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Bicycle Commuting and Facilities in Major U.S. Cities

If You Build Them, Commuters Will Use Them

Jennifer Dill and Theresa Carr

Some surveys indicate that providing bicycle lanes and paths may encourage more people to commute by bicycle. The presence of a striped lane or separated path can increase a cyclist's perception of safety. With growing concerns over traffic congestion and vehicle pollution, public policy makers are increasingly promoting bicycling as an alternative for commuting and other utilitarian trip purposes. State and local spending on bicycle facilities has increased significantly over the past decade. Previous studies have linked higher levels of bicycle commuting to various demographic and geographic variables. At least one analysis showed that cities with higher levels of bicycle infrastructure (lanes and paths) witnessed higher levels of bicycle commuting. Research was conducted that affirms that finding by analyzing data from 43 large cities across the United States. This cross-sectional analysis improves on previous research by including a larger sample of cities, not including predominantly college towns, and using consistent data from the Bureau of the Census 2000 Supplemental Survey. Although the analysis has limitations, it does support the assertion that new bicycle lanes in large cities will be used by commuters.

Increasing concern over vehicle congestion and pollution in urban areas has led to an interest in promoting bicycle use for nonrecreation (utilitarian) purposes. This interest is evident at all levels of government. In the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, the U.S. Congress opened up new sources of funding for bicycle facilities. These new funding sources continued with the Transportation Equity Act for the 21st Century (TEA-21) of 1998 and have influenced spending nationwide. In 1991, states and metropolitan planning organizations (MPOs) spent $17.1 million in federal funds on stand-alone bicycle and pedestrian projects. This figure grew to $339.1 million in 2001 (*1*). In addition, federal planning requirements now include consideration of bicyclists in state and MPO long-range transportation plans. Bicycle projects must be considered in conjunction with all newly constructed and reconstructed facilities where bicycling is permitted (*2*). Promoting bicycle travel for utilitarian purposes is a federal objective. In 1994, the U.S. Department of Transportation released the National Bicycling and Walking Study (NBWS). One of the goals of the NBWS was to double the share of trips made by foot or bicycle (*3*).

With an increased public policy focus on bicycling, researchers and planners are trying to better comprehend what motivates people to use a bicycle instead of a motorized vehicle. The NBWS reviewed existing literature to understand why bicycling is not used more extensively (*4*). Reasons were categorized as either "1. Subjective factors which have less to do with measurable conditions than with personal perception and interpretation of one's needs" or "2. Objective, physical factors which exist for everyone, though they may not be weighed equally by everyone" (*4*, p. 6). Subjective factors include distance, traffic safety, convenience, cost, valuation of time, valuation of exercise, physical condition, family circumstances, habits, attitudes and values, and peer group acceptance. Objective factors include climate, topography, presence of bicycle facilities and traffic conditions, access and linkage, and transportation alternatives. Pucher et al. (*5*) identify eight factors that affect the level of cycling in North America:

1. Public attitude and cultural differences,
2. Public image,
3. City size and density,
4. Cost of car use and public transport,
5. Income,
6. Climate,
7. Danger, and
8. Cycling infrastructure.

Public policy can influence most of these factors, to varying degrees. Current U.S. policy has focused largely on providing bicycle infrastructure, mainly through new funding made available through ISTEA and TEA-21 (*5*). From studies from the late 1970s and early 1980s, the NBWS concluded that bikeways (i.e., lanes and paths) "will significantly affect subjective perceptions of safety" (*4*, p. 11). The NBWS also cited surveys conducted by a variety of sources. For example, 12% to 17% of the active bicyclists surveyed in Phoenix, Arizona; Seattle, Washington; and Portland, Oregon, identified a "lack of facilities" as a reason for not commuting to work by bicycle. Trip distance was the most frequently cited reason. A Harris Poll (cited in the NBWS) conducted in 1991 found that 49% of active bicycle riders who did not currently commute by bicycle said they would sometimes commute by bicycle if there were safe bike lanes. Similar surveys in Davis, California, and Seattle, Washington, found that 12% and 41%, respectively, of cyclists would commute by bicycle if there were safer routes. The results of these types of surveys, however, are influenced by the wording of the questions, and they reveal only what people might do, rather than what they actually do.

REVEALED PREFERENCE RESEARCH

Of course, actual or revealed behavior does not always reflect stated preferences or desired choices. Using attitudinal surveys to predict shifts in travel resulting from bicycle improvements can overestimate

Portland State University, School of Urban Studies and Planning, P.O. Box 751, Portland, OR 92207-0751.

demand for new facilities (*6*). Although Pucher et al. (*5*) agreed that separate bike lanes and paths make cycling more attractive to noncyclists, they did not find any rigorous statistical studies that demonstrated their impact on cycling. They also speculated that, to some extent, the provision of such facilities could be a response to the level of cycling in an area, rather than a cause.

