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CYCLING: AN INCREASINGLY UNTOUCHED SOURCE OF PHYSICAL AND MENTAL HEALTH

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ABSTRACT

Cost savings associated with increased gasoline prices and lower levels of urban sprawl have been cited in terms of personal savings, environmental awareness, reduced costs through lower travel times and congestion, and reduced income inequality. Cost savings in terms of improved health, however, are often not cited yet represent another dimension of savings associated with reduced urban sprawl and gas prices. Cycling is a form of exercise that can also be used as a mode of transportation if the surrounding environment facilitates such use. According to the United States Department of Transportation, 73 percent of adults want new bicycle facilities such as bike lanes, trails, and traffic signals. Using data from the 1990, 1995, and 2001 waves of the Nationwide Personal Transportation Survey, in addition to data from the Behavioral Risk Factor Surveillance System (1996-2000), I propose to analyze the effects of variations in the built environment in the form of urban sprawl and in real gasoline prices on cycling as a form of physical activity. Using bivariate probit and propensity score methods, I show how cycling can lead to improved physical health outcomes. This is turn may carry policy implications in terms of improved public awareness and city planning.

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"Inferior legal status for cyclists turns cyclists into the lepers of the roads."
- John Forester, author of Effective Cycling. *Quote accessed at http://www.bicycledriving.com/trafficlaw.htm.*

I. Introduction

The way in which cycling as a mode of transportation is ignored is reflected in the way cyclists on the road are treated. Yet according to the US Department of Transportation, 73 percent of adult Americans want new bicycle facilities such as bike lanes, trails, and traffic signals, and fewer than 30 percent ride a bike during the summer (US Department of Transportation 2004). It is not apparent that the presence of bike paths or lanes has a significant effect on the riding decision; rather, it has an effect on the increased sense of personal safety.[1] There is very little public awareness when it comes to cycling. Many drivers are unaware that bicycles are considered vehicles,[2] while pedestrians feel having bicycles on the sidewalk is dangerous. Signs alerting individuals to "share the road" are an example of increasing public awareness. In some areas, rewards are given to people to choose to commute to work on their bicycles, which many people are unaware of. Anecdotal evidence suggests that public awareness is sparse, even among the most educated.

While there is virtually no discussion on cycling, there has been a recent upsurge in research on public health, particularly regarding the increasing obesity rates in the US. Economics has entered this area, and has shed light on various factors in the built environment contributing to behavioral changes. The problem is an urgent one, with the *Surgeon General's Call to Action to Prevent and Decrease Overweight and Obesity* (US Public Health Service 2001) and with increased funding for research on the topic, particularly to reducing and

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[1] The Department of Transportation report goes on to say that those living in neighborhoods with *no* bike paths or lanes feel the most threatened by motorists. While this may be the case, there are avid cyclists who advocate vehicular cycling as the safest method. See, for example, the Bicycle Transportation Institute's website at: http://www.bicycledriving.com.
[2] Incidentally, it is rather interesting that a small mode of transportation without an engine is considered a vehicle, while a large sports utility vehicle is not classified as a truck.

preventing childhood obesity. In addition, mental health has been an urgent issue, largely affected positively by physical activity, with calls such as the *Surgeon General's Call to Action to Prevent Suicide* (US Public Health Service 1999).

Economists have centered their focus on advancements in technology, which have been so vast and rapid that they have led to many outcomes, both beneficial ones and concurrently unintentionally unfavorable ones. Lakdawalla and Philipson (2002) find that reductions in the strenuousness of work and declines in the real price of grocery food items, due to technological advances in agriculture, have contributed to an increase in caloric intake. Cutler et al. (2003) also ascribe the surge in obesity to technological advances, as these advances have been a cause for reductions in the time costs associated with meal preparation. In previous research my colleagues and I find the increase in the number of fast-food and full-service restaurants to be a major factor in the escalation of the obesity rate over time is (Chou et al. 2004; Rashad et al. 2006). The Census of Retail Trade reveals that the number of fast-food and full-service restaurants increased over 60 percent between 1972 and 1997, from 8.84 restaurants per 10,000 population to 14.27 restaurants per 10,000 population (Bureau of the Census, various years). While obesity rates in Europe have also climbed, the increase has not been as drastic as that in the United States. The number of per capita vehicle miles driven in Europe are only about 40 percent of those driven in the United States, and not necessarily because Americans need to go farther, but because Europeans tend to substitute public transportation, walking, or biking for driving (Squires 2002). Ewing et al. (2003) have attributed part of the increase in obesity to the degree of urban sprawl, or how conducive a city is to exercise. Urban sprawl is defined as the process through which the spread of development across the landscape far outpaces population growth. Those urban areas that offer more transportation choices, are more compact, and have a variety of stores and activity centers within reach have lower rates of obesity. These compact urban areas thus potentially encourage cycling and walking much more than areas that are more sprawled do.

