OBESITY AS A FUNCTION OF EFFICIENCY IN THE ALLOCATION OF TIME AND OPTIMALITY IN CONSUMPTION: A THEORETICAL AND EMPIRICAL EXAMINATION

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Kian Alexander Pirouz

Certificate of Approval

John Jackson
Professor
Economics

Richard O. Beil, Chair
Associate Professor
Economics

James E. Long
Professor
Economics

Stephen L. McFarland
Dean
Graduate School

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Kian Alexander Pirouz

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Kian Alexander Pirouz

Signature of Author

Date

VITA

Kian Alexander Pirouz, son of Masoud and Becky Pirouz, was born February 28, 1982 in Atlanta, Georgia. He graduated from Alan C. Pope High School in Marietta, Georgia in 2000. He attended Auburn University in Auburn, Alabama where he graduated with a Bachelor of Science in Business Administration (Economics) in 2004 before he entered The Graduate School at Auburn University in August 2004. He is the proud brother of fellow Auburn University attendee, Cameron P. Pirouz.

THESIS ABSTRACT

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Kian Alexander Pirouz

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The goal of this thesis is to examine the relationship between economic conditions, such as allocative efficiency, utility maximization and time costs, and obesity. A theory is developed and two empirical models tested. The theory attempts to explain why people become obese as a function of personal choices, technological innovation and their environment. The first empirical model, developed using 2002 data on all 50 states and D.C., is used to explain variances in state level obesity and should be thought of as how peoples environment affect the body mass index. The second model is developed using roughly 11,000 observations and is used to show how people's individual choices affect their body mass index. In the conclusion the results are compared and the significant variables commented on.

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TABLE OF CONTENTS

LIST OF TABLES

I. INTRODUCTION

Obesity is one of the largest public health problems that we face today. We address the problems of cigarette smoking and alcoholism with aggressive campaigns to stop their spread and yet stopping the spread of obesity, which is the second largest cause of preventable death in the United States (American Obesity Association (AOA))[1], gets little attention. This fact is astonishing considering that, in 2000, an estimated $117 billion was spent on direct and indirect medical costs associated with obesity (AOA). That amounts to about ten percent of total health care costs for that year. Unlike other major heath concerns obesity does not receive the public education and awareness that is necessary to prevent its spread. The American Dietetic Association (ADA)[2] concludes, "Nutrition [education] -- one of the most cost-effective preventive treatments available to the American public -- remains a minor priority in federal research funding, with approximately four cents of every $100 spent on health care in the United States directed toward nutrition research". It is important as a society to try and isolate the factors and behaviors that contribute to this disease so that we may curb its prevalence for future generations.

It was not until recently that economists began to study what economic choices help to facilitate the spread of obesity. Only as health economists have started to explain

[1] This information can be found at the following website: www.obesity.org
[2] This information can be found at the following website: www.eatright.org

the underlying rationale, to why people make choices that tend to cause obesity, has the subject matter received attention from an economic perspective. In the respect that economics is the study of the efficient allocation of scarce resources it seems strange that so little time has been devoted to the subject matter. For if choice related obesity is a result of any economic conditions it must be those of utility maximization and allocative efficiency. It is the goal of this thesis to advance these ideas and attempt to contribute to the advancement of this field and of this particular subject.

The next chapter provides an overview of why obesity has grown to epidemic proportions as well as some of the consequences that we face as a result of this growth. Explanations are presented on how increases in food consumption as well as innovations in the food preparation and preservation fields lead to less nutritious diets that, paired with more complacent lifestyles contribute to obesity.

Chapter III is a literature review that consists of nine articles which are both directly and indirectly related to obesity research. Five of the papers come from the *National Bureau for Economic Research* (NBER) Working Paper Series that primarily focus on obesity. Two of these papers focus on developing the idea of obesity as a function of technological change. The third such paper focuses on the impact of technological change as well as numerous other factors. The fourth paper in the series tries to isolate the impact of various different lifestyle choices on obesity. The last of the five is a study about the impact obesity has on an obese person's life from an economic stand point. The other four papers focus on the impact of health capital, schooling, income and economic conditions, respectively, on the demand for health. All of these papers are important in developing a unified model and each one contributed in a unique manner.

In Chapter IV a unified model is developed and presented. This chapter includes a proposed model of what factors contribute to obesity as well as the economic reasoning as to how these variables affect obesity. The purpose of this chapter is to establish an economic rationale for obesity and to attempt to explain why people would behave in a manner that is most likely to result in obesity. A theory on allocative efficiency, utility maximization and cost/benefit analysis all with respect to time and opportunity costs is presented.

Using the theoretical model, two empirical models are developed which are presented in Chapter V. This chapter includes Model (1) which uses individual-level data from the National Health and Nutritional Examination Survey (NHANES). The model includes seventeen explanatory variables that are regressed on body mass index (BMI). The second model, model (2), is developed using state-level data that comes primarily from the CDC's Behavioral Risk Factor Surveillance System (BRFSS) and the US Census Office. It uses ten explanatory variables which are regressed on state-level obesity rates. Both models are subjected to tests for heteroscadesticity, multicollinearity and specification errors. The results are discussed in the next chapter.

Chapter VI contains the results of the regressions as well as the testing procedures. In this chapter the "goodness of fit" for each model is discussed as well as why or why not certain variables show up as significant. Both models are compared to each other and any variables that may be significant in one model but not in the other are discussed. Chapter VII contains the summary and conclusions reached as a result of this research. This chapter also contains suggestions for improvements in this research as well as suggestions for further research.

Overall, this thesis is written with the intention of furthering research in the fields of obesity and health economics. There is still a lot of theory and empirics that have yet to be established and tested but hopefully studies are progressing in the right direction. In future research it is important to try and find the impact of increased health education on obesity. Also, broader scale research and examination must be conducted if more cogent answers are to be found. In addition a long term study that focuses specifically on obesity related factors is a necessary next step.

II. OVERVIEW OF OBESITY

Over the past three decades there has been a growing trend in the prevalence of obesity. While this trend has been felt internationally no other country has experienced growth in obesity as rapid as the U.S. As technology and innovation have grown so have our waistlines. We have become the byproduct of our resourcefulness and demand for convenience. "For most of the 20th century, weights were below levels recommended for maximum longevity, 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" (Cutler, et. al., 2003). The measure that medical science uses to classify "fatness" is referred to as a person's body mass index (BMI), calculated as weight in Kg divided by (Height in Meters) squared. According to the CDC an obese person has a BMI $\geq$ 30, an overweight person has a BMI between 25 – 29.9 and the healthy BMI range is considered to be 20 – 24.9.

The American Obesity Association (AOA) estimates that 127 million American adults are obese or overweight. With currently about 50% of US adults and 25% of US children obese/overweight, it is becoming apparent that the concerns surrounding this epidemic are not just about image anymore. In general it is thought that both environmental influences and technological innovation have been the main catalysts for the rising occurrence of this epidemic. Environmental influences and technological innovation cannot be considered the only direct sources of obesity and being overweight but rather a composite of factors that are widely attributed to the rising number of obese and overweight people. For instance one of the main environmental influences that has an effect on obesity is a decline in nutritionally balanced eating habits. While numerous studies link diets high in fats to obesity there has still been an increase of almost 30% in the amounts of fats and oils added to foods over the past three decades (French, et. al., 2001). There is a current trend showing a decrease in milk consumption paired with a 131% increase in soft drink consumption; making the consumption rate of high-sugar-soft-drinks increase faster than any other food group (French, et. al., 2001). This is alarming considering that it has been widely speculated that the recommended three servings of dairy a day is a necessary component of weight management (in large part because calcium is necessary for weight management) and that the rising consumption of processed sugar is thought to be highly correlated with the rise in obesity/overweight due to the extra calories associated with consuming it. But, it is not just about what we eat but about how much we eat and also how active we are.

The next section presents papers by Darius Lakdawalla and Thomas Philipson and Thomas Philipson and Richard Posner, which show obesity as a function of technological change. Both papers hypothesize that increases in technology have resulted in decreased food prices, increased food availability and decreased on the job physical labor exertion. Because of technological innovations that decrease preparation/cleaning time and cost, mass preparation of food and increased portion sizes have become common place (Cutler, et. al., 2003). As food has become more readily available and in larger quantities people have not adjusted their eating habits and this has in turn lead to an overall increase in the number of calories consumed per day. Cutler, et. al., (2003) predict that this effect is the result of people's self control problems. According to the National Center for Health Statistics (NCHS)[3] from 1977 to 1995 the percentage of meals and snacks eaten at fast food restaurants increased by 200%, probably due to the 147% increase in the number of fast food restaurants over that same time period. This paired with agricultural growth and preservation technology has provided us with readily available foods, increasing supply, lowering prices, and increasing food consumption. The growth in demand for food and fast food should lead to a price increase instead of the price decrease that we witness as a result of agricultural innovation. The failure to see a price increase as a result of increased demand means that the supply is growing at a faster rate than demand, keeping prices low. Without the capacity for an ever growing future demand the supply would not grow at this increased rate, forcing prices to increase as supply slows to the rate of demand. This food price increase would help to slow rising obesity rates (Lakdawalla & Philipson, 2002). As work becomes less physically strenuous there should be a reduction in the calories that are consumed because fewer calories are needed for expendable energy. This reduction in the demand for calories should lower the demand for food. Because food is a normal good as income raises food consumption normally rises. Paired with an increase in technology that has been shown to increase sedentary behavior, obesity will continue to rise.

With technology giving rise to less physically strenuous jobs the number of people who are getting the recommended amount of daily physical activity is declining. Sedentary behavior has become, unfortunately, part of the American lifestyle. Because of increases in the number of physically sedentary jobs the government has been

[3] This information can be found at the following website: www.cdc.gov/nchs/

consistently increasing the recommended amount of daily exercise (Hill & Peters, 1998). Increases in technology and its availability and higher stress jobs that provide less free time have become a major factor in the nation's obesity epidemic. There have been consistent small decreases in the number of people who partake in free time physical activity since 1986 as well as a decreasing rate of the average number of hours spent playing sports (French, et. al., 2001). Many of these decreases begin in our schools. Decreases in mandatory physical education because of budget cuts paired with lax physical education programs taught by under qualified instructors are creating an ideal environment for obesity to prevail (Hill & Peters, 1998). A recent study shows that Americans consider TV to be the least necessary part of their lives but devote more time to it than any other leisure time activity. Americans are watching more than 15 hours of TV per week, which means they spend almost 6 times more time watching TV than they do exercising or playing sports (NCHS). Studies also show people are less likely than in previous years to walk or bike for transportation in addition to there being a suspected decrease in the amount of physical energy used at work. There have been increases in the number of health clubs and sporting goods stores (as well as increased sales for both) but a consistent decrease in the amount of people who report using leisure time for exercise or physical activity. In 1998 people who had gym memberships only used them, on average, 85 days/yr. (French, et. al., 2001). This lack of demand for active leisure locations explains why only 46% of parks and recreation facilities provide fitness trails, 29% provide hiking trails and 21% provide bike trails (French, et. al., 2001). Basketball and tennis courts do not escape this category; despite their popularity as recreational sports their location numbers are lower than recommended (NCHS).

This rising occurrence of sedentary behavior, less nutritional balanced meals containing higher caloric contents and falling food prices have all been associated with the rising trend in obesity/overweight. There are many factors that contribute to the cause of obesity in individuals and why individuals continue to behave in a manner that likely result in obesity. The next two chapters of this thesis will provide the reader with an in depth literature review and theoretical models, respectively, which are intended to introduce the economic rationale for the behavior described above.

III. LITERATURE REVIEW

Within the field of health economics the study of obesity and the economic reasoning behind its increasing prevalence is a fledgling practice when compared to other facets of the discipline. Much of the research in the field of health economics is devoted to health problems associated with alcohol and tobacco consumption but until recently obesity has been mostly ignored. This is beginning to change as people both within and outside the scientific community take notice of the growing number of reported obesity cases. Now more than ever there is an influx of information on obesity, what factors within a society contribute to it, and what its costs are to society. The papers presented, as a literature review, in the following section combined with some original ideas are intended to provide evidence for the variables used in the unified theory presented in the next section. The literature review is presented in three parts. The first part is comprised of papers that comment on what the environmental influences on obesity are while the second part presents evidence for what the technological influences on obesity are. The third part is a brief summary of the nine articles highlighting the pertinent information that is most relevant to the unified theory presented in the subsequent section. By the conclusion of this section and the one following it all of the variables used in the subsequent models, as well as the theory behind why they are used, are explained.