Bicycling is predominantly a recreational activity in the United States. Data from the Bureau of Transportation Statistics (BTS) Omnibus Survey for 2002 reveals that 14.3 % of the adult respondents rode a bicycle in the previous month (*7*). Of those, 53.9% did so primarily for recreation and 31.2% did so primarily for exercise. Only 4.9% bicycled primarily for commuting to work or school and 7.5% for personal errands. The survey did not ask for secondary purposes. Also, those people bicycling primarily for exercise might be going to work. Of the bicycle commuters, 11.0% rode primarily on bike lanes, compared with 5.6% of the recreational cyclists. Howard and Burns (*8*) found that regular bicycle commuters in Phoenix adjusted their routes to use bicycle facilities, lending support to the argument that providing facilities impacts behavior.

Nelson and Allen (*9*) used data from the NBWS to explain the relationship between bicycle commuting and bicycle pathways, controlling for extraneous variables. The data included 18 U.S. cities and used five explanatory variables:

1. Mean high temperature,
2. Number of days per year with more than 1/10 in. of rain,
3. Terrain,
4. Miles of bikeways per 100,000 residents, and
5. Percentage of college students compared with the overall resident population.

Their final linear regression model included bikeway mileage, rain days, and percentage of students as significant variables, with an adjusted R^2 of 0.825. They found that each additional mile of bikeway per 100,000 people is associated with a 0.069% increase in bicycle commuting, holding the other factors constant. The authors did not, however, interpret this as a cause–effect relationship.

Other researchers have explored the effect of additional variables on bicycle commuting. Baltes (*10*) used Census journey-to-work data from 284 metropolitan statistical areas (MSAs) to examine the relationship between bicycle commuting and various demographic and geographic factors. The analysis did not include data on bikeways, for this information is not included in the U.S. Census. A series of regression equations identified several significant variables, including the following:

1. Age (16–29 years),
2. Vehicle availability,
3. Race (Asian and nonwhite),
4. Home ownership,
5. Unemployment,
6. Percentage of students,
7. Poverty,
8. Agricultural and manufacturing employment, and
9. Share of workers and population living in the central city.

Baltes found that several variables were not significant, including population density and median income, although some of the significant variables are likely to be highly correlated with these two variables. The analysis was conducted at the MSA level for each Census region and all the MSAs combined, and it found that the variables explained at least half of the variation in the level of bicycle commuting. Baltes did conclude that bicycle commuting was most prevalent in MSAs with unique communities, such as universities or colleges. Nankervis (*11*) found that short-term and long-term weather patterns affected cycling levels, although not to the extent that he originally anticipated.

Overall, the empirical evidence explaining the link between bicycle facilities and commuting is limited. Nelson and Allen (*9*) made several recommendations on how to improve on their analysis, including a larger data set, time-series data, before-and-after studies, and including additional factors that influence mode choice. Moreover, the quality of the original data used for the analysis was problematic. The NBWS noted that "innumerable difficulties were encountered when assembling the data" and that "the quality of the data varies so much" (*4*, p. 32, note 43). This was particularly true for the bicycle commuting data and bikeway mileage. Finally, of the 18 cities included in the Nelson and Allen study, the top 4 in terms of bicycle commuting are college towns: Boulder, Colorado (31.96%); Eugene, Oregon (16%); Gainesville, Florida (24.87%); and Madison, Wisconsin (22.24%). Although the percentage of people who are students was included as a control variable, these cities may be influencing the results and might not be considered useful as models for larger cities without a university focus.

DATA AND METHODOLOGY

This analysis builds on the work of Nelson and Allen (*9*) by using new Census data, a larger sample of cities, and additional explanatory variables. Much of the data used in this study comes from the Census 2000 Supplemental Survey (C2SS). The C2SS is a demonstration program to evaluate the feasibility of collecting economic, demographic, and housing data outside of the decennial census. The C2SS sampled 700,000 housing units in 1,203 counties, sampling approximately 58,000 addresses each month. The C2SS sampling rate for most geographic areas was 5% (*12*). Although the sample size is much smaller than that used for the long form of the decennial Census, the C2SS may be more useful for this analysis because it samples households throughout the calendar year, rather than on April 1, as the decennial Census does. If bicycle commuting is influenced by weather, a random sample throughout the year may present a more accurate picture of regular behavior. In addition, at the time this research was originally conducted, the U.S. Census had not released bicycle commute data at the city level.