A sedentary lifestyle increases the risk of a host of diseases and has an adverse effect on physical and mental health. A recent study stressed the importance of embedding active modes of transportation, such as cycling and walking, into our daily lives (Fenton 2005). While the National Bicycling and Walking Study was first implemented to increase the prevalence of these two activities, relatively little progress has been made.[3] Using the Behavioral Risk Factor Surveillance System (BRFSS), one of the survey data sets used in this analysis that remains unexploited in this area, I find that 3.3 percent of the weighted sample of respondents reported bicycling for pleasure as their *primary* source of physical activity in the month prior to being interviewed in 2000. This percentage was 7.3 percent in 1984.

To further lend support to the results, I supplement BRFSS results with results using the Nationwide Personal Transportation Survey (NPTS), a comprehensive data set on household transportation choices. The NPTS can be exploited in terms of reporting bicycling that is not necessarily done for pleasure.[4] Bicycling has numerous physical and psychic benefits. Numerous studies in the medical literature stress the health effects of physical activity and the potential for commuting to work via bicycle to enhance this effect through embedding physical activity into their daily routines (Oja et al. 1998). At the same time, cycling is a relatively inexpensive, pollution-free means of transportation. Its benefits should therefore not be underestimated as they are not limited to health benefits but also entail environmental and cost saving ones.

[3] After several inquiries, it appears that these data are not publicly available. Also, while a comprehensive source of cycling information, the National Bicycling and Walking Study only seems to go as far back as 1994.
[4] The BRFSS only provides information on bicycling for pleasure.

II. Methodology

Changes in time allocation and in the built environment have largely been responsible for changes in the health of the population over time. Aside from lacking access to a bicycle, the top reason given for not cycling is being too busy or not having the opportunity. The table below shows top reasons for not cycling according to the National Survey of Pedestrian and Bicyclist Attitudes and Behaviors. It would therefore be useful if cycling were embedded in people's daily lives.

Top Reasons for Not Riding a Bicycle
Lack of access to a bicycle (26.0%)
Too busy / No opportunity (16.9%)
Disability / Health impairment (10.3%)
Bad weather (8.2%)
Don't want to / Don't enjoy it (6.5%)
Age (5.3%)
No safe place to ride (3.0%)
Prefer to walk or run (2.6%)
Source: National Survey of Pedestrian and Bicyclist Attitudes and Behaviors Highlights Report, US Department of Transportation's National Highway Traffic Safety Administration and the Bureau of Transportation Statistics.

Becker's (1965) model summarizes a theory of the allocation of time using utility provided by commodities (Z) and the services they yield rather than the goods themselves. Individuals then maximize utility subject to time and budget constraints. Time in transportation can be included in the time constraint, along with time spent working, sleeping, and enjoying the commodities (Z).[5] Health enters directly into the utility function if it is a consumption commodity according to Grossman's (1972) demand for health model. If health is viewed as an investment commodity, people demand health in order to increase their work productivity, allowing them to obtain more income to spend on other commodities. Cycling is a form of physical activity which improves health, leading to greater work productivity (investment commodity), and is enjoyable in itself (consumption commodity).[6] It may or may not decrease transportation time, but will most likely decrease monetary transportation costs.[7] Thus, if we focus on cycling, an individual's utility function can look as such:

$$U = U(B, Z)$$

where B is the commodity "bicycling" and the services it yields, which include health, enjoyment, and transportation, and Z represents a vector of all other commodities that enter the individual's utility function. Bicycling is in turn a function of the goods input (x_B), which includes the bike itself, its servicing, and its accessories, and t_B, the time used in producing B.

$$B = f(x_B, t_B)$$

If all income is earned income, the full income constraint is:

$$Income = wt_w + wt_B + wt_Z$$
$$Income = p_B x_B + p_Z x_Z + wt_B + wt_Z$$

where p_B and p_Z represent the prices of commodities x_B and x_Z, t_w represents time spent at work, t_Z represents the time used in producing Z, and w is the wage rate. The assumption here that the

[5] This was further formalized recently in terms of a *SLOTH* model (Cawley 2004), where an individual is assumed to act in his or her own interest (i.e., maximize utility or lifetime happiness) based on how time is allocated through: *S*leep, *L*eisure, *O*ccupation, *T*ransportation, and *H*ousehold work. Resources such as time and money are scarce, and people analyze the trade-offs involved in their decision-making process.

[6] It can also be viewed an investment commodity in the sense that it increases "leisure productivity," or further enjoying non-cycling leisure time due to the physical and psychic benefits it yields.

[7] Costs of bicycles are fixed, and maintenance costs are low. Yet one might also want to factor in the potentially high cost of getting into an accident, multiplied by its probability, which will vary depending on the individual and the area of residence.

wage rate is constant implies that cycling is being treated as a pure consumption commodity. The simple first order condition reveals that the marginal utility of bicycling is equal to the full price of cycling (π_B) times the marginal utility of full income (λ)[8]:

$$\frac{\partial U}{\partial B} = \lambda \left[p_B \frac{\partial x_B}{\partial B} + w \frac{\partial t_B}{\partial B} \right]$$

$$\frac{\partial U}{\partial B} = \lambda \pi_B$$

The first term on the RHS in the first equation above is likely to be low due to the low value of p_B. The second term represents the opportunity cost of cycling; the higher the wage rate, the greater the opportunity cost.[9] Also, the less time-intensive bicycling is, the lower its cost.

