ECONOMIC FACTORS AFFECTING THE INCREASE IN OBESITY IN THE UNITED STATES: DIFFERENTIAL RESPONSE TO PRICE

A Paper
Submitted to the Graduate Faculty
of the
North Dakota State University
of Agriculture and Applied Science

By

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In Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE

Major Department:
Agribusiness and Applied Economics

June 2005

Fargo, North Dakota

ABSTRACT

de Chastenet, Hélène; M.S.; Department of Agribusiness and Applied Economics; College of Agriculture, Food Systems, and Natural Resources; North Dakota State University; June 2005. Economic Factors Affecting the Increase in Obesity in the United States: Differential Response to Price. Major Professors: Dr. Dragan Miljkovic and Dr. William Nganje.

Over the past decade, the human obesity rate in the United States has experienced a big increase. Genetic factors contribute to the problem of obesity, but overnutrition is also an important factor in the recent increased prevalence. A large consumption of foods high in sugar and fat increases the likelihood of weight gain, especially with low physical activity. Sugar may play a major role in increased obesity and in binge eating. Eating sweets can be addictive and induces one to eat more. Consequently, the total energy intake rises, which causes problems of overweight and obesity.

This paper is based on the theory of rational addiction. In the case of food consumption, the theory suggests that addicts consume certain types of foods even if food prices change. The empirical results from the multinomial logit model show that overweight and obese people respond to a change in the current price of sugar. As sugar price increases, the likelihood that they will consume less sugar increases, and their body mass index (BMI in kg/m^2) tends to decrease. Even if current or future prices of potatoes (carbohydrates) increase, people will continue consuming carbohydrates. Increasing current and historical prices of milk (fats) significantly decrease the probability of falling in the "overweight" and "obese" categories. Some socioeconomic and demographic variables are included in the analysis, and it appears that education level has the greatest negative impact on the BMI. Finally, with the marginal impacts of economic determinants of obesity, this paper provides policy makers with a better understanding about which factors could be used to decrease obesity trends in the future.

ACKNOWLEDGMENTS

I would like to thank my major advisors, Dr. Dragan Miljkovic and Dr. William Nganje, for their support and guidance. I appreciate the help from my committee members, Dr. Cheryl Devuyst and Dr. Jane Edwards, for their constructive comments throughout the academic year.

I would like to thank my parents and my friends, especially Prashant Varma and Dr. & Mrs. Croll, for their encouragement.

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CHAPTER 1. INTRODUCTION

Background/Problem Statement

Today, in the United States, one of the most important problems in public health is overnutrition (American Obesity Association. "Obesity in the U.S.," 2002). Overnutrition is defined as eating too much or eating too much of certain types of foods. Many health problems find their origins in this recent phenomenon. Each year, nearly two-thirds of all deaths in the United States are due to diet-related chronic diseases, including coronary heart disease, cancer, stroke, and diabetes. Annually, diet-related illness costs the U.S. society about $75 billion in medical expenditures (Finkelstein et al., 2004).

Obesity is measured by the body mass index (BMI), which is the weight in kilograms divided by height in meters squared. Overweight, obesity, and severe obesity are defined as BMIs greater than 25, 30, and 40, respectively.

From the end of the 1970s to the beginning of the 1990s, the prevalence of overweight children almost doubled, from 8 percent to 14 percent among 6 to 11-year-old children and from 6 percent to 12 percent among adolescents. During the same period, the fraction of overweight adults increased from 25 percent to 35 percent. During the 1990s, the obesity rate for adults rose from 12 percent to 18 percent (Nestle, 2002). In 2003, according to the Centers for Disease Control and Prevention (CDC, 2003), 15 states had obesity prevalence rates between 15 and 19 percent; 31 states were between 20 and 24 percent; and 4 states had rates greater than 25 percent. Figure 1 highlights this phenomenon across the states between 1991 and 2003.

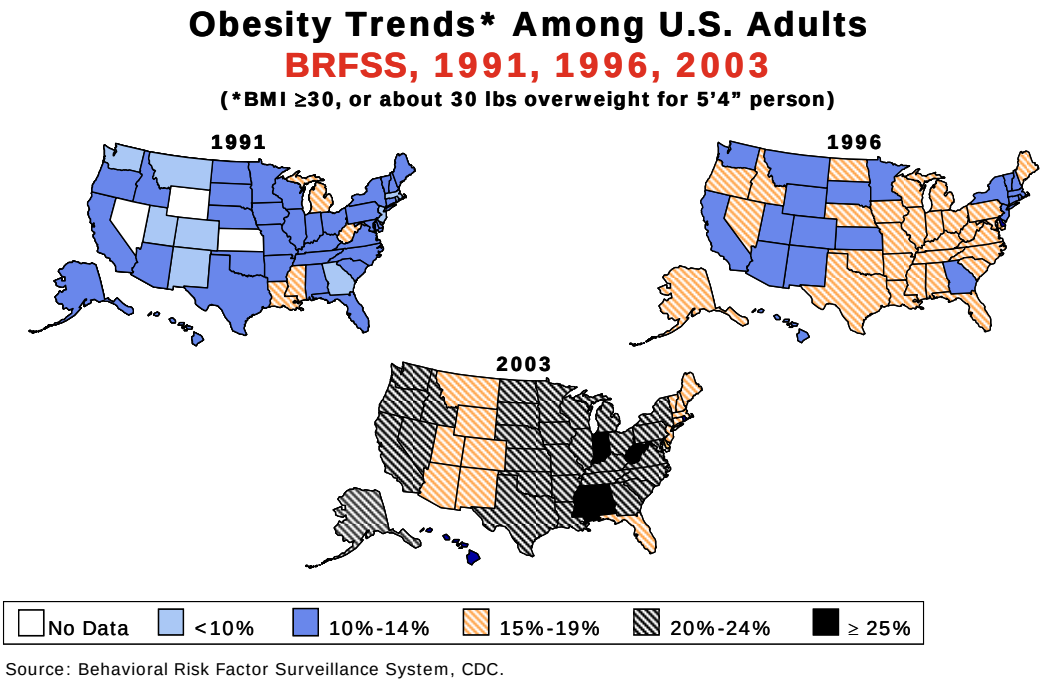

Figure 1. Obesity trends among U.S. adults (CDC, 2003).

Excessive consumption of foods since the late 1980s

The increasing rates of obesity in the USA coincide with a big increase in average calorie intake between 1985 and 2000. Fats are added in cooking, at the table, and in many processed food products, such as snack foods, baked goods, and French fries. One of the problems is that added fat in processed foods is not visible, and consumers are not aware of the fat content. Many companies add fat to improve taste (Putnam et al., 2002). Per capita daily consumption of added fats increased 16 percent between 1997 and 2000. In 2000, Americans consumed added fats accounting for 89 percent of the recommended upper daily limit for total fat intake and consumed large quantities of foods naturally high in saturated fat and cholesterol. Added sugars consumption was nearly three times the recommended dietary target. Foods high in added sugars, such as sweet snack foods, cookies, candies, and

cola drinks often supply calories but few nutrients. Average annual consumption of caloric sweeteners grew by 22 percent between 1980-84 and 2000. Moreover, U.S. per capita fruit consumption is low. American consumers eat too few fruits and vegetables and tend to eat a limited variety of vegetables. Half of Americans ate less than 1 serving of fruit daily in 1994-96 and less than a quarter consumed 3 fruits servings a day, which is the number recommended by the U.S. Department of Agriculture Food Guide Pyramid (Putnam et al., 2002).

Obesity, a socioeconomic problem

The societal cost of obesity in the United States has become a socioeconomic problem. Low income U.S. households spend a greater percentage of their annual budget on food than those with higher incomes. Low income households buy lower cost items with a high energy density, such as sweets and fats. Diets with added sugars and fats have replaced whole grain diets. With more resources, people do not necessarily consume healthier foods (Drewnowski, 2003).

Darmon et al. (2002) show that economic constraints contribute to unhealthy food choices. They predict the food choices individuals take to reduce their food budgets while maintaining diets similar to the average population diet. They model isoenergetic diets by linear programming. Then, they introduce a cost constraint to assess the effect of cost on the foods selection by the program. Among low socioeconomic groups (households with low income and low education level), the results show that the proportion of energy by meat, dairy products, vegetables, and fruits decreases, but the proportion by sweets, added fats, and cereals increases. Thus, a cost constraint influences food selection and decreases the nutrient densities of diets for low income consumers. According to their study,

economic measures could be efficient in improving the nutritional intake of low socioeconomic populations. The study also shows that although nutrition knowledge plays an important role, economic constraints influence behavior such as dietary habits.

The U.S. Government envisions new policies to combat obesity problems. The first option is to promote better food choices through better education, especially at the childhood level. The second one is to implement new tax and price policies. Today, in at least 18 states, sales of sweet and fat foods, such as soft drinks, snack foods, and candy are taxed. These taxes yield more than $1 billion per year (Nestle, 2002). The proposal is to put taxes on such products and to use tax proceeds to support health promotion campaigns. As changing prices influence purchase choices, one of the solutions is to decrease prices of vegetables and fruits to stimulate the purchase of these items (Nestle, 2002).

Justification of the Study

Obesity and overweight are both social and economic problems. The U.S. Department of Health and Human Services is worried about interwoven societal problems. How can the obesity trends among the U.S. population be reduced? What would be the leverage to achieve this goal?