ENVIRONMENTAL INFLUENCES:

"An Economic Analysis of Adult Obesity: Results from the Behavioral Risk Factor Surveillance System" by Chou, Grossman, and Saffer (2002) offers a strong theoretical framework from which a unified model evolved. The model is a cross sectional study done with data gathered from The Behavioral Risk Factor Surveillance System (BRFSS) from the years 1984-1999 and include per capita number of restaurants, prices of a meal in fast-food and full service restaurants, price of food consumed at home, the price of cigarettes, clean indoor air laws, hours worked per week, hourly wage rates by age, gender, race, years of formal schooling completed, and marital status (Chou,et. al., 2002). The model is developed as follows:

$$B_j = C_j - E_j \quad (1)$$

The above equation shows that obesity is a function of an individuals energy balance over time where B_j is the energy balance in period j, C_j is calories consumed in period j, and E_j is the amount of calories expended in period j. The authors transform the equation into an empirical model by explaining factors contributing to calorie expenditure, which is described below:

$$O = O(C, L, HC, EW, CS, A, G, R) \quad (2)$$

Where O is obesity, C is calories consumed, L is leisure time activity, HC is activity due to household chores, EW is energy expended during work, CS is cigarette smoking, A is age, G is gender, and R is racial and ethnic background. They go on to explain that the above model generates demand functions for calories consumed, active leisure, household chores, and cigarette smoking that depend on the following set of exogenous variables:

$$\text{(3)} \quad O = (H, F, P, S, M, EW, A, G, R)$$

Where H is hours worked, F is family income, P is a vector of prices for convenience foods, fast-food and full-service restaurants, the price of food requiring a high preparation time, and the price of cigarettes, S is years of formal schooling, and M is marital status.

The aforementioned framework suggests that increased calorie consumption and decreased calorie expenditure are due to increases in time costs and the marginal cost of activity and dieting. "Calories are expended at work, doing home chores, and at active leisure. Calories expended at work depend on the nature of the occupation…Individuals who work more hours in the market will substitute market goods for their own time in other activities. An increase in hours worked raises the price of active leisure and generates a substitution effect that causes the number of hours spent in this activity to fall. An increase in hours of work also lowers the time allocated to household chores" (Chou, et. al., 2002). This is not Grossman's only contribution to the study of obesity; he lays the foundation upon which future obesity articles rest by postulating a model of the demand for health.

Michael Grossman's (1972) article, published in *The Journal of Political Economy*, entitled "On the Concept of Health Capital and the Demand for Health" is one of the most influential papers published within the field of health economics. Being one of the first of its kind it has become a reference point for almost every article published afterwards that pertains to health and obesity. When analyzing this article it is important to relate the demand for health to the demand for a healthy body weight to understand how it will come to resemble the framework for a model of obesity.

Grossman creates a model of demand for 'good health' which is complete with variables that he speculates effects the demand for health. For Grossman's analysis health is treated as a durable capital stock. He assumes that individuals inherit an initial stock of health that depreciates over time – at an increasing rate – and can be increased with investment. Death occurs when the stock falls below a certain level, where $H_i = H_{min}$, where H_i is the stock of health in the *i*th time period. In this respect life depends on the quantities of H_i that maximize utility subject to certain production and resource constraints (Grossman, 1972). This approach is very similar to the concept of human capital, which can be increased with investments. The difference between the two, as Grossman points out, is that investing in one's stock of health determines how much time one can allocate between producing money earnings and producing leisure time while investing in human capital determines how productive a person can be while producing money earnings. According to Grossman, sick days yield disutility. Because one's stock of health determines how much time can be spent at work, the lower the stock of health the less time worked and therefore the fewer wages earned, thus resulting in lower income. From this idea Grossman's intertemporal utility function is as follows:

$$(4) \qquad U = U(\Phi_0 H_0, \ldots, \Phi_n H_n, Z_0, \ldots, Z_n)$$

Where H_0 is the inherited stock of health, Φ_i is the service flow per unit stock, $h_i = \Phi_i H_i$ is total consumption of 'health services' and Z_i is total consumption of another commodity in the *i*th period. In the usual intertemporal utility function n, the length of life as of the planning date, is fixed, here it is an endogenous variable. So as one's health increases so will utility. This is accomplished by investments in health capital. Where net investments in the stock of health equals gross investment minus depreciation:

$$H_{i+1} - H_i = I_i - \delta_i H_i \quad (5)$$

Where I_i is gross investment and δ_i is the rate of depreciation during the *i*th period. In this model the rates of deprecation are assumed to be exogenous, but they may vary with the age of the individual. That is, over time one's stock of health will depreciate less as investments in health increase. Grossman also assumes that at some point δ_i will become positively correlated with age regardless of the time path being monotonic or not. This is because as people age their physical and mental capacity deteriorates. What Grossman indicates is that medical care, diet, exercise, and recreation are gross investments in health capital and that without these investments individuals could experience a faster rate of depreciation on their health capital. In other words poor health habits like drug and alcohol abuse, losing sleep, not exercising, overeating, increased stress, etc., increases the rate at which health deteriorates.

From these simple models Grossman created supply and demand functions for health capital. It is the demand curve that I am interested in for the current analysis and it is as follows:

$$ln MEC_i = ln BC - (C + 1)\, ln H_i + ln W - ln \pi \quad (6)$$

Where the demand curve MEC shows the relationship between the stock of health and the rate of return on an investment in health otherwise known as the marginal efficiency of health capital. B and C are positive constants, H_i is the stock of health in the *i*th period, W is the wage rate, and π is the marginal cost of the gross investment in health. The equation is represented in Log-Log format to represent demand being downward sloping. This is interesting for the current analysis because it shows that a decreased stock of health (such as one created by obesity) increases quantity demanded of health, increased wage rates increases quantity demanded of health, and an increase in the marginal cost of investing in health decreases the quantity demanded of health.

It is important to understand Grossman's contributions because they lay the foundation for understanding why people behave they way the do with respect to health. As well as understanding how and what factors shift the demand for health (i.e. depreciation in health can shift the demand for health) his model helps us begin to understand that health is a function of income, education, diet, and exercise as well as the marginal cost of participating in these actions. It gives rise to the idea that health stock increases or decreases depending on our actions and choices of allocations and in that respect it can be related to how an individual makes choices about their body weight.

In "Healthy Bodies and Thick Wallets" author James P. Smith (1999) reinforced Grossman's theory on the relationship between wages/income and health. While most previously published papers deal primarily with the issue of income as a function of health, Smith approaches it from both sides analyzing the impact of health on income. In other words Smith examines the possibility that better health increases economic resources concluding that one's health has the largest effect on income/wealth when middle-aged or older. With this article it is assumed that poor health and obesity share similar characteristics. In this time series study Smith tracks health, wealth and the correlation between the two over a ten-year period.

Not surprisingly Smith found that not only did those who are considered in excellent health make more than those with poor health but that their income grew more over the time period than did that of those who are considered in poor health. In this consideration it is reasonable to think that better health leads to a greater ability to work longer hours and more weeks per year leading to higher incomes (Smith, 1999). Overall it is hard to isolate the impact of different levels of health on wealth across age groups because there are certain adjustments made by different age groups when their health starts to deteriorate that are hard to hold constant. Wealth and income can be very ambiguous variables when trying to find the correlation between them and health measures. This is because different individuals behave differently given certain levels of wealth.

Table 1

Median Wealth by Self-Reported 1984 Health Status

AGE GROUP	***1984***	***1989***	***1994***
All Households			
Excellent	68.3	99.3	127.9
Very Good	66.3	81.9	90.9
Good	51.8	59.6	64.9
Poor	39.2	36.0	34.7
25 - 34			
Excellent	28.5	51.5	84.3
Very Good	19.5	34.7	50.1
Good	10.5	17.2	28.2
Poor	0.9	3.1	10.4
35 - 44			
Excellent	100.1	150.1	194.7
Very Good	81.1	96.3	117.5
Good	49.5	45.3	83.5
Poor	23.8	15.5	32.4
45 - 54			
Excellent	164.2	198.3	255.8
Very Good	132.1	176.2	186.9
Good	87.8	76.9	97.1
Poor	59.7	61.6	69.4
Numbers are in thousands of 1996 dollars			

Although Smith could not find a definitive reason for the correlation, he suggests four possible reasons why economic status affects health. To begin with Smith examines the two Whitehall studies that assert "…that psychosocial factors, such as work-related stress and social support networks, have major roles to play in the social gradient in health both directly and indirectly by encouraging poor health behaviors" (Smith,1999, p.161). In other words job demand and description (i.e. stress, low job control, monotonous work, etc.) can contribute to poor health habits. Secondly, Smith proposes that children that come from better economic backgrounds lead healthier lives. He suggests this is because with a better economic status, household living standards increase causing a subsequent increase in health. A third possible explanation is what Smith calls "allostatic load" or stresses that increase the risk of high blood pressure, diabetes and high cholesterol. He does not attribute increases or decreases in stress to relatively high or low economic positions but rather to different lifestyle choices and events that happen in your life. Lastly, Smith thinks that income inequality helps explain the diversified social health gradient. Smith believes lower economic and social status leads to higher levels of stress, which negatively affect one's health, and claims "…the most often mentioned health enhancing trait is social cohesion" (Smith, 1999, p.164). These four socioeconomic factors are important because they help to explain why income variations lead to variations in health status and obesity.

"The Economic Reality of the Beauty Myth" by Susan Averett and Sanders Korenman (1993) is a study to see if wages, family income and marital status have an effect on an individuals body mass and in turn if higher body mass leads to lower employment rates. The authors recognize that income and obesity are correlated and even note that obese women have lower family incomes. The study was biased due to a slightly high correlation between income and marriage and proved it by estimating the same model with non-married persons and found a much lower correlation.

In a similar article which was mentioned earlier, "Healthy Bodies and Thick Wallets: The Dual Relation between Health and Economic Status", James P. Smith (1999) examines not only the effects of obesity on labor force participation and productivity but more generally how poor health affects these as well. While it seems obvious that a lower income means a lower availability of nutritional foods, many researchers are beginning to approach the problem through reverse causality. Susan Averet and Sanders Korenman (1993) authors of “The Economic Reality of the Beauty Myth” try to explain the estimation results by speculating that the relation between lower income and higher obesity rates should be attributed to obesity discrimination in the labor force. Though there is the possibility of an endogeneity bias the numbers are alarming, there are mean hourly wage differences of 12% for women and 5% for men (between obese and non-obese individuals) which leads to the conclusion that low income is a function of obesity and not otherwise (Averett & Korenman, 1993). It is useful to note that in “The Economic Reality of the Beauty Myth” the authors estimated two models one for men and one for women. It is important to note that Averett and Korenman speculated on the possible differences between Whites and Blacks with respect to wage and obesity. They suggest that there are different social norms pertaining to body weight with respect to different cultures. Provided that these differences do exist, they speculate and find empirically that because it is more socially acceptable to be an overweight black person than it is to be an overweight white person the economic penalties of being overweight are felt more by Whites than by Blacks. These findings are an important indicator that race and gender have an impact on obesity and are relevant to any subsequent determination models.

There is an important consideration that must be made when trying to isolate factors that contribute to obesity. In “Healthy Behavior, Health Knowledge and Schooling” author Donald S. Kenkel (1991) recognizes an important potential correlation between the amount of schooling and the likelihood of obesity. There seems to be some relationship between higher education levels and a better understanding of health risk factors (Kenkel, 1991). Kenkel asserts, "schooling improves allocative efficiency, that is, the choice of health inputs, by improving individuals' health knowledge", which is his main hypothesis being tested ((Kenkel, 1991, p.288). The data for the empirical model was taken from the Health Promotion/Disease Prevention (HPDP) supplement to the 1985 Health Interview Survey. Upon analysis of his model Kenkel concludes that schooling and health knowledge lead to increased exercise and decreases in excessive drinking and smoking. He also found that while increased knowledge of the adverse impact of poor health habits leads to increases in exercise, substantial increases in health knowledge are unlikely to change health behavior much. Therefore, increases in health knowledge produce diminishing returns to health. In his model Kenkel included many variables are consider important in the unified model and given they provide significant coefficients are extremely relevant. He used the number of cigarettes smoked per day, percent of state population that smokes as well as total number of alcoholic drinks consumed in the last two weeks.

In Christopher J. Ruhm's (2004) article "Healthy Living in Hard Times", he introduces the possibility of an interesting correlation. Rhum theorizes that "individuals might adopt healthier lifestyles when the economy weakens because increases in non-market time make it less costly to undertake health-producing activities such as exercise or the consumption of a healthy diet" (Rhum, 2004, p. 343). This theory correlates to the concept that increasing marginal costs and decreasing marginal utilities that are associated with exercise and diet relative to work are contributing factors to obesity. Rhum collected his data from the Behavioral Risk Factor Surveillance System (BRFSS) for the years 1987 through 2000 and specified his model as follows:

$$(7) \qquad Y_{ijmt} = \alpha_j + X_{ijmt}\beta + E_{mjt}\gamma + \delta_m + \lambda_t + \varepsilon_{ijmt}$$

where the subscripts represent individual *i* living in state *j* interviewed in month *m* of year *t*, and Y is income for the individual, X is a vector of individual characteristics (such as smoking, BMI, amount of leisure time activity, do you have multiple health risks, race, age, gender, education, marital status and state level variables that include % employed, weekly hours worked, and personal income), E is a measure of economic conditions and α, δ, and λ represent unobserved determinates of lifestyle behaviors associated with state, calendar month, and survey year.