The general empirical model with bicycling as the outcome variable is:

$$B = \alpha_0 + \alpha_1 X + \alpha_2 S + \alpha_3 G + \varepsilon_1$$

where X is a vector of individual characteristics such as race, ethnicity, age, marital status, employment status, family income, education, and gender; S is a vector of metropolitan statistical area (MSA)-level characteristics pertaining to urban sprawl and real gas prices; G represents the geographic identifier (the census division that the respondent resides in); and ε is an error term.

Using a measure of physical activity as the outcome variable is desirable in that it gets at one of the core inputs of health without the worry of measurement error in the health outcomes. In terms of obesity outcomes using the body mass index (BMI), researchers such as Wada (2005) and Cawley and Burkhauser (2006) have shown that body composition is the more relevant measure, due to the positive effects that having a muscular build or lean body mass may have on BMI. Nevertheless, it is useful to analyze the effect of cycling on physical health outcomes. The

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[8] The Lagrangian is $L = U(B,Z) + \lambda[Income - (p_B x_B + p_Z x_Z + wt_B + wt_Z)]$.

[9] Note that the assumption that the wage rate is constant has been made, and in reality the wage rate could be a function of bicycling, rendering the effect on the opportunity cost ambiguous.

BRFSS data set also contains information on various measures of health. Using bivariate probit and propensity score methods, I estimate the effects of bicycling on various physical health outcomes:

$$H = \beta_0 + \beta_1 B + \beta_2 X + \beta_3 F + \beta_4 G + \varepsilon_2$$

where *H* represents health and *F* is a vector of MSA-level prices pertaining to food at home, fast food, and Coke. The *health* variable is one of the following: whether or not the person can be classified as obese (with a body mass index of 30 kg/m^2 or greater, adjusted for self-reported data), whether or not the respondent has been told by a physician that he or she has high cholesterol, whether or not the respondent has been told by a physician that he or she has diabetes, and whether the respondent's mental health has been poor in at least fifteen of the thirty days prior to being interviewed.[10] Since the measure for the *B* (bicycling) variable is likely to be determined within the model and not separately from it, it is not likely to be completely exogenous. If *B* is correlated with the error term ε, results after running ordinary least squares (OLS) or probit regressions in order to determine the outcome variable will be biased. One common, effective solution to this problem is to use bivariate probit methods. Using economic variables (such as the ones used in determining *B* above) that affect bicycling as variables excluded from the health equation will help in establishing causality and in measuring the

[10] While the BRFSS does not ask specific questions on depression using accepted scales such as that of the Center for Epidemiologic Studies Depression scale (CES-D) or the the criteria of the Diagnostic and Statistical Manual, version three (DSM-III), it asks the question, "Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?" Feeling this way for one out of thirty days is not a sign of ill mental health, and over thirty percent of respondents in my sample fall into this category. Many medical websites, such as e-medicine, agree that "[y]ou may be said to have clinical depression if you have a depressed mood for at least 2 weeks and have at least 5 of the following symptoms: feeling sad or blue, loss of interest or pleasure in usual activities, significant weight loss or weight gain, inability to sleep or excessive sleeping, agitation or irritability, fatigue or loss of energy, feelings of worthlessness or excessive guilt, and thoughts of death or suicide" (http://www.medicinenet.com/depression/index.htm). A dichotomous variable is therefore created that is equal to 1 if the respondent's mental health was not good in at least 15 of the 30 days prior to being interviewed. Approximately seven percent of the sample falls into this category.

potential effect that economic variables have on health outcomes.[11] Such findings carry with them important policy implications and can outline further steps the government might take.

To further lend support to the bivariate probit results, I use propensity score matching to determine the ATT, or average effect of the treatment (bicycle use), on the treated (a dichotomous health outcome variable such as overweight status). Following Becker and Ichino (2002) and Rosenbaum and Rubin (1983), this can be estimated as follows:

$$\begin{aligned}\tau &\equiv E\{H_1 - H_0 \mid B = 1\} \\ &= E\{E\{H_1 - H_0 \mid B = 1, p(W)\}\} \\ &= E\{E\{H_1 \mid B = 1, p(W)\} - E\{H_0 \mid B = 0, p(W)\} \mid B = 1\}\end{aligned}$$

where the propensity score (*p(W)*) is defined as the probability of receiving the "treatment" (or, say, being obese) given pre-treatment characteristics (*W*).

The idea behind propensity score matching is to address the nonrandom nature of the treatment and control groups by comparing treatment and control observations that are as similar as possible based on characteristics (*W*), where vector *W* is a less parsimonious version of vector *X* (representing the characteristics used in prior regressions) in order to account for as many characteristics (and their interactions) as possible in predicting the health outcome (*H*). Indeed, the degree to which the bias is reduced "depends crucially on the richness and quality of the control variables on which the propensity score is computed and the matching performed" (Becker and Ichino 2002). In using propensity score matching, the assumption that unobservable characteristics have the same effect on the propensity score as do observable characteristics is made.

[11] In line with Rashad and Kaestner (2004), appropriate tests for the validity of exclusion restrictions were conducted in bivariate probit models.

