031)***	-0.128 (0.031)***	-0.131 (0.031)***	-0.129 (0.031)***
Income ²	-	-	-	0.002 (0.001)***	0.002 (0.001)***	0.002 (0.001)***	0.002 (0.001)***
Net worth	-	-	-	-0.007 (0.002)***	-0.006 (0.002)***	-0.006 (0.002)***	-0.006 (0.002)***
Work hours	-	-	-	0.022 (0.004)***	0.022 (0.004)***	0.022 (0.004)***	0.022 (0.004)***
Risk	-	-	-	-	-0.00003 (0.00002)	-0.00003 (0.00002)	-0.00003 (0.00002)
Discount factor measure	DF1	DF1	DF1	DF1	DF1	DF2	Avg.
Observations	6592	6588	6570	6226	6116	6116	6116

Notes: Heteroskedasticity-robust standard errors in parentheses. *** statistically significant at 1% level; ** 5% level; * 10% level. Observations are weighted using the NLSY sampling weights.

Table 5 – Heterogeneity by Gender and Race

	Dependent Variable: BMI			
	Gender		Race	
	Women	Men	White	Non-White
Discount factor	-0.620 (0.496)	-1.051 (0.406)***	-0.928 (0.374)***	-0.208 (0.527)
Demographics	YES	YES	YES	YES
Human capital	YES	YES	YES	YES
Financial	YES	YES	YES	YES
Risk	YES	YES	YES	YES
Discount factor measure	<i>DF1</i>	<i>DF1</i>	<i>DF1</i>	<i>DF1</i>
Observations	3048	3068	3975	2141

Notes: Heteroskedasticity-robust standard errors in parentheses. *** statistically significant at 1% level; ** 5% level; * 10% level. Observations are weighted using the NLSY sampling weights. "Demographic" controls include age, gender, race, and marital status. "Human capital" controls include AFQT score and the education dummies. "Financial" controls include income, income², net worth, and work hours.

Table 6 – Ordered Probit Results

Variable	Dependent Variable: BMI Category			
	Coefficient Estimate	Marginal Effects		
		Overweight	Obese (Class 1)	Severely Obese
Discount factor	-0.147 (0.066)**	-0.002 (0.001)*	-0.026 (0.011)**	-0.024 (0.011)**
Demographics	YES	YES	YES	YES
Human capital	YES	YES	YES	YES
Financial	YES	YES	YES	YES
Risk	YES	YES	YES	YES
Discount factor measure	<i>DF1</i>	<i>DF1</i>	<i>DF1</i>	<i>DF1</i>
Observations	6116	6116	6116	6116

See notes for Table 5.

Table 7 – Falsification Tests Using Various Health Conditions

	Dependent Variables:										Number of Conditions
	Height	Arthritis	Asthma	Kidney/ Bladder	Stomach	Anemia	Colds	Headaches			
Discount factor	-0.135 (0.156)	0.017 (0.019)	-0.014 (0.014)	0.013 (0.010)	-0.013 (0.017)	-0.002 (0.009)	-0.045 (0.026)*	-0.008 (0.017)			-0.045 (0.055)
Demographics	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Human capital	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Financial	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Risk	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Discount factor measure	DF1	DF1	DF1	DF1	DF1	DF1	DF1	DF1	DF1	DF1	DF1
Observations	6116	6108	6104	6104	6102	6102	6106	6106	6106	6106	6083

Marginal effects reported in all regressions. See other notes for Table 5.

Table 8 – Interaction Effects of Food Prices with Discount Factor

	Dependent Variable: BMI								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Discount factor	-8.812 (3.866)**	-8.487 (3.842)**	-8.886 (3.832)**	-9.546 (3.973)**	-9.820 (3.999)**	-6.895 (3.261)**	-10.183 (3.921)**	-10.023 (4.124)**	-10.295 (4.334)**
Food price	-1.358 (0.798)*	-1.418 (0.787)*	-1.650 (0.790)**	-1.836 (0.819)**	-1.790 (0.828)**	-0.846 (0.604)	-1.498 (0.731)**	-1.676 (0.775)**	-1.408 (0.706)**
Non-food index	-0.006 (0.007)	-0.006 (0.007)	-0.001 (0.007)	0.008 (0.007)	0.007 (0.007)	0.007 (0.007)	0.007 (0.007)	0.007 (0.007)	0.004 (0.006)
Discount factor*food price	2.304 (1.142)**	2.249 (1.134)**	2.424 (1.130)**	2.621 (1.175)**	2.681 (1.183)**	1.774 (0.958)*	2.702 (1.155)**	2.507 (1.116)**	2.347 (1.067)**
Demographics	NO	YES	YES	YES	YES	YES	YES	YES	YES
Human capital	NO	NO	YES	YES	YES	YES	YES	YES	YES
Financial	NO	NO	NO	YES	YES	YES	YES	YES	YES
Risk	NO	NO	NO	NO	YES	YES	YES	YES	YES
Discount factor measure	DF1	DF1	DF1	DF1	DF1	DF2	Avg.	DF1	DF1
Food price measure	1	1	1	1	1	1	1	2	3
Observations	5605	5602	5587	5289	5197	5197	5197	5197	5197