Ruhm's estimations lead him to the conclusion that as economic conditions worsen lifestyles become healthier. He is careful to "recognize that worse health during temporary expansions does not imply negative effects of permanent economic progress" (Rhum, 2004, p.343). What he is saying is that the lower productivity experienced during economic down turns allow individuals to allocate more time to health inputs (such as diet and exercise) because of their decreased marginal cost relative to work time. Economic downturns and the resulting reductions in income and employment related stress can also decrease the frequency of what Ruhm refers to as "self medication" by drinking and smoking. In Ruhm's estimations (2004) a one point drop in the employment rate is estimated to lower smoking, obesity, severe obesity, physical inactivity, and multiple health risks by 0.6, 0.5, 1.0, 0.5, and 1.1% for employed individuals and 0.6,0.4, 0.8,0.7, and 1.1% for the full sample. This implies that the effects of "hard times" are felt by everybody and not just those that lose their jobs. Rhum recognizes the impact different economic conditions have on different ethnic groups and genders; "Reductions in weight and increases in physical activity are more prevalent among males, Blacks and Hispanics than in women and Whites" (Rhum, 2004, p.354).

TECHNOLOGICAL INFLUENCES:

In contrast to obesity as a function of labor, marriage markets, and other environmental influences there are those who see the upward trend in obesity as a function of technological change. Most of the papers dealing with obesity in this fashion are working papers. Two such papers, "The Growth of Obesity and Technological Change: A Theoretical and Empirical Examination" by Darius Lakdawalla and Tomas Philipson (2002) and "The Long Run Growth in Obesity as a Function of Technological Change" by Tomas J. Philipson and Richard A. Posner (1999) make suggestions for future research as well as try to make arguments as to why these technological change variables are good explanatory variables. The theory of obesity as a function of technological change is based around the idea that increases in technology have decreased food prices, increased food availability and decreased on the job physical labor exertion (Lakdawalla & Philipson, 2002). In such studies increased caloric intake along with decreased physical activity help to interpret the rising trend in obesity as well as speculating that these factors also help to explain the falling correlation between income and obesity (Philipson & Posner, 1999). As was mentioned in the previous section, the growth in demand for food and fast food leads to a price increase instead of the price decrease we normally witness as a result of agricultural innovation. It is speculated that this food price increase would help to slow rising obesity rates (Lakdawalla & Philipson, 2002). There also rests the assumption that as work becomes less physically strenuous there is a reduction in the calories consumed, which will lower the demand for food. As food supply rises weight increases. Similarly as income rises food consumption normally rises and thus weight rises. Paired with an increase in technology that has been shown to increase sedentary behavior obesity continues to rise. This does not have to be the case though, "If [income growth can encourage weight control it could] offset the effect of sedentary technology and weight growth could slow. Weight could even begin to decline if the earned income effect becomes so negative that it offsets the effect of declining food prices. Historically, income and weight have grown together, indicating that the price effect has dominated or been reinforced by the income effect" (Lakdawalla & Philipson, 2002, p.10). As we become wealthier and more technologically advanced we need to become more aware that technical innovation has its costs. The next few paragraphs will discuss each paper in more detail. Specifically, I focus on the theory presented in Philipson's and Posner's paper (1999) because the theory in both papers is similar, while the empirical analysis of Lakdawalla's and Philipson's paper (2002) is discussed because Philipson and Posner did not do empirical analysis.

Philipson's and Posner's "The Long Run Growth in Obesity as a Function of Technological Change" (1999) is the first of the two papers to examine obesity as a function of technology. Their analysis is theoretical in nature and is probably the inspiration behind the work that Philipson latter did with Lakdawalla, which we will examine in the subsequent paragraphs. In their theoretical analysis the authors assumed that weight is affected by the intake and expenditure of calories according to the function:

$$W(F,S) \tag{8}$$

Where W is weight, F is the intake of calories (food), and S is the calories used in physical activity and where growth in obesity is characterized by $W_F \geq 0$ and $W_S \leq 0$

which means calories consumed (W_F) must exceed calories expended (W_S). From this the postulated utility function which is defined over weight, food consumption, and C, alternative consumption, is:

$$U(W(F,S),F,C) \tag{9}$$

Where the utility function is non-monotonic in weight and displays an inverted U-shape.

W_0 is a person's ideal weight if achieving it has no costs. Philipson and Posner (1999) assume that gaining weight is more valued the more underweight the individual and losing weight is more valued the more overweight the individual, and W_0 may or may not correspond to the weight that maximizes health or longevity. Philipson and Posner (1999) postulate that with physical activity held constant at S, the most preferred weight depends on the opportunities and preferences, as in

$$\text{Max } U(W(F,S),F,C) \qquad \text{s.t.} \qquad C + pF \leq I \tag{10}$$

Where p is the price of food and I is income. Substituting in the budget constraint they get:

$$U_W W_F + U_F = pU_C \tag{11}$$

The above equation describes that the choice of calories balances the weight effect and joy of eating against the forgone consumption of alternative goods. In this state the consumer is in equilibrium for all other goods and food. That is, their indifference curve is tangent to the budget constraint at a point that maximizes their utility otherwise known as optimal resource allocation. For all other goods (AOG) the consumers marginal utility divided by price is equal to the marginal utility (of food) divided by the price (of food). This leads them to the conclusion that for many prices and incomes the preferred weight is different from the ideal weight which helps to explain the number of both over- and underweight individuals and the divergence between the two.

In "The Growth of Obesity and Technological Change: A Theoretical and Empirical Examination" (2002) the authors Darius Lakdawalla and Tomas Philipson, conducted an empirical analysis using individual-level data from the National Health Interview Survey (NHIS), the National Health and Nutritional Examination Survey (NHANES), and the National Longitudinal Survey of Youth (NLSY). The data was merged with data that measures job strenuousness and analyzed to find the effects of income and physical activity at work on weight. The NLSY, conducted from 1978 through 1996, consisted of questions about individual's height, weight, race, sex, marital status, age, and the individual's occupation. The NHANES data set, collected from 1988 to 1994, contained self-reported height and weight as well as measured height and weight and is used to correct for reporting error in NLSY. To identify secular trends in weight as well as the empirical relationship between weight and various demographic characteristics the NHIS was used. It contained individual-level data on height, weight, income, education, demographic variables and occupation and was conducted using a repeated cross section every year for several decades. Lakdawalla's and Philipson's (2002) empirical model was tested as follows:

$$W_{it} = \beta_0 + \beta_1 Year_{it} + \beta_2 Muscle_{it} + \beta_3 S_{it} + \beta_4 Y_{it} + \beta_5 (Ed_{it}) + \beta_6 (Age_{it}) + \beta_7 (Age_{it})^2 + \varepsilon_{it} \quad (12)$$

Where W is BMI, *Year* represents a vector of year dummies, *Muscle* represents the strength requirement of a worker's job, taken from the *Dictionary of Occupational Titles*, S is job strenuousness (other than strength because they are predicted to have different effects), Y represents income, Ed is the level of education and Age is represented in this fashion so as to allow for weight to have an inverted U-shape due to biological reasons: Lakdawalla and Philipson assume people gain weight as they approach middle age, but begin to lose weight as they enter old age.

All of their variables showed up as significant at the ninety five percent significance levels. Most importantly for the current analysis is that strength requirements for a job, job strenuousness, income, age, education are significant. Strength requirements showed up as positive and it is suspected that this result is due to an increase in muscle mass as opposed to in increase in excessive weight. Job strenuousness showed up as negative producing the expected result that increased physical activity on the job reduces weight. Education and income had the expected negative effect. Age displayed the biological pattern described above with Age being positive and Age-squared being negative. The results from the data analysis lead Lakdawalla and Philipson (2002) to conclude that a worker in a sedentary job can end up with as much as 3.3 more units of BMI than someone in a highly active job, which is as large as the total weight gain that has occurred over the last century. Lakdawalla and Philipson (2002) attribute about forty percent of the growth in weight to the expansion of the supply of food, which raised BMI by about .7 units over the study period, and about sixty percent is attributed to demand forces, which increased BMI by almost a full point over the study period.

In Cutler's, Glaeser's, and Shapiro's (2002) article "Why Have Americans Become More Obese" they relate the increase in adult obesity to increased caloric consumption. This is attributed to the rise in technological innovation that has provided consumers with food prepared beyond the point of normal consumption and the ability to consume it with lower preparation and cleaning costs (Cutler, et. al., 2003). The authors of this paper do not try to determine the factors that contribute to obesity; they try to explain the rising trend in obesity as a function of increased food preparation innovation, which leads to increased calorie consumption. As food has become more readily available and in larger quantities people have not adjusted their eating habits and this has in turn lead to an overall increase in the number of calories consumed per day (Cutler, et. al., 2003). Cutler, Glaeser, and Shapiro (2003) theorize that because of the decrease in the time costs for preparing food Americans have increased the frequency with which they consume meals and snacks. The increased frequency with which we eat has lead to an overall increase in the amount of calories consumed and has thus resulted in the increasing prevalence of obesity. From this the authors postulate a theory contrary to most popular opinion. They theorize that obesity is not so much related to increased portion sizes at restaurants or increased fat consumption due to increased fast-food consumption (calories consumed at main meal have not increased) but rather to an increase in the amount of food and the calorie content of that food eaten at snacks and between meals.

This paper uses variables that are very hard to measure and become even more so if attempting to measure them over time. It would attribute the upward trend in obesity to increased calorie consumption where it defines increasing calorie consumption as a function of increases in mass preparation, increasing portion size, decreasing preparation and cleaning costs, and increasing self control problems (defined as a high time cost of dieting) (Cutler, et. al., 2003).

SUMMARY & CONCLUSIONS:

This literature review presents a summary of nine papers; each has an influence on this work in their own unique way. The papers act as a guide through the development of the field, laying a foundation while simultaneously paving the way for future research. Five of the nine papers come from the NBER Working Paper Series with the remaining four originating from published economic journals. The first paper discussed is one of the five from the NBER Working Paper Series. "An Economic Analysis of Adult Obesity: Results from the Behavioral Risk Factor Surveillance System" by Chou, Grossman, and Saffer presents a model explaining the demand function for calories consumed and activities that expend calories. Their conclusions suggest that increased calorie consumption and decreased calorie expenditure can be attributed to increases in time costs and the marginal cost of activity and dieting. The next two articles discussed both come from published journals. The first is Michael Grossman's article, published in *The Journal of Political Economy* in 1972, entitled "On the Concept of Health Capital and the Demand for Health". Grossman's article is one of the most important. He lays the ground work for my own research by creating a demand for health. His demand for health is the first theory to give rise to the notion that health (and similarly obesity) is a function of investments in health (education, diet, exercise, etc.) and income and that you choose your level of health according to your own demand schedule. The third article, "Healthy Bodies and Thick Wallets" (1999) author James P. Smith reinforced Grossman's theory on the relationship between wages/income and health. Smith hypothesizes that income levels can affect health levels as well as the opposite but concludes that the correlation is hard to measure due to variances across individual behaviors given certain levels of wealth. The fourth paper, "The Economic Reality of the Beauty Myth" by Susan Averett and Sanders Korenman (1993) is a study to see if wages, family income and marital status have an effect on an individuals body mass and, in turn, if higher body mass leads to lower employment rates. It is an empirical examination that finds differences between Whites and Blacks with respect to wage and obesity. The authors hypothesize that these differences can be attributed to different social norms pertaining to body weight and conclude it is more socially acceptable to be an overweight Black person than an overweight White person and thus the economic penalties of being overweight are felt more by Whites than by Blacks. The next article is Donald S. Kenkel's "Health Behavior, Health Knowledge and Schooling" (1991). Kenkel hypothesizes that, for an individual, increases in schooling will increase the frequency of health behavior and upon empirical analysis finds that this is indeed the case. Christopher J. Rhum's article "Healthy Living in Hard Times", published in *The Journal of Health Economics* in 2004, conducts an empirical examination to test his hypothesis that as economic conditions worsen lifestyles become healthier. He hypothesizes that this is because economic downturns allow people to allocate more time to health inputs at a lower marginal cost relative to work time. His empirical analysis recognizes this is true but he is careful not to imply that decreases in healthy behavior during temporary expansions do not mean that permanent economic progress has negative effects. The last three articles are from the NBER Working Paper Series and all include analysis of how increases in technology create increases in obesity. Philipson's and Posner's "The Long Run Growth in Obesity as a Function of Technological Change" (1999) is the first of the three papers. In this paper the authors hypothesize that technology increases calorie consumption and decreases calorie expenditure by making food cheaper and work easier. Lakdawalla's and Philipson's empirical model presented in "The Growth of Obesity and Technological Change: A Theoretical and Empirical Examination" (2002) theoretically mirrors Philipson's and Posner's work. Their empirical analysis substantiates the theory and finds all of the variables they use in their empirical model are significant at the ninety five percent significance level. In Cutler's, Glaeser's, and Shapiro's article "Why Have Americans Become More Obese" they relate increases in adult obesity to increases in caloric consumption due to technology allowing consumers to consume food prepared beyond the point of normal consumption with lower preparation and cleaning costs. These papers are presented as a literature review to give the reader a solid foundation before entertaining the concepts that are presented as a theoretical model in the next section. They should give you a good idea of how this theory is developed and why the economic rationale behind it is valid.