III. Data

The Nationwide Personal Transportation Survey (NPTS) is sponsored by the US Department of Transportation, Federal Highway Administration, and has been conducted periodically since 1969. Years 1990, 1995, and 2001 are used in this analysis and merged with price data from ACCRA and urban sprawl data from Smart Growth America.[12] Its purpose is to record an inventory of daily personal travel for individuals 5 years of age and older. All states and the District of Columbia are included. Data on method of transportation, duration of the trip, and trip purpose are included in the data set, along with geographic identifiers and thorough demographic data.

The Behavioral Risk Factor Surveillance System (BRFSS) has not previously been used to explore bicycle use. The following question is asked of respondents from 1984 to 2000: "What type of physical activity or exercise did you spend the most time doing during the past month?" Respondents then choose from a host of answers, one of which is "bicycling for pleasure." The survey goes on to ask, "What other type of physical activity gave you the next most exercise during the past month?" with the same answer choices. In the year 2000, 4032 (or 3.3 percent of respondents) chose bicycling as their primary source, while almost six percent chose cycling as either their primary or secondary source (see Figure 1). The prevalence in 2000 is a decline of 1.31 percentage points since 1984 in the percentage of people cycling for pleasure as their primary or secondary source of exercise, a decrease of 18 percent.

The BRFSS is an individual-level data set put together by state health departments in conjunction with the Centers for Disease Control and Prevention. It is conducted annually through telephone surveys. In 1984, there were 15 states in the BRFSS; by 1996, all 50 states in addition to the District of Columbia, were included. The BRFSS asks individuals 18 years of age

[12] See http://www.smartgrowthamerica.org.

and older numerous health questions, such as frequency of eating meat, fruits, vegetables, and adding salt, butter, or margarine to food. It asks questions on general health status, weight, height, smoking, use of smokeless tobacco, and engagement in various types of physical activity. Since the data on weight and height are self-reported, a correction is made based on data from the National Health and Nutrition Examination Survey (NHANES), which has both actual and self-reported height and weight. This correction is done separately by gender and race, and has previously been used (Chou et al. 2004; Cawley 1999). Data on education, marital status, race, ethnicity, gender, and age are also available in the BRFSS.

MSA-level variables pertaining to urban sprawl and real gas, food, and soda prices are included in the analysis. Sources for these data are as follows. Smart Growth America provides information on urban sprawl for 83 metropolitan areas and 448 urban counties across the United States. Sprawl measures development patterns and can provide information on how conducive a city is to exercise. Urban sprawl is defined as the process through which the spread of development across the landscape far outpaces population growth. Smart Growth America uses a comprehensive measure based on residential density; the neighborhood mix of homes, jobs, and services; strength of activity centers and downtowns; and accessibility of the street network. Higher values of urban sprawl indicate *less* sprawl, while lower values denote more sprawl. The national average is set at 100 (scaled to 1 here), with a standard deviation of 25 (0.25). In the US, the Riverside, CA, and the New York, NY, metropolitan areas are the most and least sprawling areas, respectively.

ACCRA follows commodity prices in various cities across the United States and also establishes a cost of living index for the cities. For health outcome regressions, a food-at-home price is created by using a weighted average of thirteen food prices, in which the weights are the reported average expenditure shares of these food items by consumers according to ACCRA. These thirteen foods are: steak, beef, sausage, chicken, tuna, milk, eggs, margarine, cheese, potatoes, bananas, lettuce, and bread. The ACCRA fast-food price is formed by taking the average prices of a hamburger (McDonald's), a pizza (Pizza Hut), and fried chicken (KFC).[13] The price of a 2-liter bottle of Coca Cola is included as a proxy for soft drink prices.

Gasoline prices are obtained from ACCRA. Figure 2 shows how the consumer price index (relative to that for all goods) for public transportation has increased while that for gasoline has declined or remained somewhat steady over time. Interestingly, from 1984 to 2000, the real gas CPI was at its highest (0.941) in 1984 (Figure 2), while cycling was at its highest prevalence in the BRFSS just the year following that, 1985 (Figure 1), at 8.79 percent. The gas CPI was at its lowest in 1998 (0.547), and the following year, 1999, cycling was at *its* lowest prevalence, at 5.09 percent. This may be evidence of a possible relationship between higher gasoline prices and increased levels of cycling in the US. Gasoline prices in the US still remain relatively low compared to those in European countries, and it has been suggested that the gas tax accounting for externalities should be 2.5 times the current rate (Parry and Small 2005).

IV. Results

Weighted sample means for the pooled NPTS sample, and by those who cycled in their reported daily trip, are shown in Table 1. About 1.3 percent of the sample reported cycling in their daily trip. In this data set those who cycle are less likely to be working or have high incomes, and are more likely to be younger. Those living in metropolitan areas with lower

[13] More detail on these variables can be found in Chou et al. (2004).

degrees of urban sprawl have higher rates of cycling, as are those in areas with slightly higher gas prices. Males are more likely to cycle than females.