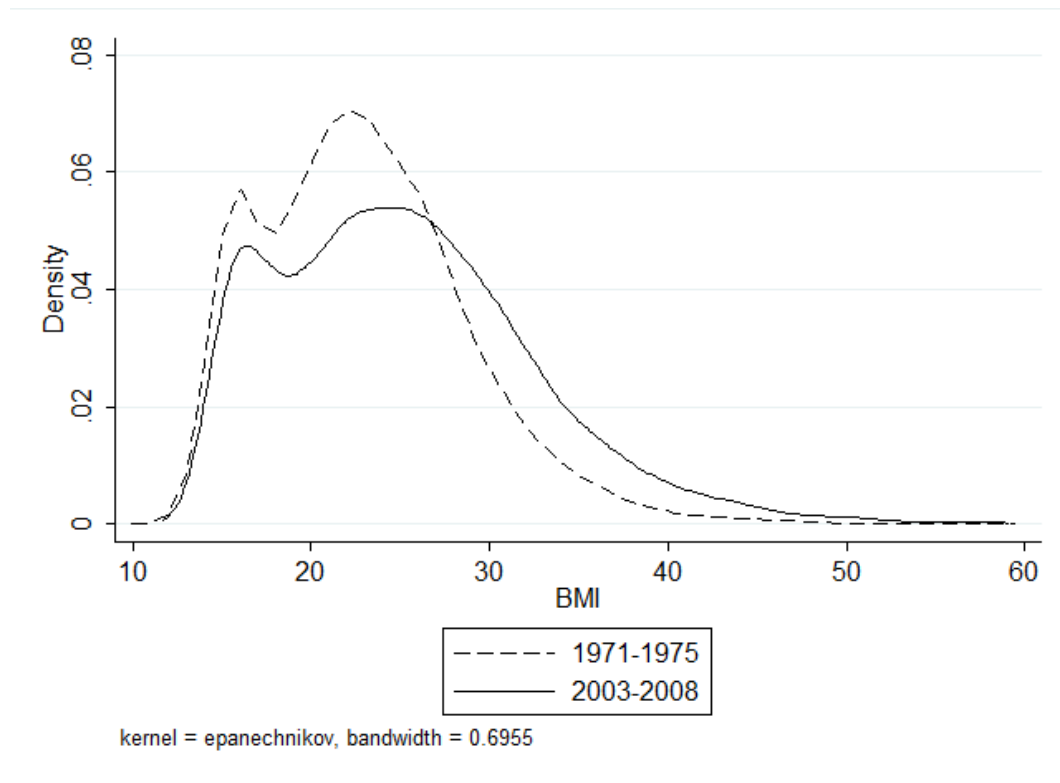
Food price measure 1 is based on the full basket of food items, measure 2 excludes fruits and vegetables, and measure 3 further excludes meats. See other notes for Table 5.

Table 9 – Probit Results for Trying to Lose Weight

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Discount factor	0.010 (0.028)	0.019 (0.029)	-0.002 (0.029)	0.002 (0.030)	-0.004 (0.031)	-0.004 (0.025)	-0.005 (0.031)	0.031 (0.033)
Demographics	NO	YES	YES	YES	YES	YES	YES	YES
Human capital	NO	NO	YES	YES	YES	YES	YES	YES
Financial	NO	NO	NO	YES	YES	YES	YES	YES
Risk	NO	NO	NO	NO	YES	YES	YES	YES
BMI	NO	NO	NO	NO	NO	NO	NO	YES
Discount factor measure	DF1	DF1	DF1	DF1	DF1	DF2	Avg.	DF1
Observations	6592	6588	6570	6226	6116	6116	6116	6116

Marginal effects reported in all columns. See other notes for Table 5.