The goal of this study is to use socio-demographic factors to explain food consumption leading to overweight and obesity. Results from this study can be used to develop fiscal and policy measures to reduce obesity. The study explores the question of whether increasing prices of fat and sweet food products, by putting higher taxes on these types of foods, is relevant to encourage people to allocate their resources toward the purchase of healthier foods, such as vegetables, fruits, and whole grain?

Description of the Study

In this study, we develop a model of rational addiction in food consumption based on the "Theory of Rational Addiction" of Becker and Murphy (1988). Rational people decide what they consume on the basis of food price and income, knowing the future health consequences of eating certain types of foods. People are potentially addicted to certain foods if an increase in their past consumption of these foods leads to an increase in their current consumption of these same foods. In this study, we use a framework suggested by this model to analyze empirically consumption of certain types of foods by using food price variables as instruments for food consumption. The Body Mass Index (BMI) is the dependent variable, divided in three categories: normal (BMI<25 kg/m^2), overweight (25≤BMI<30 kg/m^2), and obese (BMI≥30 kg/m^2). Six groups of independent variables are considered: 1) the price of calories consumed derived from prices of different food groups identified as representative of sugar, carbohydrates, and fats which are recognized to induce gain in weight when they are overconsumed; 2) household income; 3) age; 4) gender; 5) education level (top grade level attained); and 6) race.

A limited dependent variable model is used to determine which attributes (independent variables) impact BMI of overweight and obese individuals. Classifying the BMI of individuals in categories is an advantage: the effect of each attribute on the BMI is assumed to be different for consumers according to their BMI category. Marginal impacts of the independent variables on the three BMI categories (dependent variables) are determined.

Data from the National Center for Chronic Disease Prevention and Health Promotion, extracted from the Behavioral Risk Factor Surveillance System (BRFSS), are

used for this study. The objective of the BRFSS is to collect data across states by a telephone survey on preventive health practices and risk behaviors in the adult population. In our study, data for four states and three years (1991, 1997, and 2002) are used to account for the evolution of the BMI for the last decade. Monthly food prices data from the Annual Summaries of the National Agricultural Statistics Service (United States Department of Agriculture) are matched with the BRFSS survey data.

Study Objectives and Hypothesis

The specific objectives of this study are

1) To develop a model of rational addiction in food consumption
2) To determine the relationship between BMI and the selected food groups
3) To test the rational addiction model empirically and to estimate differential price effects of addictive foods on normal, overweight, and obese people

As sugar is considered as an addictive food, the hypothesis tested in this study is that lower sugar price significantly increases the Body Mass Index and the obesity rate among the population.

Outline

Chapter 2 focuses on a literature review about trends of overweight and obesity in the world and in the United States, and the addictive consumer behavior related to sugar. Chapter 3 develops the theoretical model of rational addiction in food consumption. The empirical model and data used in the analysis are presented in Chapter 4. Chapter 5 reports and discusses the results. Chapter 6 presents the conclusion and provides suggestions for policy considerations, limitations, and recommendations for further studies.

CHAPTER 2. LITERATURE REVIEW

Trends of BMI in the World and in the United States

Obesity was compared to an "epidemic" by the World Health Organization (WHO) in 2000 in Geneva and recognized it as a "neglected public health problem" today in the United States (American Obesity Association. "Obesity in the U.S.," 2002). Overweight and obesity result from an imbalance involving excessive calorie consumption and/or inadequate physical activity. For each individual, body weight is the result of a combination of genetic, metabolic, behavioral, environmental, cultural, and socioeconomic influences. A person gains weight when he/she consumes more calories from food than the body uses through its normal functions (Basal Metabolic Rate, BMR) and physical activity (U.S. Department of Health and Human Services).

Trend of BMI in the world

More than 1 billion adults in the world are overweight, and approximately 300 million are obese. The WHO (2003) mentions "epidemic proportions" and deals with "globesity." The underlying shifts in society, such as modernization and urbanization, are partially responsible for the rising prevalence of overweight and obesity.

In Africa and Asia, the BMI for adults is about 22-23 kg/m^2. But in North America, Europe, and in North African, Latin American, and Pacific Island countries, the BMI reaches 25-27 kg/m^2. In China and Japan, the current obesity level is less than 5 percent (WHO, 2002). Nevertheless, in some big cities, the obesity prevalence is much higher and can hit 20 percent. In economically advanced regions of developing countries, especially in urban areas, the obesity rate has become equal to the rate reached by industrialized countries (American Obesity Association. "Obesity – A Global Epidemic," 2002).

In Europe, obesity rates have increased by 10 to 40 percent during the last 10 years (American Obesity Association. "Obesity – A Global Epidemic," 2002). Globally, among children and adolescents, obesity rates increased in both developing and developed countries. Moreover, the higher obesity rates were obtained with women and the higher overweight rates with men. Note that under-nutrition[1] and obesity co-exist in many developing countries.

Trend of BMI in the United States

In the United States, 127 million adults are overweight; 60 million are considered as obese; and 9 million are severely obese. Table 1 contains figures about the prevalence of overweight, obesity, and severe obesity among American adults from 1976 to 2000 (American Obesity Association. "Obesity in the U.S.," 2002). Between the end of the 1970s and the end of the 1990s, the prevalence of overweight people increased by 40 percent. During this same period, the obesity prevalence had more than doubled. Between the end of the 1980s and the end of the 1990s, the severe obesity prevalence increased by 62 percent.

Table 1. Prevalence of overweight, obesity, and severe obesity among U.S. adults

	Overweight (BMI>25)	Obesity (BMI>30)	Severe Obesity (BMI>40)
1999 to 2000	64.5	30.5	4.7
1988 to 1994	56.0	23.0	2.9
1976 to 1980	46.0	14.4	No data

Source: CDC, National Center for Health Statistics, National Health and Nutrition Examination Survey. Health, United States, 2002. Flegal et. al. JAMA. 2002;288:1723-7. NIH, National Heart, Lung, and Blood Institute, Clinical Guidelines on the Identification, Evaluation and Treatment of Overweight and Obesity in Adults, 1998. (American Obesity Association. "Obesity in the U.S.," 2002).

[1] Under-nutrition: a Body Mass Index less than 18.5.

Table 2 describes the prevalence of overweight among U.S. adults by age categories and by gender for two periods, from 1988 to 1994 and from 1999-2000. Overall, whatever the gender, prevalence of overweight goes up with age. In 1999-2000, men had higher overweight prevalence than women except for the age group of 55 to 64 years. During the same period, the highest overweight prevalence among men was registered for the age group of 65 to 74 years. Women had the highest percentage of overweight when they were between 55 to 64 years old.

Table 2. Prevalence of overweight U.S. adults by age and gender

	Prevalence for Men (%)		Prevalence for Women (%)	
Age (years)	1988 to 1994	1999 to 2000	1988 to 1994	1999 to 2000
20 to 34	47.5	58.0	37.0	51.5
35 to 44	65.5	67.6	49.6	63.6
45 to 54	66.1	71.3	60.3	64.7
55 to 64	70.5	72.5	66.3	73.1
65 to 74	68.5	77.2	60.3	70.1
75 and older	56.5	66.4	52.3	59.6

Source: CDC, National Center for Health and Nutrition Examination Survey. Health, United States (Table 70) 2002. (American Obesity Association. "Obesity in the U.S.," 2002).

Table 3 reports the results about the prevalence of obesity among adults by age and gender for the same period of time as in the previous table. In 1999-2000, the prevalence of obesity was higher among women than men. During the same period, men had the highest prevalence of obesity between 65 and 74 years; whereas, women registered the highest prevalence between 55 and 64 years.

Table 3. Prevalence of obesity among U.S adults by age and gender

	Prevalence for Men (%)		Prevalence for Women (%)	
Age (years)	1988 to 1994	1999 to 2000	1988 to 1994	1999 to 2000
20 to 34	14.1	24.1	18.5	25.8
35 to 44	21.5	25.2	25.5	33.9
45 to 54	23.2	30.1	32.4	38.1
55 to 64	27.2	32.9	33.7	43.1
65 to 74	24.1	33.4	26.9	38.8
75 and older	13.2	20.4	19.2	25.1

Source: CDC, National Center for Health and Nutrition Examination Survey. Health, United States (Table 70) 2002. (American Obesity Association. "Obesity in the U.S.," 2002).

Table 4 shows the increase in prevalence of overweight and obesity among U.S. men and women by age groups between the period 1988-1994 and 1999-2000. (This table was created from Tables 2 and 3.)

Table 4. Increase in prevalence of overweight and obesity among U.S. adults by age and gender between 1988-1994 and 1999-2000

	Increase in Prevalence (%) for Men Between 1988-1994 and 1999-2000		Increase in Prevalence (%) for Women Between 1988-1994 and 1999-2000	
Age (years)	Overweight	Obesity	Overweight	Obesity
20 to 34	22.1	70.9	39.2	39.5
35 to 44	3.2	17.2	28.2	32.9
45 to 54	7.9	29.7	7.3	17.6
55 to 64	2.8	21.0	10.3	27.9
65 to 74	12.7	38.6	16.3	44.2
75 and older	17.5	54.5	14.0	30.7

All adult age categories, whatever the gender, experienced an increase in overweight and obesity. Overall, the highest increases were experienced with the youngest age group (20 to 34 years) and the two oldest age groups (65 to 74 years and 75 and older).