IV. THEORETICAL MODELS AND VARIABLES

The rising occurrence of sedentary behavior, less nutritionally balanced meals containing higher caloric contents, and falling food prices have all been associated with the rising trend in obesity/overweight. There are many factors that contribute to why these things cause obesity in individuals and why individuals continue to behave in a manner that result in increased obesity. Below is posited a theoretical model describing what factors contribute to differences in individual BMI's and if these factors have positive (increase) or negative (decrease) effects on a person's BMI. This model is developed as a unified theory of variables that are deemed important in the literature review. For the individual:

$$\text{(13)} \quad \mathbf{BMI = f(DCI^{+}, PF^{-}, I^{\pm}, PJD^{-}, HW^{+}, CIG^{-}, ALC^{+}, AGE^{+}, R^{\pm}, G^{\pm}, EDU^{-}, W^{\pm}, MBMI^{+}, FBMI^{+}, BW^{+}, EXC^{-}, MCF^{+}, ROR^{-}, MUF^{-})}$$

A persons **BMI** is their body mass index, calculated as (weight in Kg)/(Height in Meters)^2. According to the CDC an obese person has a BMI ≥ 30, an overweight person has a BMI between 25 – 29.9, and BMIs between 20 – 24.9 are considered to be healthy. While the BMI measurement is generally considered to be the best calculation of healthy weight levels there are some exceptions. "Overweight is defined as weight in excess of an ideal weight, based on height- and sex-specific standards. Overweight can result from excess of bone, muscle, fat, or, more rarely fluid…not all people who are heavy are excessively fat. The relative contributions to overweight of bone, muscle and fat vary from person to person, and it is often hard to recognize these differences" (Dwyer, et al., 1970). Bodybuilders and people who have large amounts of muscle mass are, many times, considered overweight by the standard BMI calculations. The gray area comes in for these people because while they may not be obese in terms of being overly fat they are carrying more weight than their body structure and internal organs are designed to handle. In this respect a higher BMI can have a negative impact on health.

The variable $\mathbf{DCI}^{+}$ is used to express an individual's daily calorie intake. It is widely considered as one of the major factors contributing to variations in BMI's among individuals. The expected sign of DCI is positive because an increase in calorie consumption leads to gains in weight which translates into a higher BMI. There are numerous factors that contribute to differences in DCI. Most importantly the amount of calories people consume varies with height, weight, and their amount of lean muscle mass and amount of activity. The question here though is what causes people to consume calories beyond their recommended level creating the positive correlation between DCI and BMI? Many of the factors that are included as explanatory variables for BMI also have an impact on a persons demand for calories. This could cause some multicollinearity between the variables which will be examined in later analysis. A prevalent factor contributing to excessive calorie consumption is that the marginal cost of counting calories (dieting) can far exceed its marginal benefit. This is shown by the high demand and low price of fast food. Since most fast-food meals contain more calories than should be consumed at each meal but are fast and inexpensive the demand for calories increases with an increase in the marginal cost of time. So, as your time constraint becomes more constricted you increase your demand for calories relative to all other goods (particularly your demand for a healthy BMI) increasing your daily calorie intake and subsequently your BMI (Cutler, et al., 2003).

The first explanatory variable discusses an individual's daily calorie intake (DCI) and how it affects BMI. This discussion is designed to further the reader's understanding of what is meant by the phrase "necessary calorie consumption" so they understand the ideal of an active lifestyle and healthy diet. The FDA[4] has set a general guideline of 2000 calories per day but this number is affected by body size, age, height, weight, activity level and metabolism. The FDA's Recommended Energy Intake table and subsequent activity classifications, shown below, should help give an idea as to what is considered be a normal caloric intake for different individuals:

Table 2 – Recommended Energy Intake

Recommended Energy Intake

Category	**Age**	**Calories Per Day**		
		Light Activity	Moderate Activity	Heavy Activity
Children	4 to 6		1800	
	7 to 10		2000	
Males	11 to 14		2500	
	15 to 18		3000	
	19 to 24	2700	3000	3600
	25 to 50	3000	3200	4000
	51+		2300*	
Females	11 to 18		2200	
	19 to 24	2000	2100	2600
	25 to 50	2200	2300	2800
	51+		1900*	

* based on light to moderate activity

Very light activity is defined as driving, typing, painting, lab work, ironing, sewing, cooking, playing cards, playing a musical instrument and other seated activities.

[4] This information can be found at the following website: www.fda.gov

Light activity is defined as housecleaning, child care, garage work, electrical trade work, restaurant work, golf, sailing, table tennis or walking on level surface at 2.5 to 3 mph. Moderate activity can be considered weeding, hoeing, carrying a load, cycling, skiing, tennis, dancing and walking 3.5 to 4 mph. Heavy activity is considered heavy manual digging, tree felling, basketball, climbing, football, soccer and carrying a load up hill. Further, the FDA suggest that these calories be consumed in evenly spread out meals through out the day with no single meal being the largest.

As the price of food increases the quantity demanded will fall resulting in total food consumption decreasing. That is the theory behind the variable $\mathbf{PF}^{-}$, price of food, which causes there to be a negative correlation with BMI. If there is an overall price increase for all foods due to some exogenous shock the decreases in BMI will be subtler but still noticeable. But, for "junk foods" like fast food if there is a price increase relative to all other foods the negative correlation should be stronger. If the price of all other food increases relative to "junk foods" then there arises the possibility that there is a positive correlation. A study by Cutler, et al. (2003) shows that in countries where the price of a Big Mac (though not completely exogenous, a good measure to show relative food cost) is higher the prevalence of obesity is lower. In the same study the authors observe that countries with a more regulated agricultural sector (thus higher food prices) experience lower obesity rates. In today's world the case of fast food being cheaper than almost any reasonable substitute stands as an example of how decreases in the price of substitutes can decrease demand for the other, substitutable good (in this case a healthy meal).

$\mathbf{I}^{\pm}$ is used to denote the variable income. Income is an interesting variable because of the nature of the ambiguity of the expected sign. There could be a positive or a negative correlation between income and BMI; "…declines or modest increases in real income experienced by certain groups appear to have stimulated the demand for inexpensive convenience and fast food which has increased caloric intake" (Chou, et al, 2002). A positive correlation would arise because for most individuals as a persons income goes up so does their wage rate and thus their marginal cost of time, meaning that their time is worth more in monetary terms. Since their time is worth more the cost of counting their calories increases. No longer is it just the cost of the meal that they must take into consideration but also lost wages from the preparation of a meal as opposed to just "grabbing something quick" which in most cases is a meal that contains more than the recommended allotment of calories. People are better off if the value of less time spent preparing food is greater than the weight consequences of obesity (Cutler, et al., 2003). For the person with high income there is also the possibility of income having a negative correlation with BMI. This instance would arise because as income goes up so does the productive efficiency of diet and exercise. This is achieved by raising the marginal productivity of the inputs necessary for producing a healthy BMI by using the inputs more efficiently. For instance, as the persons income goes up so does their ability to afford a nutritionist and personal trainer to help them increase their marginal productivity of the inputs diet and exercise (by teaching them how to use them more efficiently) and thereby decreasing their BMI by making them more efficient producers of fitness. These people will be better off if the time value lost while dieting and exercising is less than the gains in fitness. On the other hand low incomes could create a high marginal cost of time. Since a person with a low income will have to work more to remain at a subsistence level, to maintain life, the marginal utility they derive from counting calories is not posited to be as high as the marginal utility they derive from the income of extra time worked. It must also be taken into consideration that because of the lower income the individual may have less access to healthy food and a higher time cost for preparation and cleaning time (fruit, whole grains, etc being relatively expensive when compared to value meals at leading fast food retailers as well as taking longer to prepare). This lack of access to cheap healthy food paired with increased time costs may force lower income individuals toward the lower priced high calorie fast food meals. In this instance there would be a negative correlation between income and BMI.

The possibility of a correlation between the amount of energy exerted during "on-the-job" time and people's BMI's must be taken into consideration. $\mathbf{PJD}^{-}$, physical job demands, is the variable used to represent this possible correlation. The expected sign of this variable is negative because individuals who exert more energy during their work day expend more calories which can decrease or help maintain a healthy weight resulting in lower BMI's. The trouble with this assumption is apparent because of the possibility that, for this individual, a physically demanding job may result in a high demand for calories as well as a low demand for a healthy body weight/BMI. If this instance arises it would result in the positive correlation of PJD and BMI. Because of the greater expenditure of calories by individuals with higher PJD's there arises the possibility that their demand for calories may exceed their recommended daily allowance even when the allowance is adjusted for persons with higher calorie expenditure. This excess demand leads to increased BMI's. The low demand for a healthy BMI will arise if exhaustion due to a physically demanding job causes their marginal cost for staying fit to be too high or similarly their marginal utility derived from exercise to be low. This person may have reached their point of negative marginal returns for both their marginal product and their marginal utility for physical activity during the work day and now have no desire to burn any excess calories.

Not just income but also the amount of hours worked in a day, $\mathbf{HW}^{+}$, can impact an individual's BMI. HW is expected to have a positive correlation with BMI because as you increase the amount of hours worked in a day you probably decrease the available time for maintaining a healthy diet and exercise. With less time to pay attention to diet and exercise productive efficiency from those disciplines decreases; as your productive efficiency decreases a lower marginal product from diet and exercise results in a suspected higher BMI. This time constraint increases the marginal cost of diet and exercise as well because as the amount of hours worked increases each hour not worked becomes more valuable. So for an individual to spend increasingly more valuable "off-time" dieting and exercising requires them to derive a high level of marginal utility, relative to price, from doing so. Even for the people who derive a high utility from a healthy diet and exercise it is unlikely they would experience a negative correlation between HW and BMI. Even these people begin to feel the positive correlation as the amount of hours worked increases making each hour increasingly more valuable and pushing them to the point of negative marginal utility for diet and exercise (i.e. working a 16 hour day would leave only8 hours for sleep, exercise and relaxation). Only people with physically demanding jobs may experience a negative correlation between HW and

BMI because of the increased physical activity conditional with a healthy diet can maintain a healthy BMI or even help lower an unhealthy BMI.

The fifth variable of interest, which is represented by $\mathbf{CIG}^{-}$, is the number of cigarettes an individual smokes per day. For CIG the expected sign is negative because cigarette smoking reduces body weight through reductions in caloric intake, increases in metabolic rate, and increased level of energy expenditure (Himes, 2000). Though the marginal cost to health from smoking normally outweighs the marginal benefits in this case it is possible to have positive effects if weight gain from quitting is taken into account. As demand for cigarettes increases so does demand for a healthy or lower BMI subsequently making it so that increases in the consumption of cigarettes results in lower BMI's whether this is the intended result or not. Because of this phenomenon people who do not enjoy smoking but are above their ideal weight may actually derive additional marginal utility from smoking, in the sense that it could help them lower their weight, if the disutility incurred because of not enjoying smoking were outweighed by utility derived from the possibility of weight loss. The incentive to quit smoking is extremely low for those who are especially concerned with body size and appearance (and hence BMI). For smokers concerned with their weight there is a vicious cycle associated with quitting.

The consumption of alcohol can have an adverse impact on health in many ways but in particularly when it comes to BMI. The variable $\mathbf{ALC}^{+}$ is used to represent the number of alcoholic drinks consumed per day by an individual. Because consuming alcohol means consuming more calories there is expected to be a positive correlation between the number of alcoholic drinks consumed and a person's BMI. With this in mind it is assumed that individuals who drink excessive amounts of alcohol receive higher utility from alcohol consumption than from a lower BMI. For an individual with this type of demand schedule the marginal benefits of consuming alcohol are higher than its marginal costs. This translates into the individual receiving higher marginal utility relative to price from the consumption of alcohol than from a lower BMI. This could be the result of many factors. This person could already have a low or healthy BMI or they could simply receive higher marginal utility relative to price from alcohol even if their BMI is high.

It is important to include demographic data when considering the possible determinates of health related factors. The variable $\mathbf{AGE}^{+}$ is included in the model and thought to have a positive correlation with BMI. "As we age, we lose muscle mass. As we lose muscle mass, our metabolism slows. As our resting metabolic rate slows, we gain weight" (Johnson, 2005). According to J.B. Johnson, a fitness and health advisor for cyberparent.com, this decline in muscle mass and the subsequent reduction in our metabolic rate occurs because our bodies lose 1/3 to 1/2 pound of muscle tissue per year after age twenty. Johnson goes on to say that the implementation of an exercise program that includes fifteen to twenty minutes of aerobic and weight training twice a week, consistently, can offset this decline.

