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Input in Health Production: A Focus on Cycling

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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 Behavioral Risk Factor Surveillance System (1996-2000) and data from the 1990, 1995, and 2001 waves of the Nationwide Personal Transportation Survey, 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. An empirical exercise using the Behavioral Risk Factor Surveillance System is then done showing the potential effects that this form of physical activity may have on lowering the prevalence of obesity. This study carries policy implications in terms of improved public awareness and city planning.

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I. Introduction

It might seem odd to do an empirical study on cycling in the United States. Cycling as a form of urban travel in the U.S. has been estimated to be low relative to European countries, with prevalence estimates at around one percent compared to four percent for the U.K., 12 percent for Germany, and 28 percent for the Netherlands (Pucher and Dijkstra, 2003). Yet organizations such as the Transportation Research Board have identified research surrounding this topic as being urgent; they acknowledge, for example, the liability aspects of bikeway designation, which may discourage communities from building bike paths, and outline the effectiveness of such research in that it could "increase number of miles of effective bikeway facilities due to resolution of liability concerns and to reduce tort liability cases by promoting administrative and design procedures that reduce incidences of government negligence in the design and maintenance of bikeway facilities" and "increase the number of people bicycling thereby reducing the need for some automobile trips, which in turn could lead to lessening of congestion, pollution and obesity."[1] Nevertheless, there is an absence of research in health economics in this area. The majority of Americans do not get enough physical activity to meet health recommendations outlined by the Surgeon General's *Report on Physical Activity and Health*, in spite of the well-established relationship between physical activity and health outcomes (Ewing et al., 2003; Pratt et al., 1999). Yet according to the U.S. Department of Transportation, 73 percent of adult Americans want new bicycle facilities such as bike lanes, trails, and traffic signals. Fewer than 30 percent ride a bike during the summer, and as it currently stands, there is very little public awareness when it comes to cycling (U.S. Department of Transportation,

[1] See http://www.trb.org/.

2004).[2] Many drivers are unaware that bicycles are considered vehicles, 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 who choose to commute to work on their bicycles. Using data from the Behavioral Risk Factor Surveillance System (1996-2000), in addition to data from the 1990, 1995, and 2001 waves of the Nationwide Personal Transportation Survey, 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 are analyzed. Results indicate that cycling is promoted in less sprawling areas and areas with higher gasoline prices.

Recently there has been an upsurge in research on public health issues in various fields of study, particularly concerning the rising obesity rates in the United States. 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. The finding that urban sprawl causally affects health has been criticized, in that both variables could be simultaneously determined (Plantinga and Bernell, 2005). While this may be plausible theoretically, it is unlikely empirically, as people face family, work, and moving constraints, and may be more likely to move within a metropolitan area rather than move to another metropolitan area. Within a metropolitan area, those who live in the suburbs have higher incomes (Burchell et al., 2002; O'Connor et al., 2001),

[2] 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.

and those with higher incomes are actually less likely to be obese (Chou et al., 2004; Rashad et al., 2006). For bicycling, endogeneity may only be an issue in the tails of the distribution, where individuals have very strong preferences either for or against cycling.[3] Economists have centered their focus on advancements in technology. 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. The increase in the number of fast-food and full-service restaurants has been found to be a major factor in the escalation of the obesity rate over time (Chou et al., 2004; Rashad et al., 2006). While obesity rates in Europe have also climbed, the increase has not been as drastic as that in the U.S. The number of per capita vehicle miles driven in Europe are only about 40 percent of those driven in the U.S., and not necessarily because Americans need to go farther, but because Europeans tend to substitute public transportation, walking, or biking for driving (Squires, 2002).

Changes in time allocation and in the built environment have largely been responsible for changes in the health of the population over time. A sedentary lifestyle increases the risk of a host of diseases and has an adverse effect on physical and mental health. A study by Fenton (2005) stressed the importance of embedding active modes of transportation, such as cycling and walking, into our daily lives. Pucher and Dijkstra (2003) stress the lack of safety of cycling and walking in the United States by analyzing data on fatalities and injuries; they recommend measures that can be taken based on successful policies implemented in Germany and the Netherlands. In general, the demand for nonmotorized travel has been found to be largely

[3] Because of this potential concern, a robustness check is done with "cycling on a bicycling machine" as the dependent variable, results of which are shown in Appendix 2 and discussed in the "Results" section.

predicted by employment density, the percentage of the student population, household income, and average sidewalk length (An and Chen, 2007). Aside from lacking access to a bicycle, the top reason given for not cycling is being too busy or not having the opportunity.

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 are therefore not limited to health benefits but also entail environmental and cost saving ones.

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

[4] The BRFSS only provides information on bicycling for pleasure.

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, U.S. 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

[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.

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 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]:

[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. In regressions, the crude rate of state-level fatalities due to bicycling has a positive effect on the probability of cycling, although not always significant. This is likely due to the endogenous nature of this variable; i.e., the more people that cycle in a given area, the greater the probability of getting into an accident. Another potential concern for males is impotence, although there has been no conclusive evidence on this, and more appropriate saddles may be purchased to mitigate any concerns (Lowe et al., 2004).

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

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

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

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.[10]

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

$$B_{ijt} = \alpha_0 + \alpha_1 X_{ijt} + \alpha_2 S_j + \alpha_3 G_{jt} + \varepsilon_{ijt}$$

where *i* refers to the individual, *j* refers to the metropolitan area of residence, and *t* refers to the year of survey. *X* is a vector of individual characteristics such as race, ethnicity, age, marital status, employment status, family income, education, and gender; *S* is a comprehensive measure of urban sprawl; *G* represents the real gasoline price; and ε is an error term. Geographic identifiers pertaining to the census division that the respondent resides in are also included. Additional models control for state-level bike shops (to capture a culture toward cycling), bike fatalities, and miles of trails devoted to cycling and walking.