Among men, the overweight prevalence for people between 20 and 34 years old and for the age group of 75 and older increased by 22.1 percent and by 17.5 percent respectively. Concerning the male obesity prevalence, in one decade, the number of obese people aged 20 to 34 years increased by 70.9 percent. A high increase was also registered for men older than 75 years. High increases in overweight were registered among young women between 20 and 34 years and 35 and 44 years, respectively 39.2 percent and 28.2 percent. Other age groups had lower increases. Among women, all age groups had experienced high increases in obesity prevalence. The lowest increase was recorded among women between 45 and 54 years old (17.6 percent) and the highest one between 65 and 74 years old (44.2 percent).

Overall, men had a higher prevalence in overweight than women (68.8 percent versus 63.8 percent in 1999-2000). On the other hand, women had a higher prevalence in obesity at the same date (34.1 percent versus 27.7 percent). In the last decade, men had the highest increase in obesity (+38.7 percent); whereas, women had the highest rise in overweight (+25.7 percent).

Table 5 shows the variations of the obesity prevalence according to education levels among U.S. adults from 1991 to 2001. Overall, obesity prevalence increased for each

Table 5. Prevalence of obesity according to education levels

Education Level	1991 Obesity Prevalence (%)	1998 Obesity Prevalence (%)	2000 Obesity Prevalence (%)	2001 Obesity Prevalence (%)
Less than high school	16.5	24.1	26.1	27.4
High school	13.3	19.4	21.7	23.2
Some college	10.6	17.8	19.5	21.0
College	8.0	13.1	15.2	15.7

Source: CDC, Behavioral Risk Factor Surveillance System, 1991-2001. (American Obesity Association. “Obesity in the U.S.,” 2002).

education level in the last decade. However, people with higher education levels had lower obesity rates than people with less education.

Table 6 reports obesity prevalence for adults in the nine U.S. regions. Between 1991 and 2000, each region experienced an increase in obesity.

Table 6. Prevalence of obesity for adults in U.S. regions

Regions of the U.S.	1991 Obesity Prevalence (%)	1998 Obesity Prevalence (%)	2000 Obesity Prevalence (%)
New England (Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, Vermont)	9.90	11.40	16.95
Middle Atlantic (New Jersey, New York, Pennsylvania)	12.70	16.70	18.41
East North Central (Illinois, Indiana, Michigan, Ohio, Wisconsin)	14.10	19.10	21.00
West North Central (Iowa, Kansas, Minnesota, Missouri, North Dakota, Nebraska, South Dakota)	12.20	18.00	19.82
South Atlantic (District of Columbia, Delaware, Florida, Georgia Maryland, North Carolina, Virginia, West Virginia)	11.10	18.60	19.52
West South Central (Arkansas, Louisiana, Oklahoma, Texas)	13.10	14.10	17.10
Mountains (Arizona, Colorado, Idaho, Montana, New Mexico, Utah, Wyoming)	9.60	14.10	17.10
Pacific (Alaska, California, Hawaii, Nevada, Oregon, Washington)	10.20	17.00	19.10

Source: CDC, Behavioral Risk Factor Surveillance System, 1991-2000. (American Obesity Association. "Obesity in the U.S.," 2002).

Table 7 summarizes the obesity prevalence for the adults between 1991 and 2001 for the four states in the United States used in the study. It illustrates that the obesity prevalence increased in all the country over the last decade.

Table 7. Prevalence of obesity for U.S. adults in the four states used in the study between 1991 and 2001

U.S. states	1991 Obesity Prevalence (%)	1998 Obesity Prevalence (%)	2000 Obesity Prevalence (%)	2001 Obesity Prevalence (%)
California	10.0	16.8	19.2	20.9
Idaho	11.7	16.0	18.4	20.0
Michigan	15.2	20.7	21.8	24.4
Minnesota	10.6	15.7	16.8	19.2

Source: CDC, Behavioral Risk Factor Surveillance System, 1991-2001. (American Obesity Association. "Obesity in the U.S.," 2002).

Does Eating Sugar Make People Obese?

According to the Reference Dietary Intakes, the Food Guide Pyramid, the Dietary Guidelines for Americans, and the American Dietetic Association, all foods consumed in moderation can fit into a healthful eating style. Many factors influence eating practices: taste and food preferences, lifestyle, environment, concerns about nutrition and weight control, and food product safety.

The 2000 USDA Food Guide Pyramid provides some information and recommendations for the quantity and type of foods to eat from 5 major groups: 1) bread, cereals, rice, and pasta; 2) vegetables; 3) fruits; 4) milk, yogurt, and cheese; 5) meat, poultry, fish, dry beans, eggs, and nuts.

The pyramid (Figure 2) presents a range of recommended servings for each food group for sample levels of energy intakes. The number of servings recommended for each food group depends on an individual's age, physiological status, and energy requirements. Healthy diets, including vegetables, grains, and fruits, and low in fat, saturated fat, and cholesterol, combined with moderate and regular physical activity, reduce the risk of

diseases. But most Americans do not follow the recommendations of the 2000 USDA Food Guide Pyramid.

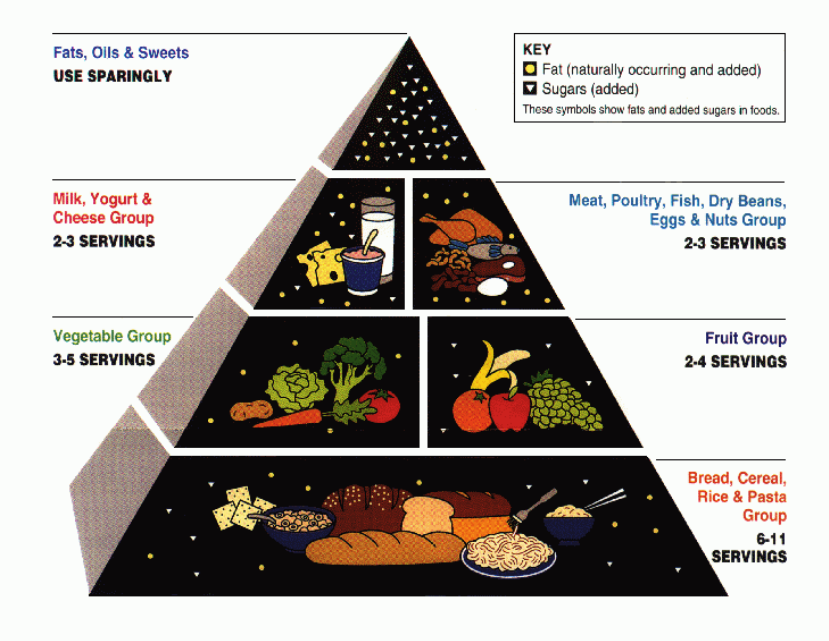

Figure 2. The 2000 USDA Food Guide Pyramid (USDA and USDHHS, 2000).

On average, Americans consume excess calories from fats, oils, and sweets, and they consume fewer fiber-rich fruits and vegetables. Only 20 percent of Americans consume the recommended number of total grain serving daily. In 1994, more than 50 percent of total dairy servings were from high-fat foods (cheese, ice cream, and whole milk), while lower fat products (1 percent and skim milk) represented 10 percent of total dairy consumption (Kantor, 1996).

A high-fat diet promotes the development of obesity with a direct relationship between the amount of dietary fat and the degree of obesity. Golay and Bobbioni (1997) indicate by animal studies that high-fat diets induce greater food intake and weight gain than high-carbohydrate diets because of several factors, such as caloric density, satiety properties, and post-absorptive processing. For instance, the satiating effects after meals with a weak "fat/carbohydrate" ratio are greater than for meals with a higher ratio. The overconsumption of energy as fat in obese patients would be due to eating a high-fat meal when hunger is high. Thus, dietary fat induces overconsumption and weight gain because of its high caloric density and its low satiety properties (Hill, 1999).

Preference for fat is a factor which must be taken into account for obesity. Some research shows that obese people prefer the same concentration of sugar but higher concentrations of fat than normal-weight people. Many popular sweet foods, such as chocolate, ice cream, cookies, and cakes, contain fat. Moreover, it is demonstrated that eating five to nine servings of fruits and vegetables daily reduces the incidence of several diseases, such as heart diseases and high blood pressure (Hill, 1999). Fruits and vegetables are sources of fiber. Fiber plays a role in regulating blood sugar, lowering blood cholesterol, and also in controlling weight.

Newby et al. (2003) find that smaller gains in BMI and waist circumference are associated with a consumption of diets high in vegetables, fruits, reduced-fat dairy, and whole grains; and low in red and processed meat, fast food, and soda (diet low in glycemic load). The greater gains are obtained with a consumption of diets high in meat and potatoes and with a consumption of diets high in white bread, pizza, and fast food (food with a high glycemic index value and low in fiber). The explanations are that fiber in vegetables, fruits,

and whole grains increases satiety and decreases insulin response, which decreases hunger and energy intake. Moreover, vegetables, fruits, and whole grains are low in energy density (Newby et al., 2003).