Figure 1 – Change in BMI Distribution from 1971-1975 to 2003-2008



The 1971-1975 distribution is estimated using the National Health and Nutrition Examination Survey (NHANES) I, while the 2003-2008 distribution is estimated by pooling the 2003-2004, 2005-2006, and 2007-2008 NHANES. Between 1971-1975 and 2003-2008, the mean of the BMI distribution rose from 23.0 to 25.3 while the standard deviation increased from 5.9 to 7.4.

Figure 2 – Marginal Effect of Food Price on BMI Across Discount Factor Distribution

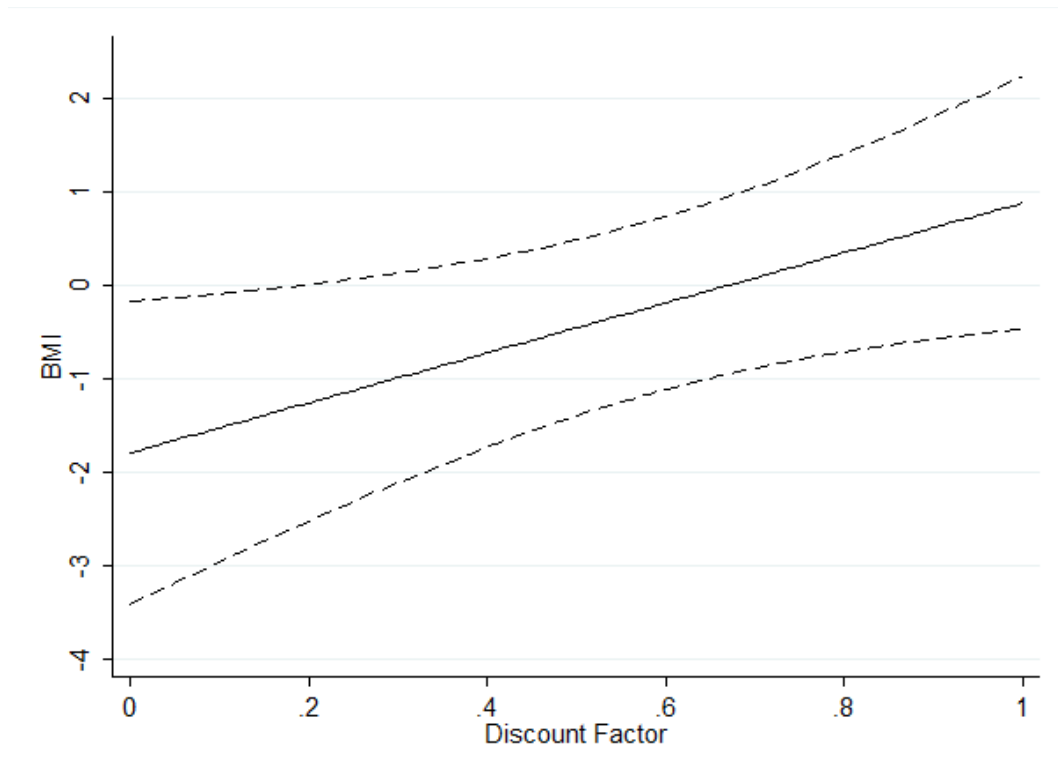


Figure 3 – BMI Distributions for Impatient and Patient Individuals if Food Price=\$3.75