The percentage of persons who are obese rises with age with more adults being obese than children but in general adults are less concerned with excess weight gain than are their younger counter parts (Dwyer & Feldman, 1970). Because of time constraints as people get older their marginal cost for maintaining a healthy BMI increases. For example, consider the average person with a full time job and a spouse and children.

This person will derive less utility out of exercise and calorie counting at this stage in life compared to when they were younger and single. This is because as they grow older different priorities, such as spending time with family and working to provide for that family, begin to take precedence. In addition to the fact that the present value of a low BMI decreases as a person ages because they have a shorter period too discount the benefits. They have reached the point in their life where they begin to experience lower marginal utility for the maintenance of a healthy BMI. This lower utility associated with diet and exercise combined with the natural slowing of the metabolism as we age creates a strong positive correlation between age and BMI.

Two very important demographic variables that must be considered in this model are race and gender, denoted by the variables $\mathbf{R}^{\pm}$ and $\mathbf{G}^{\pm}$. Both of these variables are theoretically ambiguous with regard to their correlation to BMI. The ambiguity here arises when it is taken into consideration that people may act differently because of gender or race. One sociological theory suggests that in some cultures or among certain races higher weights may be associated with power and stability (Cawley, 2004). Does being male or female cause differences in the marginal cost curves of diet and exercise and do these differences translate to race also? Can we say that because someone is a female that the marginal cost of attaining a healthy BMI is lower because stereotypically women derive more utility from being "skinny" than do men? Does a black man or woman derive lower utility out of a healthy BMI than a white man or women because of cultural backgrounds? These questions make analysis difficult because it is hard to draw the line between individuals acting as individuals and cultural differences that contribute to their behaviors and preferences. The only way to accurately determine the answers to these questions is with empirical analysis.

A number of previous authors have hypothesized that education, represented in the model by $\mathbf{EDU}^{-}$, may be negatively correlated with obesity. In his article entitled *Health Behavior, Health Knowledge, and Schooling* author Donald S. Kenkel says "Even a cursory examination of data reveals that people are not equally unhealthy: a striking pattern is that the better-educated are more likely to choose healthy life-styles." The connection here seems to be that those with a higher level of education have a better understanding of outcomes of health behavior. "Grossman (1972) hypothesized that schooling increases the efficiency of household health production" (Kenkel, 1991, p.288). The more educated a person is the more they know about the benefits of diet and exercise and the more capable they are of learning in what proportions each should be taken. Since increases in education lead to greater knowledge of health outcomes and those with higher levels of education choose to lead healthier life styles it is reasonable to suspect that increases in education will lead to lower BMIs.

A person's initial stock of wealth can play a vital role in the level of their BMI. Initial stock of wealth, $\mathbf{W}^{\pm}$ in the model, could have either a positive or a negative correlation with obesity. For a person who is born wealthy the marginal cost, as a percentage of wealth, of staying within a healthy BMI range is relatively low. There is the case that is mentioned with income and now applies here. A person's initial stock of wealth provides them with the capacity to increase their productive efficiency of health by increasing the marginal efficiency of inputs to health. These people can afford nutritionist and personal trainers, at low cost relative to wealth/income, to increase their marginal productivity making it easier for them to maintain healthy body weights. In this case being born rich may cause a negative correlation between W and BMI. Being born rich increases BMI because there could be instances where they receive low marginal utility from a healthy diet and exercise even at unhealthy BMIs. This could be due to laziness or just a hatred of diet and exercise. For those people who are not born into extreme wealth or who are born into poverty W and BMI is expected to have a positive correlation. These people, who are not born with an inherent capacity to increase productive efficiency, suffer from the burden of a higher marginal cost, relative to wealth/income, of maintaining a healthy BMI. They will have to work to earn causing time spent on maintaining a healthy diet and exercise to result in lower wages. The one instance where those in this category could see a negative correlation between W and BMI would be when the utility derived from diet and exercise outweighs the disutility as a result of lost wages. This person would see a negative correlation because they would choose to diet and exercise instead of earn wages.

Family weight history as well as personal weight history may substantially impact a person's BMI. This includes the mothers BMI, represented by $\mathbf{MBMI}^{+}$, the fathers BMI, represented by $\mathbf{FBMI}^{+}$, and birth weight, represented by $\mathbf{BW}^{+}$. The parents BMI's may affect the individual's BMI both genetically and influentially, for both biological and adopted children the trend is for fatter parents to have fatter kids with their children being about three times as fat as the children of their leaner counter parts (Kolata,1977). If obesity is a genetic disorder then the correlation between the parents BMI and the individual's BMI show a strong positive correlation. If the parents BMI's does not affect the individual's BMI on the genetic level then it may affect it through influence. Children learn their diet and exercise habits from their parents so a parents poor health habits creates children with poor health habits. Since the children of parents with poor health habits learn poor diet and exercise habits they may follow in their parent's footsteps. Even though Kolata's (1977) article *Obesity: A Growing Problem* speculates that the old saying that "fat babies grow up to be fat adults" is based in little fact the intuitive response is that higher birth weights will translate into higher BMI. Empirical evidence is necessary to make statements to the contrary.

Exercising regularly is a key component to maintaining a healthy BMI which is why it is included as the variable $\mathbf{EXC}^{-}$ to represent the average amount of exercise that an individual undertakes per day. The expected sign of EXC is negative because as you increase the amount of exercise you also increase the amount of calories expended resulting in a lower BMI. This is only the case when calories consumed are held constant or decrease. If consumption increases more or is already more than the amount of the expenditure due to exercise it will negate the effect of exercise. As the marginal cost of exercise decreases or the marginal utility increases relative to all other goods individuals will begin to exercise more which will result in the increased productive efficiency of exercise which leads to more efficient workouts and lower BMI's.

The marginal cost of fitness, which has been discussed in depth throughout this analysis, deserves its own brief discussion because it plays such a large role in the decision of individuals to diet and exercise. Represented by the variable name $\mathbf{MCF}^{+}$ its expected correlation to BMI is positive. As individual's marginal cost of fitness increases it becomes less likely they will stay fit because they have to substitute away from other goods and services to maintain their current level of fitness. One possible factor that could affect MCF is the cost of a gym membership. As the cost of a gym membership increases so does the marginal cost of fitness because it would increase the price of fitness. It is inefficient for an individual to allocate time to something that has a high marginal cost unless the marginal benefits received are also high. To misallocate your time brings you to a lower level of utility (a non-utility maximizing level). In other words it becomes increasingly costly to stay fit relative to other activities you may pursue. So this causes you to decrease consumption of the more costly good and reallocate time to achieve utility maximization.

The rate of return on investment in fitness (characterized as both a healthy diet and exercise) denoted by $\mathbf{ROR}^-$ as well as the marginal utility relative to price received from fitness, $\mathbf{MUF}^-$, both play an important role in the marginal product of fitness to individuals. Where, the ROR for fitness is the individual's perceived gains from fitness and MUF is the individual's utility gained from fitness. As the ROR for exercise increases the marginal product of exercise also increases making you a more efficient producer of health thus resulting in a lower BMI. This is a phenomenon that we observe everyday. When people first start to diet and exercise they see the most drastic results in the beginning but as time goes on the reward gets smaller and smaller (think weight loss) and they begin to lose interest or fall back on old habits. This is because their ROR for fitness has gone down which makes them less efficient producers of fitness thus prompting them to reallocate their time to reach an allocative efficiency of time. The concept for the marginal utility of fitness is similar to ROR with the exception that utility is not solely a function of gains and losses. You can be experiencing a very low ROR and still be at utility maximization. That is, even though dieting and exercising are not bringing you any noticeable physical gains because you enjoy doing them they are bringing you utility gains. Since increases in ROR and MUF increase your marginal productivity of fitness, helping you reach optimality in consumption, there is a negative correlation between them and BMI. This is because increases in the marginal productivity of fitness will help lower BMI by making the individual a more efficient producer of health.

Where as one can speculate as to what factors will affect a persons BMI and if those factors increase or decrease a persons BMI, an empirical study is necessary to find any extant of support for any of the aforementioned hypotheses. The factors listed above may still be incomplete, lacking certain variables that should be considered in the model but have been omitted. Also some of the listed variables could be irrelevant and have no bearing on the model whatsoever. It must also be taken into consideration that, because of the nature of many of the aforementioned variables some of them are theoretically valid but not empirically measurable. The next section addresses these problems with the development of two empirical models (one for state-level and one for individual-level data sets) which includes proxy and dummy variables (where appropriate) that are tested using LIMDEP and SAS, respectively, and then the results are compared.

V. EMPIRICAL DATA AND METHODOLOGY

As discussed in the previous sections obesity can be influenced by an individual's own personal choices as well as the environment in which they live. This result calls for the development and testing of two separate models. The first model (1) tested tries to isolate how individuals' decisions about time allocation and utility maximization affect their body mass index. This model contains individual-level data collected from the National Center for Health Statistics' National Health and Nutrition Examination Survey (NHANES). The survey took place from 2001-2002 and includes surveys on demographics, examinations, lab tests and questionnaires administered to 11,039 individuals. The second model (2) tested is one that contains state level data. The data is gathered from the CDC's Behavioral Risk Factor Surveillance System (BRFSS), Yellowpages.com and the US census bureau and is representative of the year 2002. The data set contains complete information on all fifty states and The District of Columbia. The empirical models for both data sets are explained in the following paragraphs.

The first model, which involves individual-level data, contains many variables similar in nature to the second model. This is important because I wish to compare the models and see which factors are significant in both models. This should give insight in to how much body mass is affected by environment and how much it is affected by habit.

The first model is tested using an OLS regression performed by SAS 9.1 with all data coming from NHANES. It is as follows:

(14) $$\text{Model (1) BMI} = \beta_0 + \beta_1(\text{WTPREF}) + \beta_2(\text{PMH}) + \beta_3(\text{FOODH}) + \beta_4(\text{WTPREV}) + \beta_5(\text{DCI}) + \beta_6(\text{ALC}) + \beta_7(\text{LEIS}) + \beta_8(\text{ACTIV}) + \beta_9(\text{CIG}) + \beta_{10}(\text{G}) + \beta_{11}(\text{AGE}) + \beta_{12}(\text{MA}) + \beta_{13}(\text{HIS}) + \beta_{14}(\text{W}) + \beta_{15}(\text{AA}) + \beta_{16}(\text{EDU}) + \beta_{17}(\text{I}) + \varepsilon_i$$

This model is developed from the theoretical model described in the previous chapter and all shared variables and their subsequent interpretations and expected signs are the same, except where noted. From model (1) equation (14) body mass index (BMI), daily calorie intake (DCI), number of alcoholic drinks consumed/day (ALC), number of cigarettes smoked/day (CIG), gender (G), age(AGE), education(high school diploma/GED) (EDU) and annual household income (I) have all been described in the aforementioned chapter. Because of limited availability some theoretical variables were measured using proxy variables in the empirical model while others are not obtainable. Because of the fact that some theoretical variables had to be left out, the following provides a short discussion of the economic interpretation of variables that were used in their place as necessary.

The NHANES survey does not include information on the price of food (PF), amount of hours worked/week (HW), the mother's or the father's BMI (MBMI and FBMI), birth weight (BW) or the cost of the respondents gym memberships (CGM). Due to this lack of information these variables are excluded from the empirical model and replaced by other measures. NHANES also does not include different dummy variables for the different races and genders so they are created in the SAS program. There is a dummy for gender represented by the respondents being men. Dummy variables for different races are also included. The survey includes five categories for race. The following dummy variables are created for four of the five races to prevent the matrix from being scalar: MA is representative of survey respondents who indicated they are Mexican-American, HIS for those who indicated they are of other Hispanic decent, W for those who indicated they are non-Hispanic White and AA for those who indicated they are non-Hispanic Black. The fifth race category is other race/multi racial. Because of the nature of the data it is also necessary to create dummy variables for income and education. Income (I) is measured with a dummy variable that indicates whether or not the individual respondent makes seventy five thousand dollars or more per year. Education (EDU) is represented by a dummy variable that indicates if the respondent obtained a high school diploma/GED or not. This does not change the interpretation or expected signs of these variables, just the manner in which they are measured.

The variable for exercise (EXC) was replaced with the variable (LEIS), which is a measure of the amount of leisure time activity the respondents participated in over the last 30 days. NHANES defines leisure activity to include exercise but also "active leisure" such as running, lifting weights, riding a bike, taking a walk, playing with your children, etc. The economic interpretation of this proxy variable is the same as for exercise and exhibits the same negative expected sign.

Due to the difficulty of measuring the three variables described as marginal cost of fitness (MCF), marginal utility of fitness (MUF) and rate of return on fitness (ROR) one encompassing proxy variable was used. The variable WTPREF, which is representative of people's desire to weigh more/less/same or they do not care, is used to express the marginal cost and marginal utility relative to price that individuals receive from fitness. This is because if people care about their weight and try to make it healthier or maintain their current level of health they will receive a higher marginal utility relative to price at a lower marginal cost from fitness. WTPREF is expected to have a negative correlation with BMI. The variable is a dummy and is measured by the respondent indicating a 1 for having a preference or a 0 if they do not.