One of the explanations about the increasing rates of overweight or obesity in the United States is recent eating habits with a sedentary lifestyle. Commonly, nutritionists implicate consumption of snacks, fast foods, and soft drinks. It is true that Americans often consume foods away-from-home. The problem is that these items contain usually more salt, sugar, and fat. Overall, the percentage of household total expenditures dedicated to food purchases decreases as income increases. According to Economic Research Service (ERS) of the USDA, in 1998, 11.6 percent of Americans' income is spent for food. Of this percentage, 7.4 percent was for at-home food and 4.2 percent for away-from-home foods (Putnam and Allhouse, 1999). Similarly, with easier access to new food technologies and to processed foods, people tend to eat more daily meals, and consequently their caloric intake increases (Culter et al., 2003). Moreover, overconsumption of sugar-sweetened beverages, corn syrup, potatoes, and refined grains induce a higher risk of diabetes and heart diseases (Drewnoswski et al., 2004).

In 2000, 77 percent of Americans thought that there were "good" and "bad" foods. But this belief induces dichotomous thinking (Freeland-Graves and Nitzke, 2002). For instance, the person feels certain self-control when he/she stays in the diet. But he/she may lose control in a high risk situation (in front of an appealing food). Freeland-Graves and Nitzke (2002) take the example of ice-cream. This food is considered as "bad", but when the dieter is attracted by this food, he/she may think, "I ate the ice-cream, I have blown my diet. I'm going to finish the carton". This thinking is related to addictive or compulsive

behaviours. The parallel is done with alcoholics when they break abstinence. When the dieter breaks his/her objectives, he/she becomes weak and indulgent with himself/herself, and the common idea is that a diet can start tomorrow.

The problem is that lower food prices induce people to consume more. Some people have trouble controlling what they eat. Culter et al. (2003) discuss about "self-control problems." According to them, $30 to $50 billion is spent per year on diets. Overall, people still overeat although they would like to lose weight.

The most important factor influencing food choice seems to be taste. The initial factors influencing the taste are primarily genetic, metabolic, and physiological. Then, individual experiences and eating behaviours play a role. Taste preference for sweetness is inborn; whereas, taste preference for fat is learned in early childhood (Drewnowski, 1997).

A sweet taste has an attraction for many animals and for humans. Many studies investigate food preference and diet-induced overeating, especially on laboratory rats. If rats have the choice between foods with different compositions, they prefer high-fat and/or high-sugar foods. Moreover, their total energy intake may rise by 20 to 40 percent. Rats may become mildly or moderately obese in eating "supermarket" foods, such as cookies or milk, with their standard chow (Sclafani, 2001). The hedonism phenomenon plays an important role with the flavor stimuli on food selection and intake.

The combination of fat and sugars in foods are commonly preferred. For fat and sugar appetites, some studies give explanations related to hormonal mechanisms, including endogenous opiate peptides (endorphins) and binge eating. Other studies find that peak hedonic rating is achieved with mixtures containing 20 percent fat and 8 percent sucrose. This peak is obtained with products such as ice cream, sweetened cream cheese, and cake

frostings. The common point between these foods is that they contain milk, cream, and sugar (Drewnowski, 1997).

Brain peptides or neurotransmitters may mediate the sensory pleasure response to sweetness and fat. Endorphins play a role in food cravings, drug reward, and in the binge-eating syndrome in obesity and bulimia nervosa. It is shown that preferences for sweet taste are increased by opiate secretion. On the other hand, opiate antagonists reduce food intake in declining taste preferences for sweet and high-fats foods. Parallels between binge-eating and drug addiction can be done because these phenomena are both under opiate control and imply loss of control and cravings. Appetites for sweets and opiate addictions are associated. Eating ice cream and chocolate decreases the feeling of opiate lack (Drewnowski, 1997).

Binge-types of foods are commonly ice cream, doughnuts, candy, cookies, popcorn, milk, and sandwiches. They are rich in fat and sugar and consumed in large quantities during a binge. According to clinical experiences, carbohydrates play the major role in obesity and in binge-eating. When people are stressed, they tend to eat sweet snacks because sugar increases endorphin production, which has a tranquilizing effect. Obese people have stronger preference for sweet tastes than non-obese people. They usually have an excess of carbohydrates in their daily diet (Fullerton et al., 1985).

Bray et al. (2004) suggest that consumption of high-fructose corn syrup (HFCS) in beverages may play a role in the increase in obesity. In the United States, HFCS represents more than 40 percent of caloric sweeteners added to foods and beverages. Moreover, it is the only caloric sweetener used for soft drinks. Between 1970 and 1990, consumption of HFCS rose more than 1,000 percent. The main reason is that HFCS is much cheaper than

sucrose (sugar) for manufacturers. HFCS is included in most soft drinks and fruit drinks, canned fruits, flavoured yogurts and dairy desserts, many cereals, jellies, and in most baked goods. This evolution is parallel to the increase of obesity. It is suggested that dietary fructose may contribute to increased energy intake and may induce weight gain. Hence, sweetened beverages may bring up caloric overconsumption. Nevertheless, many factors induce excessive caloric intake, such as increased portion sizes, overconsumption of sweetened beverages, high-fat foods, and diets high both in simple sugars such as sucrose and in HFCS as a source of fructose.

In this context, the obvious question is the following: is there significant difference between sucrose from traditional sugar (produced for instance from sugarbeets) and fructose from the high fructose corn syrup? Apparently, there is no difference. Jacobson (2004) suggests that even if soft drinks were still sweetened with sucrose, they would have contributed just as much to overweight and obesity prevalence. Moreover, the body gets almost similar amounts of glucose and fructose in consuming either HFCS or sucrose. In the beverage industry, the fructose content of high-fructose corn syrup is only slightly higher (5 percent) than the fructose content of sucrose. Overall, according to Saris (2003), there is no significant change in metabolic response with an increasing use of HFCS. Price is the only difference between sucrose and HFCS. Food companies gain 1 cent in sweetening a 12-ounce can of soft drink with HFCS instead of sucrose. In other words, it is not useful to differentiate foods sweetened with HFCS or sucrose. Moreover, it is impossible to determine by how much the shift from sucrose to high fructose corn syrup has contributed to the increasing consumption of soft drinks and in consequence to the

development of obesity (Bray et al., 2004). Finally, in this study, prices of sucrose and HFCS are assumed to be positively correlated.

In summary of the literature cited, carbohydrates, and particularly sugars, are implicated in the problem of overweight and obesity. Eating sugar leads to eating more, and the combination of increasing consumption of carbohydrate-sweetened beverages and foods with the decreasing physical activity contributes much to raise the risk of weight gain.

CHAPTER 3. A MODEL OF RATIONAL ADDICTION

According to studies on food preference, eating high-fat and high-sugar food items may induce overweight or obesity and may increase the total energy intake. Sugar is commonly preferred and seems to be particularly addictive. Becker and Murphy (1988) defined the "theory of rational addiction" and made the parallel between overeating, smoking, and drug use. They assume that addictions are rational because addicted people maximize their utility by relying on stable preferences over time.

The utility function in period t is the following:

$$U_t = u[A_t, A_{t-1}, G_t, V_t], \quad (1)$$

where A_t and A_{t-1} are the consumption of the addictive good (such as sugar) respectively in period t and t-1, G_t is a non-addictive good, and V_t represents life cycle events (such as divorce, unemployment, and depression) and are defined as unobservables.

The assumptions are

1) Individuals are infinite lived and maximize the sum of life time utility discounted at the rate r
2) G is numeraire
3) The rate of interest and the rate of time preference are equal
4) The price of addictive food in period t is written P_t

Individuals seek to maximize their utility, such as

$$\text{Max} \sum_{t=1}^{\infty} \beta_{t-1} U(A_t, A_{t-1}, G_t, V_t) \quad (2)$$

such that $A_0=A^0$ and (2a)

$$W = \sum_{t=1}^{\infty} \beta_{t-1} (G_t + P_t A_t), \quad (2b)$$

where $\beta=1/(1+r)$, P_t is the price of foods in period t, and W is the present value of wealth. Effects of addictive food's consumption on earnings, on the present value of wealth, and on the length of life are not taken into account. A^0 is the initial condition for the consumer in period 1 and measures the level of addictive food in the period prior to that under consideration.

The first-order conditions are as follows:

$$U_g(A_t, A_{t-1}, G_t, V_t) = \lambda \quad (3a)$$

$$U_1(A_t, A_{t-1}, G_t, V_t) + \beta U_2(A_t, A_{t-1}, G_{t+1}, V_{t+1}) = \lambda P_t. \quad (3b)$$

U_g is the marginal utility of consumption in each period. The summation of U_1, marginal utility of current addictive food consumption, and U_2, the discounted marginal effect of the current consumption on the future utility, is equal to the current price multiplied by the marginal utility of wealth, λ. U_2 is negative with harmful, addictive food.

Since the marginal utility of wealth, λ, is constant over time, changes in the price of the addictive food over time trace out marginal utility of wealth-constant demand curves for G and A. If utility is considered as non separable, the demand curves depend on prices in all periods through the effects of past and future prices on past and future consumption.