Table 2 presents results for the NPTS where cycling is the dependent variable. Living in a metropolitan area with a lower degree of urban sprawl increases the probability of cycling by 0.5 percent for males and 0.2 percent for females.[14] Increasing the gas price by a real 1982-84 dollar in this case significantly increases the probability of cycling by 1.5 percent for males and one percent for females. Those who work are less likely to cycle, as are those who are older and those with higher incomes. (Evaluated at the mean level of income, the coefficient is -0.04 for males and -0.03 for females.)

Table 3 shows that almost seven percent of the pooled BRFSS sample reports cycling in the past month as a primary or secondary form of activity. As in Table 1, those who are younger and in less sprawled areas are more likely to cycle. Unlike what we saw using the NPTS data, college graduates in this case are more likely to cycle, as are those with higher incomes. Note that unlike in the NPTS, the cycling variable here is limited to cycling for pleasure.

Results from regressions using the BRFSS data set are reported in Table 4. As in Table 2, individuals residing in less sprawling metropolitan areas and in areas with higher gas prices are more likely to cycle; coefficients are positive and statistically significant, with the exception of the gas price for males.

Physical health outcomes for obesity, cholesterol, and diabetes, in addition to outcomes for mental health, are shown in Table 5. Raw means for these variables in Table 3 revealed that those who cycle are less likely to be obese, less likely to have high cholesterol, less likely to have diabetes, and less likely to have poor mental health. Once other variables are controlled for, as

[14] Note that higher values of sprawl denote *lower* degrees of urban sprawl.

well as potential endogeneity, this relationship still holds for the most part, as seen in Table 5. Cycling has negative and significant effects on the probability of being obese, ranging from 2.4 to 20 percent for males and 3.4 to 18.3 percent for females.[15] The first columns for males and females reveal reductions in obesity of 12 percent and 17 percent from the mean associated with cycling. Results using propensity score matching give similar magnitudes. Results for cholesterol and diabetes also carry the expected negative signs, yet are mostly not statistically significant. The exception is possibly with diabetes outcomes for males. Propensity score matching results for mental health as the outcome reveal reductions in poor mental health associated with cycling of five percent from the mean for males, and 15 percent from the mean for females.

V. Discussion

Cycling in its current form is often a dangerous and underused activity. Changes in the built environment and decisions by policymakers have potentially unintentionally contributed to the declining physical and mental health of the US population, in addition to increased costs in terms of transportation and pollution.

Using the NPTS and BRFSS data sets, sprawling metropolitan areas and areas with low gasoline prices are found to have lower probabilities of cycling. As a "tactic for reducing society's current heavy dependence on private automobiles for ground transportation," it has been suggested that more bike paths and pedestrian-friendly street landscapes be built (Burchell et al. 2002, p501). The lower costs associated with building bike paths and sidewalks make this

[15] Bivariate probit results seem implausibly large. The value for rho, the correlation between the error terms in the two equations, is also the unexpected sign, which may be a sign of weak instruments. Bivariate probit results are therefore not stressed.

a feasible solution to the positive externalities that they carry. In addition, the lower political opposition this method faces, that alternative methods such as raising gasoline taxes which may interfere with the interests of the so-called highway lobby might be subject to, further enhance its attractiveness as a solution. That being said, increasing the gasoline tax by about 60 cents, or 2.5 times the current rate, as suggested by Parry and Small (2005) as being the optimal gasoline tax for the US after taking externalities into account, could increase cycling by 0.6 to 2.5 percentage points, an increase of 31 to 69 percent above the current mean values.

The deteriorating state of the physical and mental health of the US population and the recent calls by the US Surgeon General to prevent occurrences such as obesity and suicide highlight the urgency of implementing preventive measures to aid current and future generations. At an estimate of an increase of $732 (2002 dollars) in per capita medical expenditures for increased obesity (Finkelstein et al. 2003), an increase in cycling, estimated using probit regressions to reduce obesity by 2.4 and 3.4 percentage points for males and females, respectively, could potentially reduce national medical expenditures by about six billion dollars. There could be further gains by reducing suicide and depression through improved mental health. Cycling may thus be a source of physical and mental health in addition to being an effective mode of transportation, especially when city planners provide the means necessary to make it a safe and comfortable activity. Policy implications result in terms of improved public awareness and city planning.