Sprawling metropolitan areas are expected to have a negative effect on the probability that a given person cycles due to the time-intensive nature of the activity.[11] A higher gasoline

[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.

[10] For example, the less sprawled a metropolitan area is, the less time (fewer minutes) an individual spends cycling, which can be seen using BRFSS data. While one might argue that the more time one spends cycling, the more health benefits it yields, it can also be argued that an individual is less likely to cycle in the first place if it is a time-consuming activity, and so the frequency of cycling would be lower, leading to lower health benefits. This is why sprawling metropolitan areas are expected to have lower probabilities of cycling, *ceteris paribus*.

[11] Walking is predicted to be even more time-intensive in the context of urban sprawl. While there are many health benefits associated with walking, this study focuses on cycling. The "walking" variable in the BRFSS does not distinguish between walking on a treadmill and walking outdoors. Policy implications are more pertinent in the case of outdoor activities, which do not require gym membership.

price is expected to have a positive effect on the probability that a given person cycles. This could be due to substituting bikes for cars or for public transportation.[12]

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 Burkhauser and Cawley (2008) and Wada and Tekin (2007) 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 BRFSS data set also contains information on various measures of health. Using bivariate probit, I estimate the effects of bicycling on physical health as measured by the body mass index. Due to the self-reported nature of the BRFSS data, weight and height are adjusted for self-reported data. Since the bicycling variable is likely to be determined within the model and not separately from it, it is not likely to be completely exogenous. Results from ordinary least squares (OLS) or probit regressions in order to determine the outcome variable will thus be biased. One common, effective solution to this problem is to use bivariate probit methods.[13] Using exogenous variables that affect bicycling as variables excluded from the health equation will help in establishing causality and in measuring the potential effect that cycling as a form of

[12] While only "cycling for pleasure" is reported in the BRFSS, cycling for pleasure and cycling for commuting purposes are likely to be highly complementary.

[13] Propensity score matching is also used to further lend support to the bivariate probit results. The ATT, or average effect of the treatment (bicycle use) on the treated (obesity) is determined following Becker and Ichino (2002) and Rosenbaum and Rubin (1983). 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 individual characteristics. The results are very similar to the probit ones and are available from the author upon request.

physical activity has on health outcomes.[14] The exogenous MSA-level variables, or instruments, used to predict cycling are precipitation and sunlight hours.

III. Data

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.[15] The BRFSS asks individuals 18 years of age 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 (Cawley 1999; Chou et al. 2004; Rashad 2008). Data on education, marital status, race, ethnicity, gender, and age are also available in the BRFSS.

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:

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

[15] The following 15 states were in the BRFSS in 1984: Arizona, California, Idaho, Illinois, Indiana, Minnesota, Montana, North Carolina, Ohio, Rhode Island, South Carolina, Tennessee, Utah, West Virginia, and Wisconsin. In 1985, Connecticut, the District of Columbia, Florida, Georgia, Kentucky Missouri, New York, and North Dakota entered the survey. In 1986, Alabama, Hawaii, Massachusetts, and New Mexico entered. In 1987, Maine, Maryland, Nebraska, New Hampshire, South Dakota, Texas, and Washington entered. In 1988, Iowa, Michigan, and Oklahoma entered. In 1989, Oregon, Pennsylvania, and Vermont entered. In 1989, Colorado, Delaware, Louisiana, Mississippi, and Virginia entered. In 1991, Alaska, Arkansas, and New Jersey entered. In 1992, Kansas and Nevada entered. Wyoming entered in 1994. Rhode Island, which entered the survey in 1984, was not in it in 1994. The District of Columbia, which entered in 1985, was not in the survey in 1995.

"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 Nationwide Personal Transportation Survey (NPTS) is sponsored by the U.S. Department of Transportation and has been conducted by the Federal Highway Administration periodically since 1969. Years 1990, 1995, and 2001 are used in this analysis.[16] The purpose of the survey 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 collected through telephone interviews, along with geographic identifiers and detailed demographic data.

MSA-level variables pertaining to urban sprawl; real gasoline, food, and soda prices; precipitation; temperature; humidity; and elevation; and state-level variables pertaining to bike shops; bike fatalities; and miles of trails are merged with the individual-level data and included in the analysis. Sources for these data are as follows. Smart Growth America (http://www.smartgrowthamerica.org) 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

[16] The 2001 survey combines the Federal Highway Administration's NPTS and the Bureau of Transportation Statistics' American Travel Survey (ATS) and is actually called the National Household Travel Survey.

the process through which the spread of development across the landscape far outpaces population growth and should not simply be interpreted as population density. 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 U.S., 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).[17] 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

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

gasoline prices and increased levels of cycling in the U.S. Gasoline prices in the U.S. 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).

The Area Resource File (ARF) contains county-level indicators relating to climate and terrain. Variables used are precipitation, temperature, humidity, and elevation in feet. Precipitation, temperature, and humidity are reported for two months: January and July. The January values were used if the month of survey was between October and March, and the July values were used if the month of survey was between April and September. These variables are used in predicting cycling prevalence in structural equations.

State-level data on the number of bicycle shops, the crude rate of fatalities due to accidents involving pedaling cyclists, and miles of trails are obtained from the League of American Bicyclists (http://www.bikeleague.org), the CDC's National Center for Injury Prevention and Control (http://www.cdc.gov/ncipc/wisqars), and the Rails to Trails Conservancy (http://www.railtrails.org), respectively.

IV. Results

Cycling prevalence in the U.S. between 1996 and 2000 is found to be highest in Colorado (7.24%) and lowest in Alabama (1.66%), according to BRFSS data (Figure 3). Weighted sample means in Table 1a show that almost five percent of the pooled BRFSS sample reports cycling in the past month as a primary or secondary form of activity. Those who are younger and in less sprawled areas are significantly more likely to cycle, as are college graduates and those with higher incomes. Health variables indicate that BMI is significantly higher for those who do not report cycling. Those who cycle also report only 1.8 days in the past month in poor physical health, versus 2.3 days for those who do not cycle.