For instance, consider a utility function quadratic in G_t, A_t, and V_t. The first-order conditions are as follows:

$$U_g + U_{gg}G_t + U_g A_t + U_{y2}A_{t-1} + U_{gv}V_t = \lambda \quad (4a)$$

$$U_1 + U_{1g}G_t + U_{11}A_t + U_{12}A_{t-1} + U_{1v}V_t + \beta(U_2 + U_{2g}G_{t+1} + U_{22}A_t + U_{2v}V_{t+1}) = \lambda P_t. \quad (4b)$$

Equation 4a can be solved for G_t in terms of λ and A_t:

$$G_t = (\lambda/U_{gg}) - (1/ U_{gg}) (U_g + G_{g1} A_t + U_{22}A_{t-1} + U_{gv}V_t). \quad (5)$$

If equation 5 is substituted in equation 4b, a linear difference equation is obtained (equation 6). It expresses current addictive food consumption as a function of past and future addictive food consumption, the current price of addictive food (P_t), the change in life cycle events (V_t and V_{t+1}).

$$A_t = \gamma A_{t-1} + \beta\gamma A_{t+1} + \gamma_0 + \gamma_1 P_t + \gamma_2 V_t + \gamma_3 V_{t+1}, \quad (6)$$

where

$$\gamma = -(U_{12}U_{gg} - U_{1g}U_{2g}) / [(U_{11}U_{gg} - U^2_{1y}) + \beta(U_{22}U_{gg} - U^2_{2y})], \quad (6a)$$

$$\gamma_0 = [(U_g - \lambda) (U_{1g} + \beta U_{2g}) - (U1 + \beta U_2)] / [(U_{11}U_{gg} - U^2_{1y}) + \beta(U_{22}U_{gg} - U^2_{2y})], \quad (6b)$$

$$\gamma_1 = U_{gg} \lambda / [(U_{11}U_{gg} - U^2_{1y}) + \beta(U_{22}U_{gg} - U^2_{2y})] < 0, \quad (6c)$$

$$\gamma_2 = -(U_{gg}U_{1v} - U_{1g}U_{vy}) / [(U_{11}U_{gg} - U^2_{1y}) + \beta(U_{22}U_{gg} - U^2_{2y})], \text{ and} \quad (6d)$$

$$\gamma_3 = -\beta (U_{gg}U_{2v} - U_{2g}U_{2v}) / [(U_{11}U_{gg} - U^2_{1y}) + \beta(U_{22}U_{gg} - U^2_{2y})]. \quad (6e)$$

γ_1 is negative by concavity of U, which means that when the current price increases, the current consumption A_t goes down, while the marginal utility of wealth λ is not changed. The sign of γ determines the impacts of shifts in past or future consumption on current consumption.

We deduce from equation 6 that current consumption is independent of past and future prices when A_{t-1} and A_{t+1} are held fixed, and that any effect of past and future prices must come through their effects on A_{t-1} and A_{t+1}, respectively. Assuming that the unobservables are uncorrelated with prices in these periods, past and future prices are considered as representative of A_{t-1} and A_{t+1}, since past prices directly affect past

consumption, and future prices have a direct impact on future consumption. Thus, γ and γ_1 are estimated empirically by using past and future price variables as instruments for past and future consumption.

Lower past or future food prices are assumed to increase past or future consumption. Thus, if γ is positive, lower past or future food prices will increase current consumption. On the contrary, if γ is negative, increases in past or future consumption would bring down current consumption. Past and current consumption are complement only if γ is positive, and the addiction is stronger when γ is higher. This phenomenon is called reinforcement: it means that people with a high past consumption of goods have greater desire for present consumption. The greater the reinforcement from past consumption, the more addictive the food. In other words, a good is addictive if $\gamma > 0$ and when γ is larger, the degree of addiction is higher. The second phenomenon is called tolerance, which means that when past consumption is greater, the current utility is lower because of the harmful effects of addictive goods.

Two categories of consumers are defined. The "myopic utility maximizers" do not take into account the future consequences of their current consumption; whereas, the "rational utility maximizers" do (Becker et al., 1990). Among rational addicts, people who discount the future heavily are more likely to be addicted because they are not worried about the harmful consequences. In addition, the addiction is greater when the effects of past consumption depreciate more rapidly. In this case, current consumption does not decrease the future utility much.

Models of myopic and rational addiction are different, and their results are also different. Myopic individuals do not consider the future consequences of current

consumption and do not consider a potential change in their future utility. For them, current consumption depends on current price, the marginal utility of wealth, lagged consumption, and current events. Thus, they do not respond to future price changes as rational individuals do. For instance, if the future price changes, it will not have any impact on the current consumption of the addictive food for myopic consumers.

In this model, the first-order conditions are

$$U_g + U_{gg}G_t + U_gA_t + U_{g2}A_{t-1} + U_{gv}V_t = \lambda \quad (8a)$$

$$U_1 + U_{1g}G_t + U_{11}A_t + U_{12}A_{t-1} + U_{1v}V_t = \lambda P_t \quad (8b)$$

The term of the future impact βU_2 does not appear in equation 8b because current consumption, in this case, is not related to future consumption A_{t+1} and future life events V_{t+1}.

It is important to notice that the model of rational addiction and the model of myopic addiction, by their different structures, give different results about responses to future changes. The study focuses on the model of rational addiction in food consumption.

From the model of rational addiction developed for food consumption, an empirical test is performed (Chapter 4) using past and future prices (P_{t-1} and P_{t+1}) as instruments representative of past and future consumption (A_{t-1} and A_{t+1}) of the addictive foods. The objective of the study is to know how overweight and obese people respond to a change of prices on sweet food products in order to help to develop an effective policy using taxes.

CHAPTER 4. EMPIRICAL METHODS AND PROCEDURES

Equation (6) derived from the utility function (equation 1) is used as the basis of the empirical model in this study. Addictive food consumption in period, t, is defined as a function of addictive food consumption in period, t-1, and in period, t+1, the current price of addictive food, Pt, and the unobservables V_t and V_{t+1}. This estimation induces biased estimates because unobservable errors that affect utility in each period are likely to be serially correlated. Positive serial correlation in the unobserved effects erroneously implies that past and future consumptions have a positive impact on current consumption, even when the true value γ is equal to zero. Nevertheless, this problem can be avoided thanks to developments by Hansen (1982). Equation (6) involves that current consumption is independent of past and future prices when A_{t-1} and A_{t+1} are held fixed. This equation also implies that any impacts of past and future prices are reflected by their impacts on A_{t-1} and A_{t+1}. Moreover, the unobservables are assumed to be uncorrelated with prices in these periods. Thus, past and future prices can be used to approach past and future consumption. The empirical strategy is to estimate γ and γ_1 from equation 6 by using P_{t-1} and P_{t+1} as instruments for A_{t-1} and A_{t+1}. As data for current consumption of food are not available from the BRFSS survey, the current consumption is empirically approached by the individual body mass index. It is assumed that when the food consumption increases, the BMI increases, and vice versa.

To test the rational addiction model empirically and to estimate differential price effects of addictive foods on people, the multinomial logit model is used. This study assumes that individuals can fall into three BMI categories: normal, overweight, and obese. In this model, the probability of falling in one of the three BMI categories is a function of

past, current, and future prices of foods (sugarbeet, potato, and whole milk). Some socioeconomic variables and demographic variables are also taken into account, such as gender, age, household income, grade, and race.

The multinomial logit model is used because the dependent variable, the BMI category, is qualitative in nature, and it is classified in more than two alternatives. The marginal impacts of the independent variables, such as food prices, gender, age, income, grade, and race on the three BMI categories can be determined.

The three advantages of multinomial logit model are the following (Kennedy, 1996): 1) its computational ease; 2) the expression of the probability that a consumer selects a given alternative is easy to obtain; and 3) a likelihood function can be determined and maximized straightforward.

The probability that a consumer will fall in a given BMI category is estimated as a function of food prices and consumer attributes. The assumptions required by the model are

1) We assume that people can choose to increase their BMI by overeating addictive foods, especially when prices of these foods are low
2) ε_{ij} is a random independent variable with a Weilbull distribution, and the distribution of the differences between ε_{ij} is logistic (Domencich and McFadden, 1975)

It is assumed that the BMI category "normal" is the base category and is chosen outside of the modeling framework. Therefore, the probability of selecting or falling in the base category is undetermined in the present choice set. Nevertheless, in normalizing the coefficients for "normal" to zero, the problem disappears (Amemiya and Nold, 1975). Maximum likelihood is utilized to estimate the coefficients for the other "overweight" and

"obese" categories. The probability of the *j*th individual adopting *i*th BMI category can be calculated as (Greene, 1995):

$$\text{Prob}ij = \frac{e^{\beta' iXj}}{\sum_i e^{\beta' Xj}} \qquad (12)$$

To measure the effects of economic and demographic factors on the choice of BMI category by individuals, a single equation multinomial logit model estimated by maximum likelihood is used.

The marginal effects of price impacts and of the other socioeconomic variables can also be estimated. In the discrete choice model, the effect of a change in attribute *m* (such as prices, income, etc.) of the alternative *j* on the probability that the individual would choose alternative *k* (where *k* may or may not equal *j*) is (Greene, 1995):

$$\partial_{jk}(m) = \partial \text{Prob}[y_i=k] / \partial x_{ij}(m) = [1(j=k) - P_j P_k]\beta_m \qquad (13)$$

where P_j and P_k are the sample proportions of observations that make choices j and k respectively and, β_m is the set of parameters which reflects the changes in X on the probability.