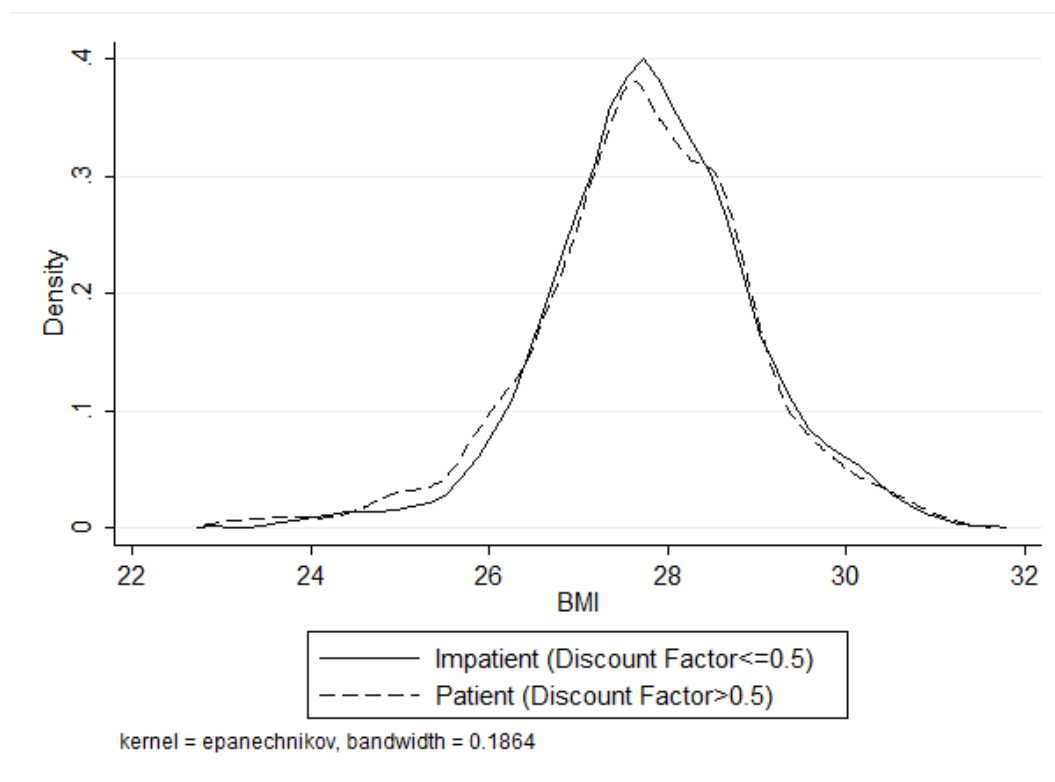


Figure 4 – BMI Distributions for Impatient and Patient Individuals if Food Price=\$3.35

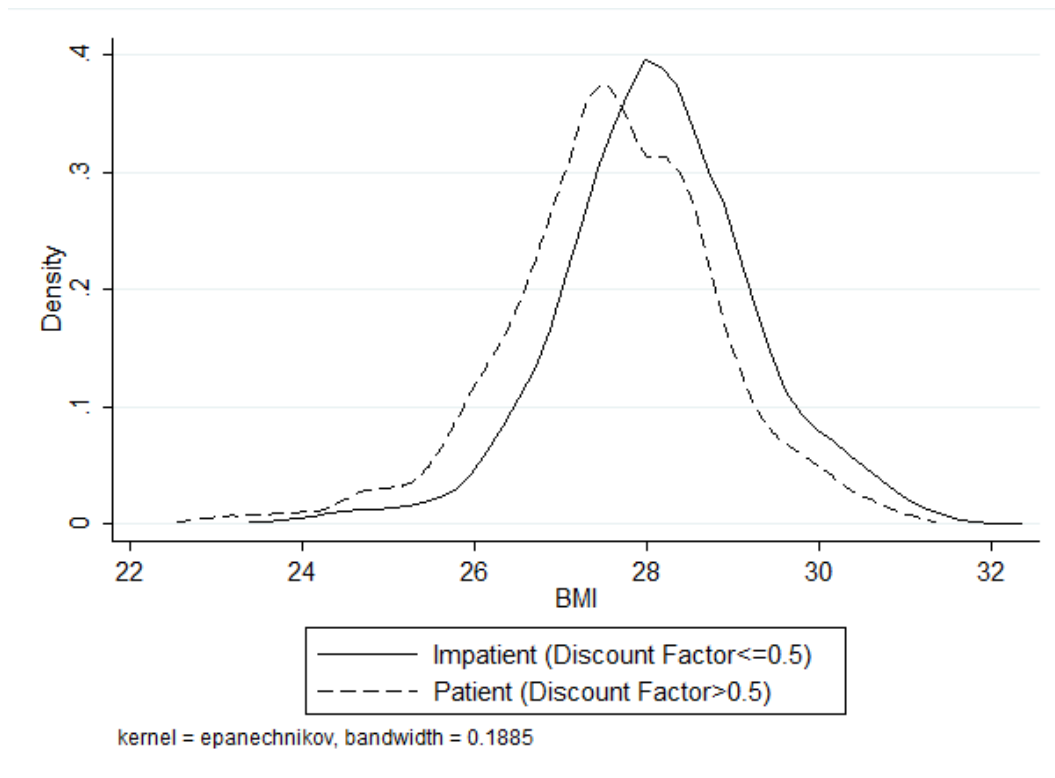


Figure 5 – BMI Distributions for Impatient and Patient Individuals if Food Price=\$2.95