Weighted sample means for the pooled NPTS sample, and by those who cycled in their reported daily trip, are shown in Table 1b. Almost one percent of the sample reported cycling in their daily trip.[18] In this data set those who cycle are less likely to be black and are more likely to be younger. Those living in metropolitan areas with lower 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.

Results from regressions using the BRFSS data set are reported in Tables 2a and 2b for males and females, respectively.[19] Column 1 of Tables 2a and 2b shows that those with higher incomes are significantly more likely to cycle, indicating that cycling in this context is a normal good. Those with higher levels of education are more likely to cycle, a result consistent with the strong observed correlation between health and schooling (Grossman and Kaestner, 1997). The key variables of interest, sprawl and the gasoline price, are added in column 2. Males and females residing in less sprawling metropolitan areas are 3.4 percentage points and 1.6 percentage points more likely to cycle, respectively.[20] Higher gasoline prices are also associated with an increased likelihood of cycling; an increase of one 1982-84 dollar in the real gasoline price potentially generates an increase of 4.7 percentage points and 3.4 percentage points in the prevalence of cycling for males and females, respectively. These results remain significant or increase in magnitude with the addition of more variables to capture bicycle culture and climate

[18] The NPTS only reports activities for one day. A one percent cycling prevalence is reflective of the U.S. population, as seen in Pucher and Dijkstra (2003). The American Time Use Survey (ATUS), conducted by the Bureau of Labor Statistics, reports lower levels of cycling prevalence in more recent years: 0.49% for 2003; 0.45% for 2004; 0.59% for 2005; and 0.62% for 2006 (author's calculations).

[19] Results from F-tests for differences in coefficients between males and females indicate that they are statistically different and thus running separate models by gender is appropriate.

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

patterns, as seen in columns 3 and 4 of Tables 2a and 2b. Column 4 reveals that both the presence of moisture in the air and sunlight hours are significantly associated with an increased cycling prevalence for both males and females. The fatalities rate for cyclists is insignificant for males yet positive and significant for females; as previously mentioned, this is likely due to the endogenous nature of the variable. The variable indicating miles of trails has a positive but insignificant effect on cycling.

Tables 3a and 3b present results for the NPTS where cycling on the day prior to survey is the dependent variable. These results are consistent with those using the BRFSS with a few exceptions. Living in a metropolitan area with a lower degree of urban sprawl increases the probability of cycling by 0.8 percentage points for males and 0.3 percentage points for females. This lower percentage point increase reflects the nature of how the variable is defined; in particular, cycling in one day is used as opposed to cycling for pleasure in the past month. Increasing the gasoline price by a real 1982-84 dollar in this case significantly increases the probability of cycling by 1.8 percentage points for males and 1.1 percentage points for females. Those who work are significantly less likely to cycle in this case, as are those with higher incomes. (As seen at the bottom of the tables, evaluated at the mean level of income, the coefficient is -0.06 for males and -0.07 for females, using values for columns 2, 3, and 4.)

The hypothesis of this paper is that people are less likely to be physically active in more sprawled areas or in areas with lower gasoline prices. These variables are entered linearly into the regressions without concern for the possible quadratic nature of these variables. In particular, one may argue that if an MSA is not sprawling at all, there would not be reason to bike or otherwise be physically active. However, it is unlikely that such an area exists, or that the benefits of physical activity in a very small area would not outweigh the benefits of, for example, walking to one's car in a sprawling area. The idea is that individuals are less likely to drive in areas that are less sprawling and more likely to substitute physically active measures. Appendix 1 shows results for sprawl and the gasoline price when they are entered in a quadratic fashion. Results at the mean values for sprawl and the gasoline price are not very different from those reported in Tables 2 and 3.

There may also be some concern surrounding the endogeneity of urban sprawl and the gasoline price. In particular, individuals with preferences toward cycling may locate in areas with less urban sprawl and higher gasoline prices. While relocating is not easy and unlikely and, as previously mentioned, may only affect those at the tails of the cycling distribution, these preferences may influence local jurisdictions and thus the layout of a metropolitan area or the policies it chooses to use. Since the focus is on cycling separate from other physical activity, Appendix 2 thus shows results where cycling on a bicycling machine is the dependent variable. Preferences for this activity are likely to be very similar to preferences for cycling outdoors and yet should not be as influenced by urban sprawl or the gasoline price, which is where policy change may be effected. Appendix 2 reveals no significant effect of these two variables on cycling indoors, suggesting that the potential endogeneity of sprawl and the gas price may not be of concern. In addition, models using only a sample of those who reported some physical activity in the past month yield the same qualitative results as those reported in Tables 2a and 2b.[21]

Physical health outcomes for BMI and poor physical health are shown in Table 4. Weighted means for these variables in Table 1a revealed that those who cycle have lower BMIs and report fewer days in poor physical health. While the medical literature has established the

[21] Results are available from the author upon request.

health benefits of physical activity, a useful exercise is to see the potential effect that cycling may have on the aforementioned health outcomes. Endogeneity in this context is of concern, as those who are in better health are more likely to be physically active (structural endogeneity) and those who are both physically active and in better health have common unobservable characteristics or tastes (statistical endogeneity). OLS estimates in columns 1 and 4 of Table 4 reveal cycling to have a protective health effect, lowering BMI by 0.51 kg/m^2 for males and 0.78 kg/m^2 for females. Cycling is also associated with 0.6 and 0.7 fewer days in the past month in poor health for males and females, respectively. Once other factors are controlled for, as well as potential endogeneity, this relationship still holds for the most part, as seen in columns 2 and 5 of Table 4. Precipitation and sunlight hours are strong, exogenous predictors of cycling prevalence.[22] IV results show significant effects for males but not for females.[23] The Durbin-Wu-Hausman exogeneity tests indicate that cycling is exogenous in the BMI regressions but not the general physical health regressions.