It is essential to evaluate the differential price impacts on BMI to show that some food pricing strategies could be employed in order to decrease BMI and, therefore decrease the obesity prevalence. It is also interesting to determine which socioeconomic factors must be considered to create some policies for the same goal.

The set of coefficients and marginal effects from the multinomial logit model are estimated by the LIMDEP econometrics software package (Nlogit version 3.0).

CHAPTER 5. EMPIRICAL RESULTS AND DISCUSSIONS

Data and Estimation Procedures

Three years of BRFSS survey data are used: 1991, 1997, and 2002. They are considered as period t. To this data set, prices for three different food commodities are added. Food commodities include sugarbeets for sugar or sweetener category, potatoes for carbohydrates, and whole milk for fat. State- and month-specific prices come from the USDA. All price measures are deflated to 1989 dollar price to obtain real prices.

States for which price data are incomplete are deleted. Consequently, data for four states are kept: California, Idaho, Minnesota, and Michigan. These represent three different regions in the United States according to the climate and life-style: California for the West Coast (Pacific), Minnesota and Michigan for the Upper Midwest, and Idaho for the Rocky Mountains. The data set is representative of three major markets among five in the United States. There is no gap in the state-specific price series for these four states. t-1 prices are compiled for the years 1990, 1996, and 2001, and t+1 prices are compiled for the years 1992, 1998, and 2003.

In the data set, there are 45,440 observations (from the four states over three years). State-specific demographic variables and BMI measures are available for the years of 1991, 1997, and 2002 and come directly from the survey. The analysis uses twenty-three explanatory variables. Among these variables, ten variables are continuous variables and represent age and food prices (historical, current, and future); two variables are discrete and represent the income and education level (grade); and eleven are dummy variables for gender, trends (time), regions, and races. The basic data used in the multinomial logit

model are presented in Table 8. This table reports variable definitions, means, and standard deviations of the variables (data for four states and for the years 1991, 1997, and 2002).

Table 8. Descriptive statistics of data

Variable Name	Variable Description	Mean	Standard Deviation
CURRENTS	Current price of sugarbeet ($/ton)	38.95	1.75
CURRENTP	Current price of potato ($/ton)	7.62	4.04
CURRENTM	Current price of milk ($/ton)	12.18	1.06
HISTSUGA	Historical price of sugarbeet ($/ton)	40.96	4.05
HISTPOTA	Historical price of potato ($/cwt)	7.71	3.17
HISTMILK	Historical price of milk ($/cwt)	13.91	1.39
FUTURESU	Future price of sugarbeet ($/ton)	38.95	3.52
FUTUREPO	Future price of potato ($/cwt)	7.31	3.39
FUTUREMI	Future price of milk ($/cwt)	13.2	2.01
AGE	Age of survey participants	46.65	17.64
INCOME	Household income 1=less than $10,000 2=$10,000 to less than $15,000 3=$15,000 to less than $20,000 4=$20,000 to less than $25,000 5=$25,000 to less than $35,000 6=$35,000 to less than $50,000 7=$50,000 to less than $75,000 8=$75,000 or more 77=Don't know/Not sure 99=Refused		
GRADE	Highest grade or year of school completed 1=Eight grade or less 2=Some high school 3=High school grad. or GED cert. 4=Some technical school 5=Technical school graduate 6=Some college '7=College graduate 8=Post grad or professional degree 9=Refused		
SEX	Dummy for gender 1=Male 0=Female		
DY97	Dummy for the year 1997 1=Year 1997 0=Otherwise		

Table 8. (continued)

Variable Name	Variable Description	Mean	Standard Deviation
DY02	Dummy for the year 2002 1=Year 2002 0=Otherwise		
DR1	Dummy for California 1=California 0=Otherwise		
DR2	Dummy for Idaho 1=Idaho 0=Otherwise		
DR4	Dummy for Minnesota 1=Minnesota 0=Otherwise		
RBLACK	Race:Black 1=Black 0=Otherwise		
RASIAN	Race: Asian or Pacific Islander 1=Asian or Pacific Islander 0=Otherwise		
RINDIAN	Race: American Indian or Alaska Native 1=American Indian or Alaska Native 0=Otherwise		
ROTHER	Race: Other 1=Other 0=Otherwise		
DHISP	Hispanic origin 1=Hispanic origin 0=Otherwise		

In the BRFSS survey, only adults, defined as individuals with an age equal or greater than 18 years, are interviewed. The average age of the sample used for the analysis in this paper is 46.65 years, and the standard deviation is 17.64 years. The data set is composed of 43.32 percent of men and 56.68 percent of women; whereas, for the United States, the estimates for gender in 2004 are 49.22 percent of men and 50.78 percent of

women (Population Division, U.S. Census Bureau, 2005). Women are more interviewed than men by the BRFSS.

Empirical Results

The number of individuals interviewed in 1991, 1997, and 2002 are 10,388, 16,029, and 19,023 respectively for the four states. In this sample, 46.1 percent of the individuals are classified as normal weight (BMI<25), 35.8 percent as overweight (25<BMI<30), and 18.1 percent as obese (BMI>30) according to their BMI.

The goal of the study is to determine which category of individuals, according to their BMI, is more responsive to change in price of addictive foods. In the model of rational addiction, the main implication is that addictive food consumption decisions are linked over time. Indeed, current consumption is affected by both past and future consumption. Past and future prices of addictive food affect directly past and future consumption of this commodity and affect indirectly its current consumption when current prices are held constant.

Three goodness of fit measures evaluate the overall fit of the model. This is due to the type of model employed. Multinomial logit model has more than one goodness of fit measure. It differs from the least square models, which have a single goodness of fit measure.

Three goodness of fit measures are used in this study and are as follows:

1) McFadden R^2 is defined as $R^2 = 1 - L\Omega / L\varphi$, where $L\Omega$ is the unrestricted maximum log-likelihood, and $L\varphi$ is the restricted maximum log-likelihood (slope coefficients equal to zero)

2) The likelihood ratio test is calculated as $2(L\Omega - L\varphi)$ and is distributed as a χ^2 random variable

3) The third goodness of fit measure is the percentage of correct predictions

These three measures, together, indicate the explanatory power's level of the model.

The estimated value of the McFadden R^2 is 13.12 percent. The explanatory variables explain a significant portion of the variation in each variable on BMI categories. The estimated chi-square test statistic is equal to 12,327.04 with 44 degrees of freedom, and it is significant at 1 percent level. The percentage of correct predictions is equal to 90.94. The three measures of fit together indicate that the explanatory power of the model is good. Moreover, a choice-based sampling is used to ensure the robustness of the model. Thus, the estimation errors are minimized, but the coefficients are not affected.

To evaluate the significance of a variable, the p-value is used. The p-value is determined when the standard normal probability of N[0,1] is greater or equal to the ratio of the estimated variable to the estimated standard error of the variable (Greene, 1990). To interpret the results, a 5 percent level of significance is chosen.

As the model is a multinomial logit, two sets of coefficients are mentioned: one for "overweight" BMI category and one for "obese" BMI category. Whatever the set, most of the coefficients are significant at 5 percent. Table 9 shows the estimated results. At 5 percent level of significance, higher current prices of sugar significantly decrease the probability of being overweight and obese. At the same level of significance, future prices of sugar significantly decrease the probability of being overweight, but they do not affect the probability of being obese. According to the theory of rational addiction, people consider the future. Knowing that the future sugar price will increase, addicted people such

as overweight people reduce their current consumption of sugar. Nevertheless, obese people do not change their behavior if they perceive an increase in future prices of sugar.

Table 9. Results of Multinomial Logit Model

Variable	Coefficient	Standard Error	P[|Z|>z]	Mean of X
Characteristics in numerator of Prob[Y = overweight]				
CURRENTS	-.07680001	.01080260	.0000	38.9491915
CURRENTP	.04528994	.00632349	.0000	7.61806756
CURRENTM	-.15255329	.01541028	.0000	12.1823059
HISTSUGA	.01070024	.00963436	.2667	40.9633321
HISTPOTA	-.06424005	.00663573	.0000	7.70904137
HISTMILK	-.20540939	.01218226	.0000	13.9051664
FUTURESU	-.01154373	.00474701	.0150	38.9475040
FUTUREPO	.04361099	.00782818	.0000	7.31170401
FUTUREMI	.57064080	.00919774	.0000	13.2036466
AGE	.01371975	.00066510	.0000	46.6506162
INCOME	-.00301098	.00057399	.0000	10.6086048
DSEX	-.91287802	.02271410	.0000	.56683539
GRADE	-.06795582	.00799855	.0000	4.76170775
DY97	-.65729332	.04267503	.0000	.35275088
DY02	.74438978	.06145698	.0000	.41863996
DR1	-.25700066	.06498955	.0001	.24282570
DR2	.26278263	.06789775	.0001	.24991197
DR4	-.03647870	.06363508	.5665	.27451585
RBLACK	.31481508	.05589249	.0000	.04612676
RASIAN	-.55477871	.08706321	.0000	.01828785
RINDIAN	.21817161	.11222424	.0519	.01100352
ROTHER	.08167952	.09030770	.3658	.01762764
DHISP	.20056348	.04636514	.0000	.07185299
Characteristics in numerator of Prob[Y = obese]				
CURRENTS	-.10144671	.01498595	.0000	38.9491915
CURRENTP	.09746130	.00832766	.0000	7.61806756
CURRENTM	-.34685136	.02045973	.0000	12.1823059
HISTSUGA	.01550283	.01376143	.2599	40.9633321
HISTPOTA	-.14303207	.00921846	.0000	7.70904137
HISTMILK	-.41522533	.01618589	.0000	13.9051664
FUTURESU	-.00982464	.00610750	.1077	38.9475040
FUTUREPO	.08373276	.00974071	.0000	7.31170401
FUTUREMI	.99200330	.01417189	.0000	13.2036466
AGE	.00975946	.00082204	.0000	46.6506162
INCOME	-.00652733	.00077843	.0000	10.6086048
DSEX	-.45742857	.03012516	.0000	.56683539
GRADE	-.16756340	.01102296	.0000	4.76170775
DY97	-1.28613944	.05599277	.0000	.35275088
DY02	1.43462536	.08817164	.0000	.41863996
DR1	-.73003552	.08531408	.0000	.24282570
DR2	.09243341	.08620950	.2836	.24991197
DR4	-.41096176	.08322180	.0000	.27451585
RBLACK	.65952757	.06653430	.0000	.04612676
RASIAN	-1.33054840	.14795942	.0000	.01828785
RINDIAN	.55100566	.12989077	.0000	.01100352
ROTHER	.22196769	.11035116	.0443	.01762764
DHISP	.25710376	.05608637	.0000	.07185299