Though an exact measure of physical job demands is not obtainable there is a measure for non-leisure time activity in the last 30 days, ACTIV. This variable is measured by the number of times the respondent reports participating in physical activity during work time in the past 30 days. For all practical purposes the variable, ACTIV, should have the same economic interpretation and a negative expected sign as is discussed for physical job demands.

The variable FOODH represents the number of meals the respondents prepare and eat at home/week. The addition of this variable is used to measure the impact of a quick service food industry on individual body mass indexes. Its expected sign is negative because it is hypothesized that food prepared and eaten at home is better for you than food which is eaten at restaurants and fast-food stores. Fast-food and convenience food are inexpensive and have high caloric density (calories per pound) which can lead to over consumption (Chou, et. al., 2002).

The addition of the variable WTPREV, which is a measure of weight gain or loss over the last ten years (current weight at screening – self reported weight ten years ago), is included in the empirical model to represent weight history. Since both the mother's and father's BMI and the birth weight were not available this variable is used as a measure of genetics or parental influence. It could be either negatively or positively related to BMI. If you were obese ten years ago the likelihood that your BMI is to high now is positive. There is also the possibility that your weight ten years ago was considered "healthy" and that now it is considered obese or vice versa. It is hypothesized that the expected sign on WTPREV is positive because most people gain weight as they age.

The last new variable that is added is a measure of physical inactivity due to poor mental or physical health, PMH. The variable is measured by the number of days in the past 30 days that the respondent reported being physically inactive due to poor physical or mental health. The purpose of this variable is to examine the relationship between being sick and being obese. The expected sign is positive because inactivity contributes to obesity. For these individuals the marginal utility derived from fitness is lower due to illness. The marginal cost may also be very high depending on the severity or type of illness and efficient allocation of time might prevent the person from using time and energy on diet and exercise that would otherwise be used for treatment of their illness. There is the possibility that this effect is offset by the illness. In this case the person's illness causes obesity to decrease because of the severity of the illness.

The second empirical model uses state-level data and is tested as an OLS regression using LIMDEP 8.0. It is as follows:

(15) Model (2)[5] $OBESE = \beta_0 + \beta_1(SEDENTARY) + \beta_2(NUTRITION) + \beta_3(PARKS) + \beta_4(HFPC) + \beta_5(GYMD) + \beta_6(CIG) + \beta_7(ALC) + \varepsilon_\iota$

Where:

[5]This model was also estimated with the inclusion of state-level variables for per capita income, % of the population who is non-white and the median age of the population. These variables were not significant and the model had a poorer fit so the variables were not included in the final regression.

OBESE = percentage of the state population that is obese (BRFSS) transformed to lgt(obese) for the regression [log(obese/1-obese)] so as to express the log odds ratio of obesity in a state.

SEDENTARY= sedentary life style; percentage of state population who reported they had participated in no leisure time physical activity (BRFSS)

NUTRITION = nutrition; percentage of state population that reported not eating the recommended 5 servings of fruits and vegetables a day (BRFSS)

PARKS = total number of state forests/parks and national forests/parks (US Census)

HFPC = total number of health food stores in the state per capita (Yellowpages.com)

GYMD = total number of gyms, athletic clubs, health clubs, exercise facilities and physical fitness facilities per 100,000 residents (Yellowpages.com & US Census)

CIG = All respondents 18 and older who have ever smoked 100 cigarettes in their lifetime and reported smoking every day or some days. (BRFSS)

ALC = All respondents 18 and older who report having five or more drinks on an occasion, one or more times in the past month (BRFSS)

The following provides an economic interpretation for variables included in the state-level model but have yet to be explained.

SEDENTARY is a variable used to represent the percentage of the population reporting they participated in no leisure time activities in the last 30 days. It is expected to have a positive sign, because sedentary behavior leads to obesity. For the people who report no leisure time physical activity the marginal cost of physical activity during their leisure time must be high relative to other opportunities.

The total number of state and national parks in a state (PARKS) as well as the number of gyms per capita (GYMD) in a state are expected to be negatively correlated with obesity rates; because the more open non-developed area present in a state the more likely its residents are to make use of it for recreational activities that increases calorie expenditure, lowering BMI. More gyms per capita means higher demand for physical fitness. This is because the more abundant the recreational space or gyms the lower the marginal cost of recreation/exercise. The marginal cost decreases because people use less time looking for recreational space and gyms.

Eating nutritionally balanced meals is important for weight management which is why the variable NUTRITION is included. Poor nutritional values which are thought to lead to obesity are expected to have a positive sign. This is because the marginal cost of time for maintaining a healthy diet is high (preparation, clean up, etc) and for most people, an inefficient allocation of time, thus they allocate their time to things other than maintaining a healthy diet. Another variable that is included in the field of nutrition is the number of health-food stores in each state. For health-food stores the expected sign is negative. These variables are lumped together because they are all factors in the demand for nutrition. As the demand for better nutrition goes up people's nutritional values increase and they substitute away from fast-food for increased consumption of health food thus causing obesity to decrease.

This chapter focused on the development and explanation of the empirical models that are run. In the next chapter the results from the regressions will be presented and interpreted and the models are tested to make sure that the estimators are the best linear unbiased estimators. The models are tested for heteroscadesiticity, multicollinearity and irrelevant or missing variables. After the regressions are run, the implications of the significant variables from each model are compared. The summary and conclusions of the results is discussed focusing on how each variable affects obesity and why variables may be significant in one model but not the other.

VI. RESULTS

Regression results for both obesity models are detailed below. The first model, which is discussed in the first section, is for individual-level and data contains 11,039 observations from 2001 - 2002. The dependent variable is body mass index (BMI) and the independent variables are weight preference (WTPREF), inactive days due to poor physical or mental health (PMH), frequency of food prepared and eaten at home (FOODH), amount of weight gained or lost over the ten years (WTPREV), daily calorie intake (DCI), number of alcoholic drinks/day (ALC), number of cigarettes per day (CIG), amount of leisure time activity (LEIS), amount of non-leisure time activity (ACTIV), gender(G), age (AGE), race (MA, HIS, W and AA), education (EDU) and annual household income (I). The goal of the Model (1) is to see to what degree the aforementioned explanatory variables affect a person's BMI while Model (2) isolates the impact of the models explanatory variables on state obesity rates. The second model, developed with state-level data, is discussed next. And finally the results between the two models are compared.

Model (1) ordinary least squares (OLS) regression was run using the SAS 9.1 program. The results, which can be seen in table 3, produced significant coefficients for all but two of my variables[6]. The R^2 value is .6957 which means the variables chosen explained a relatively high proportion of the variance in the data. Almost all of the

[6]See Appendix III – Table 10 for Model (1) Descriptive Statistics

variables met the *a priori* expectations with regard to the expected signs. The response to the question would you like to weigh more, less, same represented by the variable WTPREF, showed up as significant at the .001 significance level. This variable is a dummy variable which means that respondents who answered the question experience lower BMI's while those who chose not to answer the question by indicating they did not care did not experience the negative effects on BMI. It has a coefficient value of - 2.71, which means that as an individual's concern for fitness grows their BMI decreases -2.71.

Table 3 OLS regression results – Model (1)

VARIABLE	COEFFICIENT	STANDARD ERROR	t - Value	Pr > │t│
*Constant	27.65750	0.90949	18.99	<.0001
*WTPREF	-2.71038	0.13966	-19.41	<.0001
*PMH	-0.11480	0.02822	-4.07	<.0001
*FOODH	-0.47490	0.17275	-2.75	0.0060
*WTPREV	0.11339	0.00228	49.62	<.0001
DCI	-0.34252	0.38882	-0.88	0.3784
*ALC	0.47090	0.04024	11.70	<.0001
LEIS	0.00689	0.00637	1.08	0.2797
*ACTIV	0.04149	0.00745	5.57	<.0001
*CIG	-0.03024	0.00936	-3.23	0.0013
*G	3.63147	0.20271	17.92	<.0001
*AGE	0.02429	0.00828	2.93	0.0034
*MA	1.43341	0.58034	2.47	0.0136
*HIS	-1.51509	0.70251	-2.16	0.0311
*W	-1.35352	0.54972	-2.46	0.0139
*AA	0.53700	0.57718	2.93	0.0034
*EDU	-1.00475	0.23739	-4.23	<.0001
*I	1.48266	0.19388	7.65	<.0001

*significant at the 5% level

Another variable that showed up as significant at the .001 level is WTPREV. It's coefficient value of 0.11339 means that your weight in the past increases your BMI by 0.11339 in the present. So the heavier you were ten years ago the likelier you are to be heavier now. The variable FOODH is significant at the .05 significance level with a -0.47490 coefficient. This means that the more meals an individual prepares and eats at home the lower the individual's BMI is. As the number of alcoholic drinks consumed per day, which is represented by the variable ALC, increases so does your BMI. This is represented by ALC having a coefficient value of 0.47090 which is significant, as was predicted, at the .001 significance level. Although alcohol consumption increases BMI, cigarette smoking decreases BMI. CIG which is significant at the .005 significance level has a coefficient value of -0.03024. This is as hypothesized and most evidence supports the idea that smoking increases metabolism and decreases appetite. The Constant also showed up as significant at the .0001 level with a coefficient estimate 27.65750. All of the above variables met my *a priori* expectations. Income (I) and education (EDU) also met my *a priori* expectations. Education (EDU) has a -.028662 coefficient value which is consistent with expectations. The dummy variable for EDU is significant at the .001 significance level. This means that the obtainment of a high school diploma results in a 1.00475 decrease in BMI. So, increases in education lead to lower BMIs which is the result of increased health knowledge and understanding. Income (I), the always ambiguous variable, has a coefficient value of 1.48266 which is significant at the .001 significance level. This resolves the ambiguity showing that respondents with a household annual income of seventy five thousand dollars or more experience increases of 1.48266 in BMI. In other words higher incomes do lead to higher BMIs. Next I address the demographic variables, their significance and their impact on BMI.

All of the demographic variables showed up as significant at the .05 significance level. The age variable met my a priori expectations. It has a coefficient value of 0.02429 which indicates that as people age their BMI naturally increases. The dummy variable for gender is significant at the .001 significance level. The variable is representative of men and has a coefficient value of 3.63147 which translates into a 3.63147 increase in BMI for males. All of the race dummy variables are consistent with the other demographic variables in that they are all significant; though they are only significant at the .05 significance level. Whites have a coefficient vale of -1.35325, Blacks have a coefficient value of 0.53700, Hispanics (non-Mexican) have a coefficient value of -1.51509 and Mexican-Americans have a coefficient value of 1.43341. These findings indicate that race does play a part in influencing your BMI. Cultural differences contribute to life-style choices and habits so it is not surprising to find that BMIs will fluctuate among the different races. The following paragraph addresses variables that either showed up as insignificant or with the opposite sign of the one expected.

Two of the variables showed up as insignificant and two had signs opposite to those that were expected. The number of day's individuals spent inactive due to poor physical or mental health (PMH) showed up as significant at the .001 significance level but has a negative impact on obesity (-0.11480). More than likely this is because the more days spent inactive due to illness the sicker the individual has been. In the event that this is the case it is probably the illness that is decreasing their BMI and not their lack of physical activity. The most surprising result is for the coefficient ACTIV, which is a measure of the amount of non-leisure time activity the individual participated in. The variable showed up as significant at the .0001 significance level but with a coefficient value of 0.04149. This means that an increase in the amount of work related activity that an individual participates in increases individuals BMIs. An initial impression might be to assume that this is a result of people over reporting the amount of physical activity their job provided. However if we remember that Philipson and Posner (1999) showed a correlation between increased body mass and increased work related physical labor this result makes sense. The correlation is probably due to increases in muscle mass due to the heavy lifting and other strenuous activities that physical laborers endure. This explains why the strong correlation but such a low coefficient value. Increases in strenuous physical labor increases body mass index through muscle mass increases not from increased fatness. DCI and LEIS both show up as insignificant. DCI or the individual's daily calorie intake probably showed up as insignificant because it is a self reported measure. It is suspected that most individuals under report their total calorie consumption, because they do not realize how many calories they actually eat in a day, which would cause it to be insignificant. If this variable is accurately measured it should be significant and have a positive correlation with obesity because as you consume more calories you gain more weight which increases your BMI. LEIS, the amount of leisure time activity an individual participates in, showed up with a negative sign, as expected, but is insignificant. This problem may be related to the strenuousness of the reported activity or the amount being over reported as individuals assume they are more active than they really are.