V. Discussion

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

[22] Tests after the inclusion of other MSA-level variables, such as sprawl and the gasoline price, revealed these potential instruments to be endogenous, and thus poor instruments in predicting health outcomes.

[23] Instrumental variables results are larger than OLS ones, which may be a sign of weak instruments. Nevertheless, the instruments pass the standard tests, and therefore the direction and significance of the coefficients are stressed rather than their magnitudes. In addition, exogeneity tests indicate that OLS estimates are unbiased in BMI regressions.

Using the BRFSS and NPTS 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 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 hurt the economy might be subject to, further enhance its attractiveness as a solution.

The deteriorating state of the physical and mental health of the U.S. population and the recent calls by the U.S. Surgeon General to prevent occurrences such as obesity highlight the urgency of implementing preventive measures to aid current and future generations. Cycling may thus be a source of physical 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 1a

Weighted Sample Means, Behavioral Risk Factor Surveillance System

Variable	Description	All	Bike=1	Bike=0
Bike	Dichotomous variable that equals 1 if respondent cycled for pleasure in the past month, and 0 otherwise	0.049/ (0.216)	1.000 (0.000)	0.000 (0.000)
BMI	Body mass index, measured as weight in kilograms divided height in squared meters, adjusted	26.739/ (5.367)	26.092 (4.543)	26.466 (5.006)
Poor physical health	Number of days in the past month in poor physical health (self-reported)	2.965/ (7.179)	1.841 (5.112)	2.326 (6.068)
Family income	Real family income in tens of thousands of 1982-84 dollars	3.431/ (2.872)	3.981 (3.041)	3.730 (2.972)
Married	Dichotomous variable that equals 1 if respondent is married	0.577/ (0.494)	0.546 (0.498)	0.581 (0.493)
Divorced	Dichotomous variable that equals 1 if respondent is divorced or separated	0.128 (0.334)	0.123 (0.329)	0.120 (0.325)
Widowed	Dichotomous variable that equals 1 if respondent is widowed	0.062/ (0.240)	0.025 (0.157)	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	0.070/ (0.255)	0.044 (0.205)	0.053 (0.224)
High school	Dichotomous variable that equals 1 if respondent completed exactly 12 years of schooling	0.290/ (0.454)	0.236 (0.425)	0.266 (0.442)
Some college	Dichotomous variable that equals 1 if respondent completed at least 13 but less than 16 years of school	0.282 (0.450)	0.294 (0.456)	0.296 (0.456)
College	Dichotomous variable that equals 1 if respondent graduated from college	0.320/ (0.466)	0.413 (0.492)	0.363 (0.481)
Black	Dichotomous variable that equals 1 if respondent is black and not Hispanic	0.120/ (0.325)	0.076 (0.264)	0.112 (0.316)
Hispanic	Dichotomous variable that equals 1 if respondent is of Hispanic origin	0.131/ (0.337)	0.112 (0.315)	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)	0.043 (0.203)	0.048 (0.214)
Work	Dichotomous variable that equals 1 if respondent is employed	0.686/ (0.464)	0.771 (0.420)	0.705 (0.456)
Age	Age of respondent in years	43.796/ (16.515)	39.830 (14.072)	42.868 (16.224)
Sprawl	Sprawl index in respondent's MSA of residence, with higher values denoting *less* sprawling areas	1.046/ (0.281)	1.069 (0.262)	1.046 (0.280)
Gas price	Real ACCRA gasoline price in respondent's MSA of residence, in 1982-84 dollars	0.680 (0.133)	0.682 (0.131)	0.681 (0.132)
Bike shops	State-level number of bicycle shops, 2007	225.766/ (188.938)	241.651 (193.051)	226.102 (190.178)
Fatalities	State-level bicycle fatalities, crude rate	0.292/ (0.158)	0.314 (0.172)	0.290 (0.155)
Miles	State-level number of miles reserved for trails from rails, for cycling, walking, and other activities	404.715 (370.943)	408.271 (369.705)	404.857 (374.498)

Precipitation	Monthly 1976 county-level precipitation in inches	3.002/ (1.700)	3.091 (1.815)	2.999 (1.703)
Sunlight hours	Monthly 1976 county-level sunlight hours	235.798/ (84.437)	253.179 (78.981)	237.307 (84.684)
Male	Dichotomous variable that equals 1 if respondent is male, and 0 if respondent is female	0.496/ (0.500)	0.616 (0.486)	0.505 (0.500)

Note: Standard deviation is reported in parentheses. Number of observations is 146,730. 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 1b