Obese people might be too addicted to sweet foods to reduce their consumption of sweets. The other problem is that, in consuming sweet foods, people feel immediate gratification, but the harmful consequences occur only in the future (Culter et al., 2003).

The effect of historical prices of sugar on the probability of falling in the "overweight" or "obese" category is not significant.

In addition, the impact of current and future prices for potatoes (the proxy for carbohydrates) on the BMI is significant and positive. According to the medical literature, people addicted to sugar tend to eat more foods with high fat content and more carbohydrates. Thus, even if current or future prices of potatoes increase, people will continue consuming carbohydrates, and they may consume higher quantities due to their addiction to sugar. For overweight and obese consumers, the impact of historical prices for potatoes is negative. It seems that higher historical prices for this food will be more likely to induce people to decrease the consumption of potatoes and to decrease the probability of being overweight or obese. One reason for this phenomenon is that potatoes are not an addictive food.

Current and historical prices of milk, representing fats, significantly decrease the probability of adopting each of the BMI categories ("overweight" and "obese") and vice versa. However, if the future price of milk goes up, it is more likely that people will move to BMI categories other than the "normal" category.

Some demographic variables are analyzed, such as age, household income, and education level. The prevalence of overweight and obese adults goes up with age whatever the gender: as people age, they become more likely to be overweight or obese. As the household income rises, people are more likely to be less overweight and less obese. With higher income, people can afford a variety of healthy foods, such as fruits and vegetables. The results show that, with a higher education level, people are less likely to have a BMI classified as overweight or obese. This result was expected because we suppose that

individuals with better education receive more information about nutrition and are more aware of what a good diet should be. Moreover, with more disposable income, they can afford more quality foods.

Finally, in the last set of variables, some binary dummy variables are used. They provide information about trend (time), gender, races, and regions. The interpretation of the coefficients from these dummies is done relative to the omitted dummy for each category of variables.

Compared to 1991, the BMI trend in 2002 is significantly positive at 5 percent level for “overweight” and “obese” categories. Indeed, CDC statistical results show a big increase in overweight and in obesity in the United States between the beginning of 1990s and now. The significant and negative estimate obtained for the year 1997 is unexpected. This result could be explained by the fact that, between 1991 and 1997, the obesity rates for the four given states did not increase much compared to the national obesity trend. Concerning gender, men are less likely to be obese. This result corresponds to the literature and CDC statistics. Nevertheless, it appears that men are less likely to be overweight, which is belied by the CDC statistics. One explanation might be that the sample used for the analysis is reduced and is not representative enough for the variable “gender”. Indeed, more women than men were interviewed in the survey. Concerning races, the omitted dummy is white individuals. All the interpretations are done relative to white individuals. The results show that all the races, such as Blacks, American Indians, and Hispanics are more likely to have overweight and obese people than the white race. The only exception is represented by the Asians. Compared to white people, they may have significantly lower BMI. Note that these results are not surprising.

The estimated coefficients of the regional dummies are interpreted relative to Michigan. Individuals living in California are more likely to have a lower BMI than Michigan because of the high percentage of Asians in this state (10.9 percent versus 1.8 percent)[2], and the lower percentage of Blacks also (6.7 percent versus 14.2 percent) contribute to these results. In addition, California residents are recognized as the healthiest eaters in the United States. These people consume more salads, fresh eggs and yogurt, bottled water, and wine (Nielsen, 2002). According to the U.S. Census Bureau, in San Francisco, more than 94,000 people walk to get to work-at least twice as many per capita as in any other city. San Francisco has many fitness centers, and a quarter of the Bay City's fitness facilities is constituted by yoga studios; whereas, Detroit has few fitness centers-only about 1 for every 69,000 people (Horn, 2002). In Idaho, people are more likely to be overweight than people living in Michigan. The reason could be that in Idaho there are more people with Hispanic origin than in Michigan (7.9 percent versus 3.3 percent), and as we have seen before, Hispanics are more likely to have a higher BMI compared to Whites. Idaho is not significantly different from Michigan for the "obese" category. In addition, Minnesota is not significantly different from Michigan for the "overweight" category, but people from this state are less likely to be obese than people in Michigan. Michigan is more industrial than Minnesota, and the population is composed by 14.2 percent of Blacks versus 3.5 percent in Minnesota. As previously, black people are more likely to be overweight and obese compared to white people.

Marginal Impacts Analysis

[2] Source: 2000 resident census population.

To understand how each independent variable impacts the results of the model, the marginal probability of the variable must be determined. Table 10 reports the marginal impacts of variables averaged over individuals on the probability to be classified as "normal", "overweight," and "obese" according to the BMI. The entire results of the marginal impacts are included as Appendix A.

Table 10. Summary of marginal effects

Variable	Y=Normal	Y=Overweight	Y=Obese
CURRENTS	.0166	-.0091	-.0075
CURRENTP	-.0119	.0026	.0093
CURRENTM	.0411	-.0075	-.0336
HISTSUGA	-.0024	.0012	.0012
HISTPOTA	.0171	-.0034	-.0137
HISTMILK	.0524	-.0139	-.0385
FUTURESU	.0022	-.0018	-.0004
FUTUREPO	-.0109	.0033	.0076
FUTUREMI	-.1366	.0503	.0863
AGE	-.0025	.0022	.0003
INCOME	.0008	-.0002	-.0006
DSEX	.1550	-.1623	.0073
GRADE	.0190	-.0024	-.0166
DY97	.1654	-.0475	-.1179
DY02	-.1861	.0554	.1307
DR1	.0774	-.0021	-.0753
DR2	-.0424	.0496	-.0072
DR4	.0283	.0220	-.0502
RBLACK	-.0817	.0196	.0621
RASIAN	.1534	-.0224	-.1310
RINDIAN	-.0619	.0068	.0551
ROTHER	-.0240	.0014	.0226
DHISP	-.0429	.0243	.0185

Increasing the current price of sugar by one percent decreases the probability of being in the "overweight" category by 0.91 percent, decreases the probability of being in the "obese" category by 0.75 percent, and increases the likelihood of being in the "normal" BMI category by 1.66 percent. Whatever the BMI category, marginal effects of historical prices of sugar are not significant. People classified as "normal" and "overweight"

significantly respond to change in future prices of sugar. If future prices of sugar rise by one percent, the likelihood of being in the "normal" BMI category goes up by 0.22 percent, and the likelihood of being in the "overweight" category goes down by 0.18 percent, at 5 percent significance level. On the other hand, obese people do not significantly respond to shifts in future prices of sugar. This lack of response may find its origin in the higher level of addiction in sugar for obese people. As these individuals are highly addicted to sweet foods, the future does not seem important to them. According to this analysis, obese people do not change their consumption of sugar even if prices of sugar in the future increase. For overweight and obese individuals, one percent higher current and future prices of potato significantly increase the BMI.

On the other hand, a rise in historical prices of potatoes induces a decrease in the probability of being in the "overweight" and "obese" categories by respectively 0.34 percent and 1.37 percent. Opposite results are found for individuals who are neither overweight nor obese. Concerning whole milk, an increase by one percent in its historical and current prices decreases the probability of being in the "overweight" and "obese" categories; whereas, the same increase in future price for this commodity causes this probability to increase. Results for individuals in the "normal" category are opposite.

With the age, the probability of being in the "normal" category decreases by 0.25 percent, and the probability to move to "overweight" and "obese" categories increases respectively by 0.22 percent and 0.03 percent. The marginal effect of income is significant and decreases the probability of higher BMI for overweight and obese individuals, respectively by 0.02 percent and 0.06 percent. These effects are not really important because Americans spend less than 10 percent of their income on food (Nestle, 2002).

Likewise, the marginal effect of education level decreases the probability of being in the "overweight" and "obese" categories, respectively by 0.24 percent and 1.66 percent. These higher figures show that education may be an essential policy variable to decrease the prevalence of overweight and obesity.