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Table 1

Weighted Sample Means, Nationwide Personal Transportation Survey

Variable	Description	All	Bike=1	Bike=0
Bike	Dichotomous variable that equals 1 if respondent cycled in day trip, and 0 otherwise	0.013/ (0.113)	1.000 (0.000)	0.000 (0.000)
Family income	Real family income in tens of thousands of 1982-84 dollars	3.635/ (3.086)	3.352 (2.876)	3.638 (3.089)
Single	Dichotomous variable that equals 1 if respondent single and not living with another adult	0.166 (0.372)	0.166 (0.373)	0.166 (0.372)
High school	Dichotomous variable that equals 1 if respondent has graduated from high school	0.262/ (0.440)	0.173 (0.378)	0.263 (0.440)
Some college	Dichotomous variable that equals 1 if respondent has completed some college	0.235/ (0.424)	0.162 (0.369)	0.236 (0.424)
College	Dichotomous variable that equals 1 if respondent has graduated from a four-year college	0.274/ (0.446)	0.217 (0.412)	0.275 (0.447)
Black	Dichotomous variable that equals 1 if respondent is black and not Hispanic	0.132/ (0.339)	0.086 (0.280)	0.133 (0.340)
Hispanic	Dichotomous variable that equals 1 if respondent is of Hispanic origin	0.136 (0.343)	0.143 (0.350)	0.136 (0.343)
Other race	Dichotomous variable that equals 1 if respondent's race is other than white, black, or Hispanic	0.055 (0.228)	0.041 (0.199)	0.055 (0.229)
Work	Dichotomous variable that equals 1 if respondent is employed	0.625/ (0.484)	0.460 (0.499)	0.628 (0.483)
Age	Age of respondent in years	38.706/ (18.857)	27.377 (17.404)	38.855 (18.830)
Sprawl	Sprawl index in respondent's MSA of residence, with higher values denoting *less* sprawling areas	1.019 (0.328)	1.021 (0.325)	1.019 (0.328)
Gas price	Real ACCRA gasoline price in respondent's MSA of residence, in 1982-84 dollars	0.712 (0.114)	0.715 (0.110)	0.712 (0.114)
Male	Dichotomous variable that equals 1 if respondent is male, and 0 if respondent is female	0.486/ (0.500)	0.697 (0.460)	0.483 (0.500)

Note: Standard deviation is reported in parentheses. Number of observations is 89,647. NPTS sample person weights are used in calculating the mean and standard deviation. A slash denotes that the difference between cyclists and non-cyclists for the given variable is statistically significant at the five percent level.

Table 2

Dependent Variable: Cycled in Day Trip, NPTS 1990-2001

	(1)	(2)	(3)	(4)
	Males, Limited	Males, Extended	Females, Limited	Females, Extended
Sprawl		0.005* (1.90)		0.002** (2.04)
Gas price		0.015*** (2.61)		0.010*** (2.73)
Family income	-0.002*** (3.79)	-0.002*** (3.78)	-0.001** (2.15)	-0.001** (2.07)
Family income squared	0.0001*** (2.79)	0.0001*** (2.80)	0.00003* (1.75)	0.00003* (1.73)
Single	0.003** (2.01)	0.003** (2.02)	0.001 (1.19)	0.001 (1.26)
High school	-0.006*** (3.68)	-0.006*** (3.71)	-0.002** (2.18)	-0.002** (2.20)
Some college	-0.007*** (4.45)	-0.007*** (4.49)	-0.001 (0.76)	-0.001 (0.77)
College	-0.002 (1.33)	-0.002 (1.33)	0.001 (0.73)	0.001 (0.73)
Black	-0.006*** (4.46)	-0.006*** (4.42)	-0.002** (2.45)	-0.002** (2.38)
Hispanic	-0.002 (1.38)	-0.002 (1.20)	-0.002* (1.72)	-0.002 (1.55)
Other race	-0.003 (1.55)	-0.002 (1.44)	-0.002** (2.56)	-0.002** (2.42)
Work	-0.011*** (5.01)	-0.011*** (5.02)	-0.002** (2.32)	-0.002** (2.38)
Age	-0.00003 (0.17)	-0.00004 (0.18)	-0.0002*** (3.89)	-0.0002*** (3.86)
Age squared	-0.000004 (1.60)	-0.000004 (1.59)	0.000001 (1.12)	0.000001 (1.09)
Observations	42,392	42,392	47,255	47,255

Note: Marginal effects of probit coefficients are shown. Absolute value of t statistics in parentheses. Controls for census division and year of survey are included in all regressions. Regressions are clustered by metropolitan area. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