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	0.009/	1.000	0.000
		(0.092)	(0.000)	(0.000)
Family income	Real family income in tens of thousands of 1982-84 dollars	3.615	3.350	3.617
		(3.073)	(3.115)	(3.072)
Single	Dichotomous variable that equals 1 if respondent single and not living with another adult	0.167	0.196	0.167
		(0.373)	(0.398)	(0.373)
High school	Dichotomous variable that equals 1 if respondent has graduated from high school	0.303	0.269	0.303
		(0.459)	(0.444)	(0.460)
Some college	Dichotomous variable that equals 1 if respondent has completed some college	0.272	0.260	0.272
		(0.445)	(0.439)	(0.445)
College	Dichotomous variable that equals 1 if respondent has graduated from a four-year college	0.313	0.351	0.312
		(0.464)	(0.478)	(0.463)
Black	Dichotomous variable that equals 1 if respondent is black and not Hispanic	0.133/	0.081	0.133
		(0.339)	(0.274)	(0.340)
Hispanic	Dichotomous variable that equals 1 if respondent is of Hispanic origin	0.127	0.164	0.127
		(0.334)	(0.371)	(0.333)
Other race	Dichotomous variable that equals 1 if respondent's race is other than white, black, or Hispanic	0.054	0.044	0.054
		(0.225)	(0.205)	(0.225)
Work	Dichotomous variable that equals 1 if respondent is employed	0.709	0.714	0.709
		(0.454)	(0.452)	(0.454)
Age	Age of respondent in years	42.964/	37.931	43.007
		(16.580)	(15.880)	(16.579)
Sprawl	Sprawl index in respondent's MSA of residence, with higher values denoting *less* sprawling areas	1.048/	1.087	1.048
		(0.284)	(0.273)	(0.284)
Gas price	Real ACCRA gasoline price in respondent's MSA of residence, in 1982-84 dollars	0.705	0.707	0.705
		(0.112)	(0.118)	(0.112)
Bike shops	State-level number of bicycle shops, 2007	255.033/	300.483	254.639
		(199.420)	(214.610)	(199.240)
Fatalities	State-level bicycle fatalities, crude rate	0.338/	0.373	0.338
		(0.191)	(0.198)	(0.191)
Miles	State-level number of miles reserved for trails from rails, for cycling, walking, and other activities	430.779	416.170	430.905
		(365.353)	(332.163)	(365.627)
Precipitation	Monthly 1976 county-level precipitation in inches	2.977	2.866	2.978
		(1.738)	(1.900)	(1.737)
Sunlight hours	Monthly 1976 county-level sunlight hours	237.371/	257.514	237.197
		(85.702)	(79.682)	(85.732)
Male	Dichotomous variable that equals 1 if respondent is male, and 0 if respondent is female	0.481/	0.694	0.479
		(0.500)	(0.461)	(0.500)

Note: Standard deviation is reported in parentheses. Number of observations is 73,903. 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 2a

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

	(1)	(2)	(3)	(4)
Sprawl		0.034*** (3.32)	0.045*** (4.93)	0.044*** (4.88)
Gas price		0.047** (2.17)	0.061*** (2.87)	0.043* (1.77)
Bike shops			0.0001*** (4.09)	0.0001* (1.95)
Fatalities				0.006 (0.52)
Miles				0.00001 (1.30)
Precipitation				0.002** (2.26)
Sunlight hours				0.0001*** (6.28)
Family income	0.005*** (2.71)	0.005*** (2.78)	0.005*** (2.85)	0.005*** (2.89)
Family income squared	-0.0003** (2.15)	-0.0003** (2.20)	-0.0004** (2.32)	-0.0004** (2.32)
Some high school	0.005 (0.43)	0.005 (0.44)	0.005 (0.47)	0.004 (0.41)
High school	0.016* (1.83)	0.015* (1.83)	0.016* (1.88)	0.015* (1.82)
Some college	0.025*** (2.82)	0.025*** (2.83)	0.025*** (2.81)	0.024*** (2.74)
College	0.033*** (3.92)	0.033*** (3.96)	0.033*** (3.94)	0.032*** (3.92)
Black	-0.021*** (7.58)	-0.021*** (7.60)	-0.021*** (8.65)	-0.020*** (8.70)
Hispanic	-0.012*** (3.09)	-0.012*** (3.19)	-0.016*** (4.71)	-0.015*** (4.50)
Other race	-0.017*** (3.55)	-0.017*** (3.69)	-0.016*** (3.51)	-0.015*** (3.05)
Work	-0.00005 (0.02)	-0.00002 (0.00)	0.0004 (0.14)	0.0005 (0.16)
Age	0.002*** (4.06)	0.002*** (4.04)	0.002*** (4.07)	0.002*** (4.14)
Age squared	-0.00002*** (5.49)	-0.00002*** (5.51)	-0.00002*** (5.61)	-0.00002*** (5.67)
Married	-0.023*** (9.17)	-0.023*** (8.99)	-0.023*** (8.83)	-0.023*** (8.94)
Divorced	-0.008** (2.44)	-0.008** (2.40)	-0.007** (2.35)	-0.008** (2.40)
Widowed	-0.009 (1.16)	-0.009 (1.14)	-0.008 (1.08)	-0.008 (1.03)
Observations	62,013	62,013	62,013	62,013
Joint p-value, income	0.001	0.0008	0.001	0.0007
Value at mean income	0.02	0.02	0.02	0.02

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 values of t statistics are reported 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 2b

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

	(1)	(2)	(3)	(4)
Sprawl		0.016** (2.31)	0.023*** (3.87)	0.022*** (4.09)
Gas price		0.034*** (2.91)	0.043*** (4.03)	0.029*** (3.38)
Bike shops			0.0001*** (4.38)	0.00003** (2.42)
Fatalities				0.015** (1.97)
Miles				0.00001 (1.45)
Precipitation				0.001* (1.91)
Sunlight hours				0.0001*** (10.58)
Family income	0.002 (1.28)	0.002 (1.41)	0.002 (1.53)	0.002 (1.60)
Family income squared	-0.0001 (0.71)	-0.0001 (0.83)	-0.0001 (1.02)	-0.0001 (1.07)
Some high school	0.022** (2.24)	0.021** (2.23)	0.022** (2.28)	0.022** (2.31)
High school	0.028*** (3.02)	0.027*** (3.01)	0.028*** (3.07)	0.028*** (3.12)
Some college	0.034*** (3.54)	0.033*** (3.53)	0.034*** (3.56)	0.033*** (3.60)
College	0.046*** (4.45)	0.045*** (4.46)	0.045*** (4.48)	0.045*** (4.54)
Black	-0.018*** (9.81)	-0.018*** (10.06)	-0.018*** (10.34)	-0.017*** (10.36)
Hispanic	-0.008*** (4.09)	-0.008*** (4.22)	-0.010*** (5.64)	-0.010*** (5.34)
Other race	-0.010*** (3.40)	-0.010*** (3.52)	-0.009*** (3.70)	-0.009*** (3.74)
Work	-0.0001 (0.04)	-0.0002 (0.12)	-0.00001 (0.01)	-0.0001 (0.07)
Age	0.0002 (0.91)	0.0002 (0.87)	0.0002 (0.86)	0.0002 (0.88)
Age squared	-0.00001*** (3.60)	-0.00001*** (3.58)	-0.00001*** (3.59)	-0.00001*** (3.55)
Married	-0.005*** (3.43)	-0.005*** (3.42)	-0.005*** (3.06)	-0.005*** (3.33)
Divorced	-0.004** (2.22)	-0.004** (2.19)	-0.004** (2.04)	-0.004** (2.19)
Widowed	-0.004 (1.38)	-0.004 (1.36)	-0.003 (1.26)	-0.004 (1.49)
Observations	84,717	84,717	84,717	84,717
Joint p-value, income	0.02	0.01	0.03	0.02
Value at mean income	0.01	0.02	0.02	0.02