To test for heteroscedasticity a model SPEC test was performed in SAS. The SPEC test performs a model specification test. The null hypothesis for this test maintains that if the model is correctly specified, that the model is homoscadasitic and independent of the regressors and the basic linear assumptions of the model are valid. Rejection of the null hypothesis is evidence of heteroscedasticity. The SPEC test's calculated Chi – squared ($X^{2}*$) is 128.7 with the Chi – squared critical value (X^{2}) at the 95% confidence level being 144.4. So since $X^{2}* < X^{2}$ we fail to reject H_0 and conclude that the model is homoscedastic. In addition to the SPEC test a correlation matrix is also created to check for the presence of multicollinearity which is not apparent[7]. The correlation matrix indicates a low level of correlation among the variables so we conclude no extreme multicollinearity. To make sure that the model is correctly specified Ramsey's RESET, which is an F-test on the joint significance of the terms and the powers of the estimated dependent variable, is run. Ramsey's RESET test checks to make sure that the model does not have the specification errors known as omitted variables, irrelevant variables, incorrect functional form and simultaneity. The null hypothesis is that the model is correctly specified and there are no specification errors. The calculated F-statistic (F*) is 1.04 and the F-statistic from the F table (F) is 2.60. So, since $F^* < F$ we fail to reject the null hypothesis and conclude that there are no specification errors in the model.

To illustrate the impact of these variables three hypothetical people are created and their BMIs calculated according to the following model of significant variables from above:

[7] See Appendix I – Table 7

(16) BMI = 27.66 - 2.71(WTPREF) – 0.115(PMH) – 0.475(FOODH) + 0.113(WTPREV) + 0.471(ALC) + 0.041(ACTIV) – 0.030(CIG) + 0.024(AGE) – 1.00(EDU) + 1.48(I) + 3.63(MALE) – 1.35 (W) + 0.54(AA) – 1.52(HIS) + 1.43(MA)

The table below represents these hypothetical people. The numbers in parentheses are either a dummy (as indicated by *) to indicate if that person falls in that category or the number of times the person participated in the given activities (whichever is appropriate) followed by how much it impacted BMI. To calculate BMI sum the person's column.

Table 4 Hypothetical Person's BMIS

VARIABLE	COEFFICIENT	PERSON 1	PERSON 2	PERSON 3
Constant	27.65750	27.65750	27.65750	27.65750
***WTPREF**	-2.71038	(1) = -2.71	(1) = -2.71	(0) = 0
PMH	-0.11480	(5) = -.574	(0) = 0	(2) = -.2296
FOODH	-0.47490	(10) = -4.749	(14) = -6.6486	(5) = -2.3745
WTPREV	0.11339	(+10) = 1.339	(0) = 0	(20) = 2.2678
ALC	0.47090	(1) = .47090	(0) = 0	(3) = 1.4127
ACTIV	0.04149	(1) = .04149	(4) = .16596	(30) = 1.2447
CIG	-0.03024	(20) = -.6048	(0) = 0	(10) = -.3024
***MEN**	3.63147	(1) = 3.63147	(0) = 0	(1) = 3.63147
AGE	0.02429	(40) = .9716	(25) = .60725	(45) = 1.09305
***MA**	1.43341	(0) =0	(1) = 1.43341	(0) = 0
***HIS**	-1.51509	(0) =0	(0) = 0	(0) = 0
***W**	-1.35352	(1) = -1.35352	(0) = 0	(0) = 0
***AA**	0.53700	(0) =0	(0) = 0	(1) = .53700
***EDU**	-1.00475	(1) = -1.00475	(0) = 0	(1) = -1.00475
***I**	1.48266	(1) = 1.48266	(0) = 0	(1) = 1.48266
BMI	**N/A**	**24.39345**	**20.50552**	**35.41563**

* indicates variable is measured with a dummy

In the following paragraphs a description of the hypothetical people from the table above is given to confer a better understanding of who these people may be. The first person is a 40 year old White male with a high school diploma making more than $75,000/year. He exercises but has gained 10 lbs over the last 10 years, eats about 10 meals/week at home, got the flu and was sick for 5 days last month probably because he smokes a pack of cigarettes/day. He normally has 1 alcoholic drink/day and reported having to move some boxes one day at work this month. According to the above equation this man has a predicted 24.4 BMI.

The second person is a 25 year old Mexican-American Female with less than a high school education and is making less than $75,000/year. She exercises and has not put on any weight in the last 10 years, has not taken any sick days this month, eats about 14 meals/week at home, does not drink or smoke. Because of her job at the local fast-food restaurant she has to do some semi-heavy lifting about 4 times/month. This person has a predicted 20.5 BMI.

The third person is a 45 year old Black Male with a high school diploma making more than $75,000/year. He does not exercise and has gained 20 lbs over the last 10 years. He eats only 5 meals/week at home smokes half a pack of cigarettes/day and drinks 3 alcoholic drinks per day. Because of his job as a contractor he does heavy lifting every day of the week. This person has a predicted 35.42 BMI.

Now I will present the findings from the state-level data regressions. An Ordinary least squares (OLS) regression estimation of Model (2) equation (15) yielded the results found below, in table 5[8]. The dependent variable is in log odds ratio format

[8]See Appendix II – Table 9 for Model (2) Descriptive Statistics

{Log (obese/1-obese)} which means that the independent variables explain increases or decreases in the log odds ratio of a given person in the state being obese. Contrary to expectations not all of the variables are significant. Despite this the R^2 is .6945 which leads to confidence in the model. As shown in Table 5 the constant, the percentage of people in a state reporting they had participated in no leisure time activity in the last 30 days (SEDENTARY), the percentage of people in a state reporting not eating the recommended 5 servings of fruits and vegetables per day (NUTRITION), the number of gyms per 100,000 people (GYMD), the percentage of the population in a state who report being current smokers (CIG) and the number of health food stores per capita (HFPC) all showed up as being a significant while the number of parks in a state (PARKS) and the percentage of the population in a state who report being chronic drinkers (ALC) show up as insignificant.

Table 5 **–** OLS Regression Results Model (2)

VARIABLE	COEFFICIENT	STANDARD ERROR	t-ratio	P [│t│]>t	MEAN OF X
*CONSTANT	-2.19281042	.33460847	-6.553	.0000	
*SEDENTARY	.00842466	.00425085	1.982	.0539	23.9372549
*NUTRITION	.00795936	.00334085	2.382	.0217	76.50
PARKS	.00029718	.00020240	1.468	.1493	79.1568627
*GYMD	-.02253339	.00758572	-2.971	.0048	10.4884314
ALC	.00923361	.00799567	1.155	.2545	5.78039216
*CIG	.01721209	.00428913	4.013	.0002	23.3215686
*HFPC	-2816.15504	1071.40816	-2.628	.0118	.516333D-04

* indicate variables that statistically significant at the 10% level

Sedentary behavior shows a moderate positive impact on the log odds ratio of Obesity (.00842466), which translates, as expected, into meaning a higher percentage of the state population that reports sedentary behavior increases the log odds of a person in the state being obese. The variable nutrition is significant and has a coefficient value of

.00795936. This means that as the number of people in a state who report not eating the five servings of fruits and vegetables per day increases so does the log odds of a given person in the state being obese. Gym demand, which has a coefficient value equal to -.02253339, has a moderate negative impact on the log odds ratio of obesity. This is as expected, the more gyms in a state the lower the log odds ratio of obesity will be. The real surprise is in the coefficient for current smokers, which is .01721209, being positive which is contrary to expectations because most evidence suggests that smoking lowers body weight. The number of parks and the number of chronic drinkers are both positive but insignificant. The higher level of data aggregation may be why these variables showed up as insignificant. I will examine this relationship and comment more in the next chapter.

Several tests are run to verify that the results are not flawed or biased. These included the Breusch-Pagan test for heteroscedasticity, a correlation matrix and an F-test for multicollinearity, and Ramsey's RESET test for specification errors. For the Breusch-Pagan test for heteroscedasticity the null hypothesis is that the model is homoscedastic. The Breusch-Pagan statistic is 5.84 and is statistically insignificant. This means we fail to reject the null hypothesis and conclude that the model is homoscedastic. To test for multicollinearity a correlation matrix is run[9]. Though there does not seem to be a high correlation between any of the variables an F-test is run to check for the presence of multicollinearity. The null hypothesis of the F-test is no multicollinearity. The F* is 20.07 which is greater than the F table value of 2.40 so the null hypothesis is rejected and the conclusion is reached that some multicollinearity must exist. The RESET test showed

[9] See Appendix II– Table 8

that there are no specification errors which mean that no correction for incorrect functional form, omitted variables, measurement error, or simultaneity is necessary. The F* value in the RESET test is .5197 which is less than the F- statistic table value of 2.84. This means that we fail to reject the null hypothesis and conclude that the model is correctly specified. In accordance with the above results and subsequent regression results are B.L.U.E. and the findings are legitimate.

The following section provides two hypothetical states to be evidence for the impact the above mentioned significant variables have on the log odds ratio of obesity. The following model of significant variables is such that:

$$\text{lgt(obese)} = -2.19 + .0084(\text{SEDENTARY}) + .0079(\text{NUTRITION}) - .0225(\text{GYMD}) + .0172(\text{CIG}) - 2816.15504(\text{HFPC})$$

Table6 - Hypothetical Log Odds Ratio of Obesity

VARIABLE	COEFFICIENT	STATE 1	STATE 2
CONSTANT	-2.19281042	-2.19281042	-2.19281042
SEDENTARY	.00842466	(25%) = .0021	(40%) = .0034
NUTRITION	.00795936	(58%) = .0046	(80%) = .0063
GYMD	-.02253339	(20) = -.45	(10) = -.225
CIG	.01721209	(40%) = .0069	(63%) = .0108
HFPC	-2816.15504	(.00003) = -.0845	(.00002) = -.0563
LOG ODDS RATIO OF OBESITY	N/A	**-2.7137**	**-2.4536**

The first hypothetical state has 3 million people with 25% of the population leading sedentary lifestyles, 58% reporting poor nutritional habits, 20 gyms/100,000 people, 40% of the state who report being chronic smokers and 100 health-food stores in the state (.00003 per capita). The second hypothetical state also has 3 million people with 40% of the state population leading sedentary lifestyles with 80% reporting poor nutritional habits. They also have 10 gyms/100,000 people, 63% of the population report being chronic smokers and 60 health-food stores in the state (.00002 per capita). The table below outlines the impact these figures have on log odds ratios of obesity in the hypothetical states. Transforming the log odds ratios into probabilities means that for State 1 there is a 7.09% chance that a randomly selected individual from this state is obese. Similarly, in State 2 the above statistic translates into a 9.4% chance that a randomly selected individual from this state is obese.

Now let's examine the relationship of the variables in the two models by comparing similar variables and commenting on why some variables are significant in one model but not the other. The significance of the findings and their bearing on the initial model is crucial to the development of future research.

The number of alcoholic drinks consumed/day is significant in the individual-level model while the percent of the state population that report being chronic drinkers is not significant in the state-level model. This is probably because the amount an individual drinks affects that person's BMI directly while the percentage of the state population who report being chronic drinkers is not directly related to the number of obese individuals in a state. Alcohol can increase your body mass through increases in calories consumed but alcoholism may have the opposite effect. This relationship shows that the effect of alcohol consumption on the individual is not representative of what the effect of the consumption of alcohol is on society.

Cigarette smoking is significant in both models. However, they have opposite signs in model (1) the number of cigarettes smoked/day decreases BMI while in model

(2) the percent of the state population that reports being a current smoker increase the state level rate of obesity. Cigarette smoking decreasing BMI is an *a priori* expectation but increases in the rate of obesity as the number of current smokers' increases is unusual. A potential reason for this curious result is that people who are obese are already leading unhealthy lifestyles (i.e. smoking, over eating, sedentary, etc.) and smoking is not causing obesity but that obese people are more likely to be smokers.

The number of people who reported a sedentary lifestyle, in the state-level model, is significant and increased the prevalence of obesity in Model (2). While, in Model (1), a similar variable, self reported amount of leisure time activity, showed up as insignificant but negative none the less. This means that, even though the second variable mentioned was insignificant, activity does facilitate healthy body weight. Lakdawalla and Philipson (2002) show that this very possibility can arise because of offsetting effects of the sedentary life style; as an individual participates in a sedentary lifestyle they receive a lower marginal benefit from eating because of the reduction in the amount of necessary calories. In this case a sedentary life style does not cause obesity because it is offset by a reduction in caloric intake. An increase in BMI occurs when the decrease in activity is not offset by a reduction in caloric intake. If a standard accurate measure of this variable can be implemented the amount of activity incorporated into ones life will almost always be significant in the prevention of obesity.

The measure of demand for fitness, WTPREF and GYMD in the two respective models, both show up as significant with a negative correlation. This means that increases in the demand for fitness decrease BMI and obesity respectively. In other words for those that care about their weight and in states that have a higher frequency of fitness facilities obesity is less of a problem. As individuals marginal utility of fitness increases so does their concern about their weight as well as their demand for fitness facilities. This substantiates the claim that increases in the marginal utility of fitness decrease the prevalence of obesity.