Among the regions, when the marginal effects are significant at 5 percent level, they are important. In this way, compared to Michigan, living in Idaho induces an increase in the probability of being overweight by 4.96 percent. Marginal effects of regions such as California and Minnesota on the probability of being overweight compared to Michigan are not significant at 5 percent level. Likewise, the marginal effect of Idaho on the probability of being obese compared to Michigan is also not significant for the same level. Nevertheless, the marginal effects of living in California and in Minnesota decrease the probability of being obese by 7.53 percent and 5.02 percent respectively, compared to Michigan.

CHAPTER 6. CONCLUSIONS

Brief summaries are presented in this chapter about the problem addressed, the objectives, the methodology, and the results. Finally, limitations of this study and implications for further studies are stated.

Summary of Problem

In the United States, obesity is identified by the authorities now as the most important public health concern. Moreover, it has become a socioeconomic problem due to the cost to society. Approximately two-thirds of all deaths in the United States per year are blamed on diet-related chronic diseases attributable to excess of weight. It costs the country hundreds of billions of dollars annually in medical care and lost productivity (Finkelstein et al., 2004). To bring down the obesity rate among the population, the U.S. Department of Health and Human Services seeks a leverage as solution.

Some new policies are envisioned. The leverage would be to implement new tax and price policies on some types of foods considered as harmful for health.

Summary of Objectives

The main objective of this study was to determine which economic factors affect the increase in obesity in the United States. A theory of rational addiction adapted to food consumption has been developed and has been tested by multinomial logit model. It was used to predict how people, according to their body mass index, would respond to price changes of "addictive" foods. The impacts of prices on people who were neither overweight nor obese, on overweight people, and on obese people were determined. This study will help policy makers quantify the marginal effects of food prices on the probability of people being in one of the three categories of BMI.

Summary of Methodology

According to the medical literature, sugar is an addictive food. Thus, eating large quantities of sugar is compared to an addictive behavior. This study developed a model of rational addiction in food consumption based on the "Theory of Rational Addiction" of Becker and Murphy (1988). The model was tested empirically using the multinomial logit model. The population was divided into three categories according to the body mass index to specify the differential responses to price of each group. In this model, the probability of being in one of the three BMI categories ("normal," "overweight," and "obese") was a function of past, current, and future prices of foods and a function of several socioeconomic and demographic variables.

Summary of Results

To evaluate the effectiveness of a potential "fat" tax policy, it is necessary beforehand to determine which economic factors have impacts on people and, more particularly, on which categories ("normal," "overweight," and/or "obese"). The application of the multinomial logit model to our sample gave interesting results.

At a 5 percent level of significance, while current prices of the addictive food (sugar) are higher, the probability of being overweight and obese decreases because overweight and obese people respond to this change in price by lowering their consumption of sugar. Conversely, while the current price of sugar is low, people tend to eat more sweets because they are affordable. Moreover, overweight individuals, assumed addicted to sugar, might change their sugar consumption if they are aware that the price of sugar will be higher in the future. In the same context, people who are obese will not reduce their consumption because their addiction level is too high. Besides, knowing that eating sugar

leads to higher consumption of other foods, it is not surprising to obtain the following result: even if current or future prices of potatoes (carbohydrates) increase, individuals who are overweight or obese will still consume this food and may even increase their consumption.

Concerning demographic factors, education level appears to have the greatest impact on the BMI. People who get higher education level are less likely to be overweight and obese than people with lower levels of education. This result shows that efforts undertaken to reduce overweight and obesity prevalence should turn their attention to a better education about nutrition and health.

Study Limitations

This study provides explanation of how consumers respond to change in food prices. However, this study was limited by availability of food price data. First, a high variability in food prices was wished. Monthly data for each commodity representing sugar, carbohydrates, and fats were sought for each U.S. state and for three years (1991, 1997, and 2002). The problem was that many states did not have any prices available. Thus, we deleted from the survey all the data from the states having missing prices. Data from only four states were kept to create the data sample of the framework.

All prices come from the Annual Summary of Agricultural Prices of the USDA. The summary contains prices that farmers receive for commodities sold, such as sugarbeets and potatoes, and prices paid for production input goods, such as whole milk. These prices do not correspond to prices that consumers pay in grocery stores. But these last prices are difficult to obtain and, such a data set is expensive too. Nevertheless, even if food prices from grocery stores were available, the analysis should not have been more accurate

because it is impossible to know exactly which price an individual has paid for a given commodity in a given place at a given time because notably of the multiple different types of grocery stores and promotion. As we have seen, high fructose corn syrup is the main sweetener used in food industry today. But prices for this commodity were not available, so prices for sugarbeets were used in the analysis. Although all these prices are believed to be highly correlated, the results may have been more conclusive with the high fructose corn syrup prices.

Finally, in the survey, individuals interviewed by phone may have underreported their actual weight, so their BMI may have been lower than actual values. Nevertheless, if this underreporting is constant over time, the analysis still holds.

Implication for Further Study

The increasing obesity prevalent among the entire U.S. population concerns now all public sectors. The U.S. government and the medical and health sectors are worried about this epidemic. Similarly, economists have become involved in this preoccupation because of the cost to society that increases each year. Some researches have attempted to evaluate this cost, but few have been undertaken to find solutions to check the increasing evolution of obesity. Until now, no research has identified which economic factors have impact on food consumption, and how they can be a leverage to bring down the obesity prevalence. This study tried to provide some information about the effects of some economic factors on the BMI index which can help policy makers faced with this problem to envision some new efficient policies.

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APPENDIX A. SUPPLEMENT RESULTS

Table 11. Summary of marginal effects on probability of being in the "normal," "overweight," or "obese" category

Variable	Coefficient	Standard Error	P[|Z|>z]
Marginal effects on Prob[Y = normal]			
CURRENTS	.02075563	.00256457	.0000
CURRENTP	-.01483788	.00146147	.0000
CURRENTM	.05126104	.00352337	.0000
HISTSUGA	-.00298628	.00227381	.1891
HISTPOTA	.02137705	.00153910	.0000
HISTMILK	.06544597	.00288463	.0000
FUTURESU	.00274537	.00111166	.0135
FUTUREPO	-.01358956	.00176502	.0000
FUTUREMI	-.17066369	.00222302	.0000
AGE	-.00313054	.00015666	.0000
INCOME	.00098976	.00013679	.0000
DSEX	.19504857	.00536064	.0000
GRADE	.02373581	.00187071	.0000
DY97	.20648475	.00964555	.0000
DY02	-.23233126	.01472376	.0000
DR1	.09641556	.01510067	.0000
DR2	-.05343814	.01575125	.0007
DR4	.03490053	.01462669	.0170
RBLACK	-.10190156	.01308350	.0000
RASIAN	.19119252	.02084114	.0000
RINDIAN	-.07710408	.02618669	.0032
ROTHER	-.02994883	.02105386	.1549
DHISP	-.05366327	.01074831	.0000
Marginal effects on Prob[Y = overweight]			
CURRENTS	-.01229057	.00232282	.0000
CURRENTP	.00501484	.00138397	.0003
CURRENTM	-.01579029	.00340037	.0000
HISTSUGA	.00163119	.00211266	.4401
HISTPOTA	-.00682886	.00146549	.0000
HISTMILK	-.02433475	.00257115	.0000
FUTURESU	-.00216918	.00101420	.0325
FUTUREPO	.00542910	.00173343	.0017
FUTUREMI	.07718681	.00186948	.0000
AGE	.00269183	.00013883	.0000
INCOME	-.00033056	.00012177	.0066
DSEX	-.19049556	.00480966	.0000
GRADE	-.00625923	.00174722	.0003
DY97	-.08039365	.00956166	.0000
DY02	.09234803	.01315822	.0000
DR1	-.01795614	.01408475	.2024
DR2	.05716472	.01462455	.0001
DR4	.01568639	.01397559	.2617
RBLACK	.03592282	.01165631	.0021
RASIAN	-.05331868	.02018560	.0083
RINDIAN	.01932124	.02333810	.4077
ROTHER	.00630314	.01910016	.7414
DHISP	.03256110	.00985276	.0010

Table 11. (continued)

Variable	Coefficient	Standard Error	P[|Z|>z]
Marginal effects on Prob[Y = obese]			
CURRENTS	-.00846506	.00174238	.0000

CURRENTP	.00982305	.00096938	.0000
CURRENTM	-.03547075	.00237523	.0000
HISTSUGA	.00135509	.00162828	.4053
HISTPOTA	-.01454819	.00108191	.0000
HISTMILK	-.04111122	.00178759	.0000
FUTURESU	-.00057618	.00069802	.4091
FUTUREPO	.00816046	.00114817	.0000
FUTUREMI	.09347688	.00135568	.0000
AGE	.00043871	.907884D-04	.0000
INCOME	-.00065920	.888081D-04	.0000
DSEX	-.00455301	.00342632	.1839
GRADE	-.01747658	.00128930	.0000
DY97	-.12609109	.00681070	.0000
DY02	.13998323	.01034089	.0000
DR1	-.07845941	.00983418	.0000
DR2	-.00372658	.00993888	.7077
DR4	-.05058692	.00980906	.0000
RBLACK	.06597874	.00728109	.0000
RASIAN	-.13787383	.01820682	.0000
RINDIAN	.05778285	.01407900	.0000
ROTHER	.02364569	.01237373	.0560
DHISP	.02110217	.00631251	.0008