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 values of t statistics are reported 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 3a

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

	(1)	(2)	(3)	(4)
Sprawl		0.008** (2.10)	0.010*** (2.67)	0.009** (2.19)
Gas price		0.018*** (3.29)	0.025*** (4.10)	0.020*** (3.35)
Bike shops			0.00002*** (3.12)	0.00001* (1.75)
Fatalities				0.005 (1.22)
Miles				0.000001 (0.35)
Precipitation				0.0005 (1.42)
Sunlight hours				0.00003*** (4.91)
Family income	-0.003*** (5.61)	-0.003*** (5.52)	-0.003*** (5.50)	-0.003*** (5.25)
Family income squared	0.0002*** (4.82)	0.0002*** (4.78)	0.0002*** (4.70)	0.0002*** (4.48)
High school	-0.002 (1.36)	-0.002 (1.41)	-0.002 (1.42)	-0.002 (1.44)
Some college	-0.003** (2.26)	-0.003** (2.35)	-0.003** (2.16)	-0.003** (2.23)
College	0.002 (1.55)	0.002 (1.48)	0.002 (1.41)	0.002 (1.44)
Black	-0.004** (2.38)	-0.004** (2.34)	-0.003** (2.24)	-0.003** (2.28)
Hispanic	0.00002 (0.01)	0.0003 (0.18)	-0.0004 (0.27)	-0.0004 (0.25)
Other race	-0.002* (1.96)	-0.002* (1.84)	-0.002* (1.89)	-0.002* (1.78)
Work	-0.005** (2.57)	-0.005** (2.55)	-0.005*** (2.64)	-0.005*** (2.76)
Age	-0.0003* (1.70)	-0.0003* (1.79)	-0.0003* (1.92)	-0.0003** (1.96)
Age squared	0.0000001 (0.05)	0.0000002 (0.13)	0.0000004 (0.25)	0.0000004 (0.26)
Single	0.004*** (2.88)	0.004*** (2.89)	0.004*** (2.83)	0.004*** (2.88)
Observations	34,369	34,369	34,068	34,068
Joint p-value, income	<0.0001	<0.0001	<0.0001	<0.0001
Value at mean income	-0.07	-0.06	-0.06	-0.06

Note: Marginal effects of probit coefficients are shown. Absolute values of t statistics are reported 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 3b

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

	(1)	(2)	(3)	(4)
Sprawl		0.003** (2.38)	0.004*** (2.66)	0.003** (2.54)
Gas price		0.011*** (5.20)	0.014*** (4.94)	0.010*** (5.08)
Bike shops			0.00001** (2.16)	0.000001 (0.31)
Fatalities				0.005*** (4.25)
Miles				0.000001 (1.46)
Precipitation				-0.00001 (0.05)
Sunlight hours				0.00001*** (4.50)
Family income	-0.001*** (3.25)	-0.001*** (3.13)	-0.001*** (2.77)	-0.001*** (2.58)
Family income squared	0.0001*** (2.75)	0.0001*** (2.68)	0.0001** (2.40)	0.00005** (2.26)
High school	0.001 (0.89)	0.001 (0.82)	0.001 (0.85)	0.001 (0.85)
Some college	0.003** (1.98)	0.003* (1.91)	0.003* (1.78)	0.003* (1.73)
College	0.005** (2.57)	0.005** (2.53)	0.005** (2.55)	0.004** (2.55)
Black	-0.002* (1.84)	-0.001* (1.74)	-0.001* (1.68)	-0.001 (1.54)
Hispanic	-0.001 (1.43)	-0.001 (1.18)	-0.001 (1.27)	-0.001 (1.38)
Other race	-0.002* (1.76)	-0.001 (1.55)	-0.001 (1.53)	-0.001 (1.49)
Work	-0.0001 (0.17)	-0.0002 (0.26)	-0.0002 (0.30)	-0.0002 (0.33)
Age	-0.00005 (0.66)	-0.00004 (0.66)	-0.00004 (0.62)	-0.00004 (0.65)
Age squared	-0.0000004 (0.49)	-0.0000004 (0.51)	-0.0000004 (0.55)	-0.0000003 (0.54)
Single	0.0002 (0.34)	0.0003 (0.47)	0.0004 (0.63)	0.0005 (0.74)
Observations	39,328	39,328	38,945	38,945
Joint p-value, income	0.0004	0.001	0.005	0.01
Value at mean income	-0.08	-0.07	-0.07	-0.07

Note: Marginal effects of probit coefficients are shown. Absolute values of t statistics are reported 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 4