These are the main variables that are comparable between the models with the rest of the variables in each model being more specific to state or individual level data. Though there are some discrepancies in the significance or impact of the variables there is no less value to the findings. In addition to the first model being more micro in nature and the second model being more macro in nature the inconsistency between the findings in the two models may be blamed on the lack of observations in the second model; there are more than 11,000 observations in the first model compared to only 51 observations in the second. Though both models passed specification tests and their estimators are the best linear unbiased ones an under representation of the population will always result in less significant results than a larger more in depth study. Even if you try to explain every possible factor that could contribute to obesity/overweight it would still exist. It could just be that obesity is ingrained in the nature of our society. Here in the land of the large over consumption is not just an option but a way of life.

VII. SUMMARY AND CONCLUSIONS

The purpose of this thesis is to isolate factors that contribute to obesity and increase BMIs and understand the economic rationale behind them. While the number of papers published on this topic are beginning to rise there is still room for improvement. My objective in writing this paper is to improve on previous theory and lay a solid empirical foundation. “Why Have Americans Become More Obese?” (Cutler, et. al., 2003) tries to isolate the impact of changes in technology on weight. “The Economic Reality of the Beauty Myth” (Averet & Korenman, 1993) details the economic impact of obesity on an individuals life. “An Economic Analysis of Adult Obesity” (Chou, et. al., 2002) begins to scratch the surface of the impact of individual choice on obesity but falls short with insufficient observations (they do not have observations on the individual). So, to my knowledge this is the first paper to find the significance of individual life style choices on an individual’s BMI.

As our society has grown so has its waist line. Increases in time costs and technological innovation have made us a society in love with convenience. And while everybody loves the quick fix there is always a long term price to pay. The development of two models to represent the population, the first on an individual level the second on a state-wide level, is used to show how allocative efficiency with respect to time and utility maximization impact our choices, with the consequence of obesity. First an overview of the problem of obesity is presented. Then a unified economic theory is presented to explain how the concepts of utility maximization and allocative efficiency can cause individuals to make decisions that can result in obesity. The following section outlines the two empirical models and their regression results, which are detailed below.

The first model, which was developed using 11,039 observations from the NHANES survey for the years 2001 – 2002, is representative of individual-level data. The model states that a persons BMI is a function of their weight preference, physical and mental health, number of meals prepared and eaten at home, weight ten years ago, daily calorie intake, number of alcoholic drinks consumed/day, number of cigarettes smoked/day, amount of leisure time activity, amount of work time activity, gender, age, race, education level, and annual household income. In this model all of the variables were significant with the exception of leisure time activity and daily calorie intake. It is likely that the insignificance of both of these variables is due to over and under reporting across all individuals. Most of the variables met the *a priori* expectations with the most notable difference being the positive sign associated with amount of work time physical activity with respect to BMI. Philipson and Posner (1999) showed a correlation between increased body mass and increased work related physical labor that can be contributed to the increases in muscle mass, as opposed to increases in fatness, necessary to perform more physically demanding jobs.

Many of the variables that showed up as significant in the models are considered important in papers that are preludes to this work, which is why they are included in the analysis. For example, in Donald Kenkel's (1991) paper, "Health Behavior, Health Knowledge, and Schooling" he predicted that increases in schooling increase health knowledge and understanding which increase people's concern for their health. This interpretation leads one to believe that the same is also true for obesity as well. The variable included to represent education, EDU, in this model had a negative impact on BMI, which substantiates the initial impression that schooling does affect health.

The second model is representative of state-level data collected from all 50 states and D.C. The data comes from the BRFSS and is for the year 2002. This model states that the log odds ratio of obesity in a given state is a function the percentage of the state population that reports leading sedentary lifestyles, the percentage of the state population that reported not eating the recommended five servings of fruits and vegetables/day, the number of parks in the state, the number of gyms per 100,000 people in a state, the percentage of the state population that reports being chronic drinkers, the percentage of the state population that reports being current smokers, the number of health-food stores per capita in a state. In this model the constant, the percentage of the population that reports leading sedentary lifestyles, the percentage of the population that reported not eating the recommended five servings of fruits and vegetables per day, the number of gyms per 100,000 people in a state, the percentage of current smokers in a state and the number of health-food stores per capita in a state are all significant. It is not surprising that increased sedentary behavior increases obesity while increased gym demand decreases. These things have been speculated not only in this paper but also presented as evidence in many of the papers in the literature review. The most interesting result is the correlation between smoking and obesity in model (2). The results found that as the percentage of current smokers in a state increases so does the obesity rate. While this is contrary to most evidence the findings were significant at the 1% level. A possible explanation is that the frequency of smokers who are already obese is high. This means that while smoking may help prevent an individual from weight gain, smoking combined with other bad habits may contribute to obesity. Since the regression for the second model failed the F-test for multicollinearity, in the future studies should be aware that a relatively high correlation exists between some of the explanatory variables. A possible solution is to try to isolate the variables that are causing the multicollinearity and drop them from the regression. Though, to avoid any bias from dropping variables (omitted variable bias) it would be best to avoid this tactic unless it is absolutely necessary (i.e. the presence of extreme multicollinearity).

In future analyses there are hosts of other variable that should be included to determine if they exhibit a correlation with obesity, including examinations of food, cigarette and alcohol prices. A more specific study, one whose questions pertains directly to obesity and does not rely on self-reporting, is necessary to the advancement of the field. This study would involve long term studies and accurate measurements of how much people eat, how much they exercise, how often they eat out, level of alcohol and cigarette consumption and prices, prices of various different food items as well as any number of other factors that may be linked to obesity.

Obesity is not a disease that can be wiped out using the normal medical treatments and preventative measures. It is reaching epidemic proportions and must be treated accordingly. Attempting to educate our children about the spread and prevention is important to the future and a good start but it is only a start. Education on the impact of obesity and the importance of diet and exercise needs to be disseminated to the public as a whole. As a society, to preserve our health, we must take the initiative and increase the economic incentives of fitness. It would be helpful if employers reduce the time costs associated with eating a health meal. They can provide healthier foods available through the cafeteria so that fast-food is not such a necessity. Employees must also take steps to curb this growing epidemic. For example, take the stairs instead of the elevator to your floor. These are just a few examples. Overall our national health is everyone's responsibility because we are all paying the costs.

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APPENDICES

APPENDIX I

Table 7 - Model (1)Correlation Matrix

	WTPREF	**PMH**	**FOODH**	**WTPREV**	**DCI**	**ALC**	**LEIS**	**ACTIV**
WTPREF	1	-0.0319	-0.0911	-0.0683	0.0443	0.0392	-0.0494	0.1195
PMH	-0.0319	1	-0.0641	0.029	0.0673	0.1761	0.0091	-0.1281
FOODH	-0.0911	-0.0641	1	-0.036	-0.0232	-0.027	0.0262	-0.0168
WTPREV	-0.683	0.029	-0.036	1	0.0458	0.0452	-0.0143	-0.1183
DCI	0.0443	0.00673	-0.0232	0.0458	1	0.1371	-0.0133	-0.027
ALC	0.392	0.1761	-0.027	0.0452	0.1371	1	-0.0947	-0.1367
LEIS	-0.494	0.0091	0.0262	-0.143	-0.0133	-0.0947	1	0.2596
ACTIV	0.1195	-0.1281	-0.0168	-0.1183	-0.027	-0.1367	0.2596	1
CIG	0.368	-0.0003	-0.075	0.2138	0.0034	-0.0568	-0.0482	-0.0483
AGE	0.1054	-0.0534	-0.1159	0.0757	-0.1325	-0.2945	0.0964	0.1351
EDU	-0.0208	0.0362	-0.0049	-0.083	0.0095	0.1568	-0.0887	-0.0417
I	-0.0553	-0.0786	0.1281	0.0761	-0.0722	-0.1961	-0.005	-0.047
G	0.1475	0.0196	-0.0188	0.5059	0.1105	0.2811	-0.0215	-0.0106
W	0.0216	0.029	0.0305	-0.0332	-0.0153	-0.1518	-0.0065	-0.1056
AA	-0.0711	-0.0473	-0.0182	0.1588	0.0629	-0.0286	-0.0223	0.0979
HIS	-0.0466	0.0888	0.0799	-0.0042	-0.0325	-0.054	0.1095	0.0662
MA	0.0565	-0.0684	-0.0575	-0.0937	-0.0198	0.2363	-0.0344	0.0359

CIG	**AGE**	**EDU**	**I**	**G**	**W**	**AA**	**HIS**	**MA**
0.0368	0.01054	-0.0208	-0.0553	0.1475	0.0216	-0.0711	-0.0466	0.0565
-0.0003	-0.0534	0.0362	-0.0786	0.0196	0.029	-0.0473	0.0888	-0.0684
-0.075	-0.1159	-0.0049	0.1281	-0.0188	0.0305	-0.0182	0.0799	-0.0575
0.2138	0.0757	-0.083	0.0761	0.5059	-0.0332	0.1588	-0.0042	-0.00937
0.0034	-0.1325	0.0095	-0.0722	0.1105	-0.0153	0.0629	-0.0325	-0.0198
-0.0568	-0.2945	0.1568	-0.1961	0.2811	-0.1518	-0.0286	-0.054	0.2363
-0.0482	0.0964	-0.0887	-0.005	-0.0215	-0.0065	-0.0223	0.1095	-0.0344
-0.0483	0.1351	-0.0417	-0.047	-0.0106	-0.1056	0.0979	0.0662	0.0359
1	0.1656	0.0083	0.1073	0.0995	0.2845	-0.0784	-0.0677	-0.2541
0.1656	1	-0.2084	0.0761	0.0491	-0.0545	0.0271	0.0426	0.0215
0.0083	-0.2084	1	0.0288	-0.0544	0.1114	-0.0439	-0.0344	-0.0855
0.1073	0.0761	-0.0288	1	-0.0216	0.1537	-0.0434	0.0982	-0.2091
0.0995	0.0491	-0.0544	-0.0216	1	-0.1275	0.1597	-0.0981	0.035
0.2894	-0.0545	0.1114	0.1537	-0.1275	1	-0.5861	-0.2301	-0.5434
-0.0784	0.0271	-0.0439	-0.0434	0.1597	-0.5861	1	-0.0825	-0.1949
-0.0677	0.0426	-0.0344	0.0982	-0.0981	-0.2301	-0.0825	1	-0.0765
-0.2541	0.0215	-0.0885	-0.2091	0.035	-0.5432	-0.1949	-0.0765	1

This Correlation matrix indicates a low level of correlation among the variables so we conclude no extreme multicollinearity.

APPENDIX II

Table 8 - Model (2) Correlation Matrix

	SEDENTARY	NUTRITION	PARKS	ALC	CIG	GYMD	HFPC
SEDENTARY	1	0.21235	-0.24121	-0.26744	0.5269	-0.37238	-0.45746
NUTRITION	0.21235	1	-0.27929	-0.33002	0.32463	-0.55379	0.21261
PARKS	-0.24121	-0.27929	1	0.1214	-0.27699	0.20156	0.15257
ALC	-0.26744	-0.33002	0.1214	1	-0.11376	0.40453	0.04413
CIG	0.5269	0.32463	-0.27699	-0.11376	1	-0.35939	-0.30826
GYMD	-0.37238	-0.55379	0.20156	0.40453	-0.35939	1	0.04532
HFPC	-0.45746	0.21261	0.15257	0.04413	-0.30826	0.04532	1

This Correlation matrix indicates a low level of correlation among the variables so we conclude no extreme multicollinearity.

Table 9 – Model (2) Descriptive Statistics

VARIABLE	MEAN	STD. DEV.	MIN	MAX	CASES
SEDENTARY	23.9372549	4.3534796	15	33.6	51
NUTRITION	76.5	4.0504321	16.1	85.7	51
PARKS	79.1568627	59.575959	17	282	51
ALC	5.78039216	1.3938464	2.8	8.7	51
CIG	23.3215686	3.3108497	12.8	32.6	51
GYMD	10.4884314	2.1337117	7.02	16.85	51
HFPC	5.16E-05	1.34E-05	3.02E-05	1.02E-04	51
OBESE	21.7803922	2.7236754	16.5	27.5	51

APPENDIX III

Table 10 – Model (1) Descriptive Statistics

VARIABLE	MEAN	STD. DEV.	MIN	MAX	CASES
WTPREF	0.627995	0.483365	0	1	11039
PMH	1.4420459	5.3460617	0	30	11039
FOODH	10.323838	1.1667648	0	30	11039
WTPREV	10.271948	12.627995	0	300	11039
DCI	2140.2948	173.99783	0	5384	11039
ALC	2.7105075	4.2525745	1	99	11039
LEIS	19.675228	12.738012	10	30	11039
ACTIV	12.777183	15.818609	0	30	11039
CIG	15.067226	9.213799	1	65	11039
AGE	30.100795	24.753687	0	85	11039
EDU	0.1359486	0.3427352	0	1	11039
I	0.6044159	0.4889775	0	1	11039
G	0.4858879	0.4998025	0	1	11039
W	0.4448186	0.4969474	0	1	11039
AA	0.2230654	0.4163033	0	1	11039
HIS	0.0442007	0.2055414	0	1	11039
MA	0.2486721	0.4322448	0	1	11039
BMI	24.746996	6.9218941	7.99	65.41	11039