Table 3

Weighted Sample Means, Behavioral Risk Factor Surveillance System

Variable	Description	All	Bike=1	Bike=0
Bike	Dichotomous variable that equals 1 if respondent cycled in day trip, and 0 otherwise	0.068[/] (0.251)	1.000 (0.000)	0.000 (0.000)
Obese	Dichotomous variable that equals 1 if respondent has an adjusted BMI ≥ 30 kg/m², and 0 otherwise	0.194[/] (0.396)	0.169 (0.374)	0.196 (0.397)
Cholesterol	Dichotomous variable that equals 1 if respondent has high cholesterol	0.275 (0.447)	0.253 (0.435)	0.276 (0.447)
Diabetes	Dichotomous variable that equals 1 if respondent has diabetes	0.053[/] (0.224)	0.039 (0.192)	0.054 (0.226)
Mental health not good	Dichotomous variable that equals 1 if respondent's mental health was not good in 15+ of past 30 days	0.073 (0.261)	0.070 (0.255)	0.074 (0.261)
Family income	Real family income in tens of thousands of 1982-84 dollars	3.747[/] (2.968)	3.976 (3.027)	3.731 (2.963)
Married	Dichotomous variable that equals 1 if respondent is married	0.580[/] (0.494)	0.542 (0.498)	0.582 (0.493)
Divorced	Dichotomous variable that equals 1 if respondent is divorced or separated	0.122 (0.327)	0.123 (0.328)	0.122 (0.327)
Widowed	Dichotomous variable that equals 1 if respondent is widowed	0.050[/] (0.218)	0.028 (0.164)	0.052 (0.222)
Some high school	Dichotomous variable that equals 1 if respondent completed at least 9 but less than 12 years of school	0.053[/] (0.224)	0.043 (0.203)	0.054 (0.225)
High school	Dichotomous variable that equals 1 if respondent completed exactly 12 years of schooling	0.263[/] (0.440)	0.230 (0.421)	0.265 (0.441)
Some college	Dichotomous variable that equals 1 if respondent completed at least 13 but less than 16 years of school	0.295 (0.456)	0.294 (0.456)	0.295 (0.456)
College	Dichotomous variable that equals 1 if respondent graduated from college	0.368[/] (0.482)	0.422 (0.494)	0.364 (0.481)
Black	Dichotomous variable that equals 1 if respondent is black and not Hispanic	0.110[/] (0.312)	0.078 (0.269)	0.112 (0.315)
Hispanic	Dichotomous variable that equals 1 if respondent is of Hispanic origin	0.110 (0.313)	0.114 (0.318)	0.110 (0.313)
Other race	Dichotomous variable that equals 1 if respondent's race is other than white, black, or Hispanic	0.049 (0.216)	0.046 (0.210)	0.049 (0.216)
Work	Dichotomous variable that equals 1 if respondent is employed	0.707[/] (0.455)	0.761 (0.426)	0.703 (0.457)
Age	Age of respondent in years	42.718[/] (16.100)	39.838 (14.049)	42.927 (16.219)
Sprawl	Sprawl index in respondent's MSA of residence, with higher values denoting *less* sprawling areas	1.054[/] (0.284)	1.074 (0.272)	1.052 (0.284)
Gas price	Real ACCRA gasoline price in respondent's MSA of residence, in 1982-84 dollars	0.710 (0.136)	0.709 (0.135)	0.710 (0.137)
Male	Dichotomous variable that equals 1 if respondent is male, and 0 if respondent is female	0.513[/] (0.500)	0.618 (0.486)	0.505 (0.500)

Note: Standard deviation is reported in parentheses. Number of observations is 74,048. BRFSS sample weights are used in calculating the mean and standard deviation. A slash denotes that the difference between cyclists and non-cyclists for the given variable is statistically significant at the five percent level.

Table 4

Dependent Variable: Cycled for Pleasure in Past Month, BRFSS 1996-2000

	(1)	(2)	(3)	(4)
	Males, Limited	Males, Extended	Females, Limited	Females, Extended
Sprawl		0.037*** (2.66)		0.021* (1.96)
Gas price		0.035 (1.09)		0.042** (2.31)
Family income	0.001 (0.26)	0.001 (0.29)	-0.0003 (0.16)	0.0003 (0.02)
Family income squared	-0.00002 (0.09)	-0.00002 (0.12)	0.0001 (0.44)	0.0001 (0.28)
Some high school	-0.002 (0.13)	-0.001 (0.10)	0.020 (1.31)	0.020 (1.31)
High school	0.008 (0.68)	0.009 (0.74)	0.021 (1.55)	0.021 (1.54)
Some college	0.012 (0.93)	0.012 (0.99)	0.025* (1.67)	0.025* (1.66)
College	0.019 (1.57)	0.019 (1.63)	0.035** (2.28)	0.034** (2.26)
Black	-0.024*** (5.80)	-0.024*** (5.77)	-0.020*** (6.03)	-0.020*** (6.00)
Hispanic	-0.006 (0.83)	-0.006 (0.91)	-0.007** (1.97)	-0.007* (1.93)
Other race	-0.018*** (2.61)	-0.019*** (2.82)	-0.013** (2.21)	-0.012** (2.23)
Work	-0.003 (0.52)	-0.003 (0.53)	-0.001 (0.24)	-0.001 (0.33)
Age	0.004*** (5.22)	0.004*** (5.20)	0.0004 (1.06)	0.0004 (1.04)
Age squared	-0.0001*** (5.90)	-0.0001*** (5.90)	-0.00001*** (3.18)	-0.00001*** (3.19)
Married	-0.030*** (7.97)	-0.030*** (7.94)	-0.007** (2.30)	-0.007** (2.34)
Divorced	-0.011* (1.95)	-0.010* (1.91)	-0.003 (0.75)	-0.002 (0.72)
Widowed	-0.009 (0.82)	-0.009 (0.81)	0.001 (0.26)	0.001 (0.25)
Observations	32,439	32,439	41,609	41,609

Note: Dependent variable is equal to 1 if respondent cycled for pleasure as the main or secondary form of exercise in the month prior to survey. Marginal effects of probit coefficients are shown. Absolute value of t statistics in parentheses. Controls for census division and year of survey are included in all regressions. Regressions are clustered by metropolitan area. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