Physical Health Outcomes, BRFSS 1996-2000

	(1)	(2)	(3)	(4)	(5)	(6)
	Males			Females		
	OLS	IV	First stage	OLS	IV	First stage
Dependent variable: BMI						
Bike	-0.506*** (8.07)	-2.134** (2.01)		-0.776*** (10.79)	-0.654 (0.37)	
Precipitation			0.003*** (3.13)			0.002*** (2.96)
Sunlight hours			0.0002*** (10.49)			0.0001*** (12.22)
Observations	93,604	93,604	93,604	123,816	123,816	123,816
F test on instruments			64.97			80.63
P value on instruments			<0.0001			<0.0001
Overid p-value			0.3953			0.3900
Durbin-Wu-Hausman p-value			0.121			0.945
Dependent variable: Poor Physical Health (Days in past month)						
Bike	-0.594*** (7.47)	-5.766*** (4.00)		-0.719*** (8.03)	-14.227*** (5.29)	
Precipitation			0.003*** (3.12)			0.002*** (3.05)
Sunlight hours			0.0002*** (10.65)			0.0001*** (12.48)
Observations	92,901	92,901	92,901	122,470	122,470	122,470
F test on instruments			66.72			84.15
P value on instruments			<0.0001			<0.0001
Overid p-value			0.8270			0.5759
Durbin-Wu-Hausman p-value			0.0004			<0.0001

Note: Marginal effects are shown. Absolute values of t statistics are reported 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. Regressions are clustered by metropolitan area. *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

Appendix 1

Regression Results for Cycling Using Quadratic Terms for Sprawl and Gasoline Price

	(1)	(2)	(3)	(4)
	Males BRFSS	***Females BRFSS***	***Males NPTS***	***Females NPTS***
Sprawl	0.025 (0.53)	0.022 (0.69)	-0.008 (0.90)	-0.000 (0.04)
Sprawl squared	0.008 (0.34)	-0.002 (0.14)	0.010 (1.47)	0.002 (0.84)
Gas price	0.317** (2.37)	0.077 (0.89)	0.082 (0.84)	0.068 (1.41)
Gas price squared	-0.206** (2.01)	-0.034 (0.53)	-0.041 (0.60)	-0.041 (1.19)
Observations	62,013	84,717	34,369	39,328
Joint p-value, sprawl	0.0005	0.09	0.08	0.02
Joint p-value, gas price	0.006	0.06	0.002	0.0002
Value at mean sprawl	0.042	0.017	0.012	0.005
Value at mean gas price	0.037	0.030	0.024	0.010

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 values of t statistics are reported in parentheses. Controls for education, race/ethnicity, marital status, family income, age, employment status, 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.

Appendix 2

Dependent Variable: Cycled on a Bicycling Machine in Past Month, BRFSS 1996-2000

	(1)	(2)
	Males	***Females***
Sprawl	0.006 (1.51)	0.006 (1.49)
Gas price	0.002 (0.33)	0.003 (0.41)
Observations	62,013	84,717

Note: Dependent variable is equal to 1 if respondent reported cycling on a bicycling machine in the month prior to survey. Marginal effects of probit coefficients are shown. Absolute values of t statistics are reported in parentheses. Controls for education, race/ethnicity, marital status, family income, age, employment status, 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.

Figure 1

Trends in Cycling for Pleasure in the U.S., 1984-2000
Behavioral Risk Factor Surveillance System