Table 5

Health Outcomes, BRFSS 1996-2000

	Males			*Females*		
	Probit	**Biprobit**	**PropScore**	**Probit**	**Biprobit**	**PropScore**
Dependent variable: Obese						
Bike	-0.024*** (2.80) [-0.12]	-0.199*** (4.81) [-1.03]	-0.032*** (8.23) [-0.16]	-0.034*** (3.85) [-0.18]	-0.183*** (4.67) [-0.94]	-0.035*** (8.78) [-0.18]
		ρ=0.552***			ρ=0.543***	
Dependent variable: Cholesterol						
Bike	-0.005 (0.22) [-0.02]	-0.158 (0.55) [-0.57]	-0.001 (0.32) [-0.004]	-0.020 (0.98) [-0.07]	0.444 (0.65) [1.61]	-0.027*** (6.07) [-0.10]
		ρ=0.283			ρ=-0.538	
Dependent variable: Diabetes						
Bike	-0.006** (1.96) [-0.11]	-0.025 (1.54) [-0.47]	-0.004** (2.25) [-0.08]	-0.006 (1.52) [-0.11]	-0.021 (0.78) [-0.40]	-0.004 (1.56) [-0.08]
		ρ=0.266			ρ=0.096	
Dependent variable: Mental Health Not Good						
Bike	-0.003 (0.73) [0.04]	0.019 (0.18) [0.26]	-0.004* (1.78) [0.05]	-0.010 (1.52) [0.14]	0.035 (0.37) [0.48]	-0.011*** (3.80) [0.15]
		ρ=-0.093			ρ=-0.124	

Note: Marginal effects are shown. Absolute value of t statistics in parentheses. Controls for education, race/ethnicity, marital status, family income, age, employment status, food-at-home price, fast-food price, Coke price, census division, and year of survey are included in all regressions. Semi-elasticities of health outcomes with respect to cycling, evaluated at the sample mean, are reported in brackets. Regressions are clustered by metropolitan area. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

Figure 1

Trends in Cycling for Pleasure in the US, 1984-2000
Behavioral Risk Factor Surveillance System

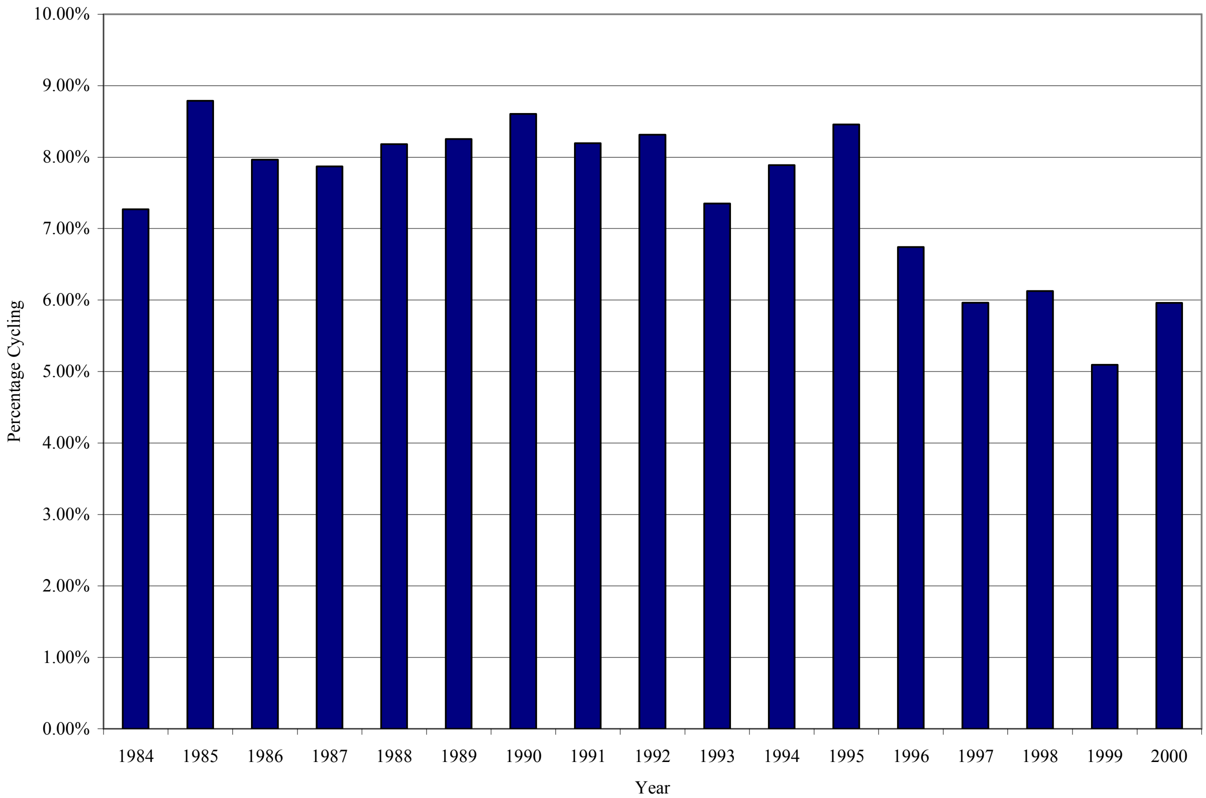

Figure 2

Trends in Real Gasoline and Public Transportation CPIs, 1984-2000
Bureau of Labor Statistics