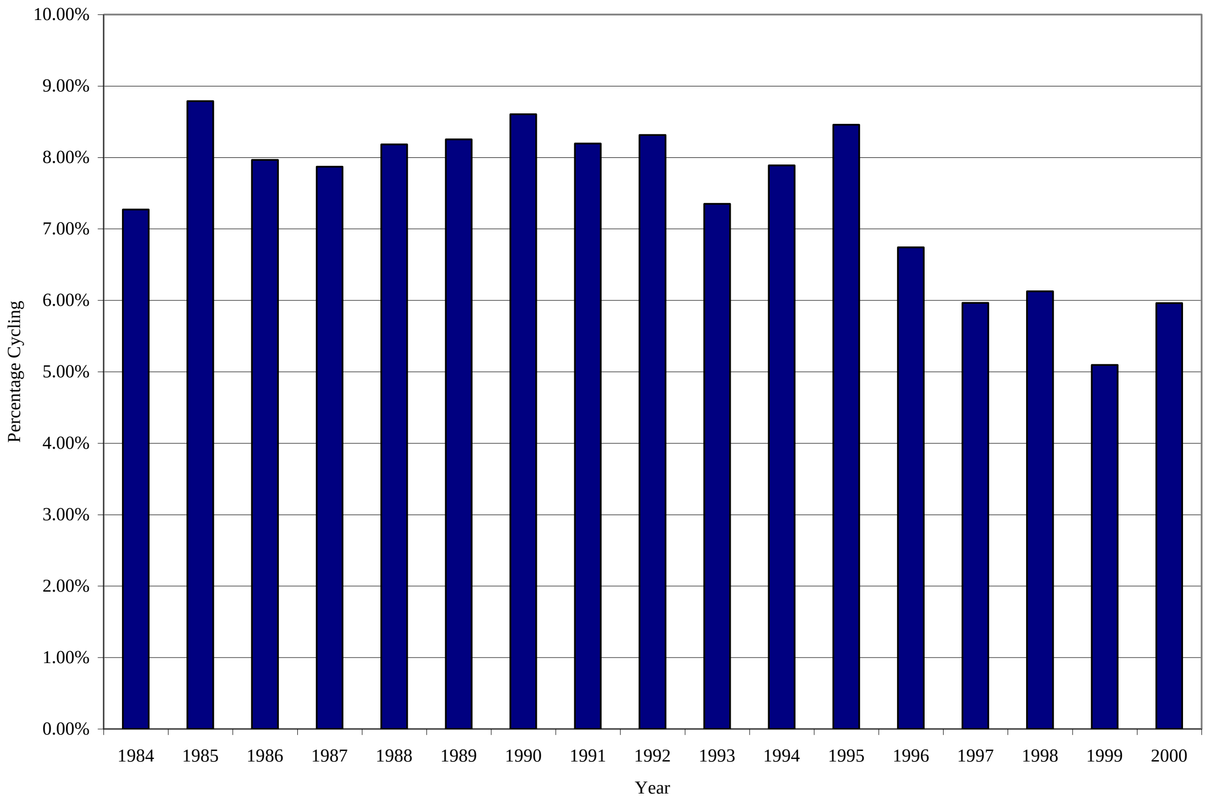


Figure 2

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

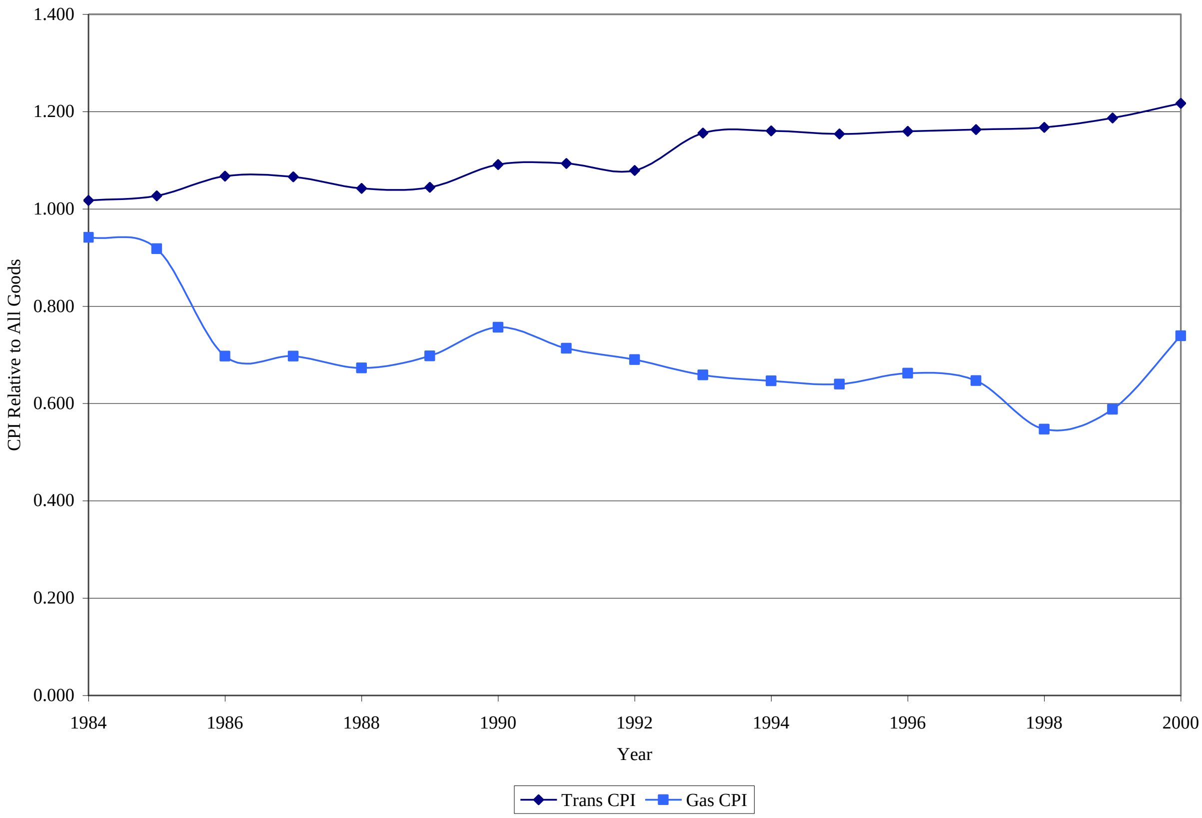
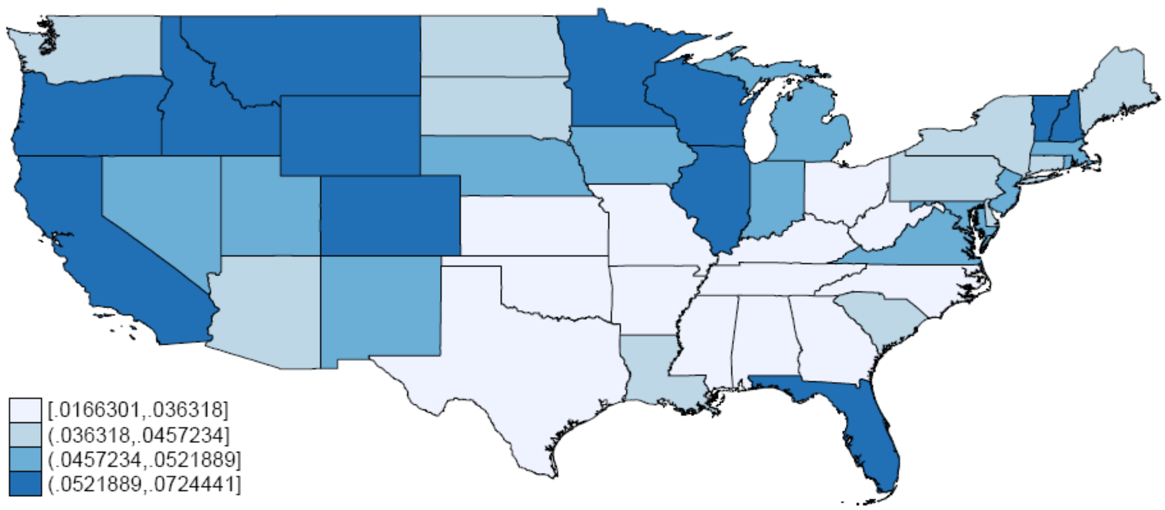


Figure 3

Prevalence of Cycling in the United States, 1996-2000
Behavioral Risk Factor Surveillance System



Note: All means are weighted. Means for Alaska and Hawaii are 5.74% and 3.90%, respectively.