The C2SS includes data for 64 incorporated or Census-designated places with a household population of 250,000 or higher. Three U.S. cities have a population greater than 250,000 but were not included in C2SS: Lexington and Louisville, Kentucky, and Corpus Christi, Texas. Bicycle commuting rates in the top 55 cities ranged from 2.63% (Minneapolis, Minnesota) to 0.04% (Dallas, Texas) (*13*). Nine cities had estimates of 0% of the workers' commuting by bicycle. This result is probably a result of the sample size. Bicycle coordinators or other staff at the top 50 cities were contacted to obtain information on the number of miles of Class I and Class II bike facilities that they had at the end of the year 2000. Class I facilities, also known as bike paths or shared use paths, are defined as bikeways physically separated from motorized vehicular traffic. Shared use paths may also be used by pedestrians, skaters, wheelchair users, joggers, and other nonmotorized users. Class II facilities, also known as on-street bicycle lanes, are defined as portions of a roadway that have been designated by striping, signing, and pavement markings for the preferential or exclusive use of bicyclists (*14*). Some cities also had bike routes, wide shoulders, bike boulevards, and other facilities. Although these other facilities may have some impact on bicycle commuting, the analysis was limited to Class I and II facilities to maintain consistency among cities, as well as to focus the analysis on the highest level of facilities. Class I and II facility data were obtained from 43 cities. Also asked was whether or not the city had a designated bicycle coordinator on staff. This variable is an indicator of the amount of policy support at the local level for bicycling, which may or may not be reflected in the level of facilities existing in 2000.

From the previous research as mentioned, a number of other variables were selected that could influence the level of bicycle commuting in a city. These are shown in Table 1.

FINDINGS

Data for the top cities, of which 43 provided specific information about bike facilities, appear in Table 2, sorted by the percentage of bicycle commuters. The rankings in the first column are from the original list of 64 cities from the C2SS. When looking at the data, one can notice few consistent trends. The top four cities have some of the highest numbers of bike lanes and paths per square mile, although cities further down the list (e.g., St. Paul, Long Beach, and San Jose) also have high numbers. The aforementioned BTS data described above indicated that commuters are more likely than other cyclists to use bike lanes. Therefore, the number of Class II bike lanes per square mile is also included in the table. Three of the top 10 cities have more than 100 days of rain per year, lending some doubt that rain is a significant deterrent to bicycle commuting. However, only 4 of the bottom 10 cities had under 100 days of rain. The maximum percentage of residents that are college students is 12.23% in Boston, (as shown in Table 2), significantly lower than rates found in Boulder, Gainesville, and Madison in the Nelson and Allen data (*9*). Most cities have a relatively high rate of vehicle ownership: more than one vehicle per household for all but five cities (Boston, Washington, D.C., New York City, Philadelphia, and Baltimore).

The percentage of people commuting by bicycle is significantly correlated with the bicycle infrastructure and gasoline price variables in Table 2, but not with any other variables listed in Table 1 or 2. The strongest and most significant correlation was with the number of Class II bike lanes per square mile (Pearson correlation = 0.49, $p < 0.01$). There was no significant correlation between state spending on bicycle and pedestrian projects or the presence of a bicycle coordinator and any of the three infrastructure variables—that is, bike lanes and paths per square mile, bike lanes per square mile, and bike paths per square mile. Several explanations are possible. First, the funding variable is for the state level and also includes pedestrian projects. Also, the funds could be spent on types of bicycle facilities and projects other than Class I or II paths and lanes, such as safety enhancements or intersection signals and detection equipment. The variable is included in this analysis as a possible indicator of states providing all types of bicycle facilities and overall public support for bicycling.

TABLE 1 Variables and Data Sources

Variable	Source
Occupation/Employment	
Percentage of population that are college students	C2SS (*15*)
Percent of workers by industry category (agriculture, construction, manufacturing, wholesale trade, retail trade, transportation/warehousing/ utilities, information, finance/insurance/real estate, professional/scientific, education, arts/entertainment/recreation, and public administration)	C2SS (*16*)
Percent of workers by occupation category (management/professional, service, sales/office, farm/forestry, construction, and production/transportation/manufacturing)	C2SS (*16*)
Availability/Attractiveness of Other Modes	
Mean number of vehicles per household	C2SS (*17*)
Percentage of households with zero vehicles	
Transit Availability -	National Transit Database
Transit vehicle revenue miles per mile of service area	2000 Transit Profiles
Gasoline price (state average, with taxes for 2000)	Energy Information Administration (*18*)
Land Use	
Percentage of housing units built before 1950 (a proxy for a grid-like street pattern)	C2SS (*19*)
Population density	2000 Census (*20*)
Socio-economic Characteristics	
Median and mean household income	C2SS (*16*)
Percent of persons over 18 in poverty	C2SS (*16*)
Weather	
Average annual number of days of rainfall (.01 inches or more)	National Climatic Data Center (*21*), Western Regional Climate Center (*22*)
Average annual precipitation (total inches)	
(Data for next closest city if city data not available)	
Public Support for Bicycling	
Average per capita annual state spending on bicycle and pedestrian improvements, 1990-1999 (federal funds)	Surface Transportation Policy Project (*23*)

TABLE 2 Cities and Data Used in the Analysis

Rank	City	% Commuting by Bicycle	Bike Lanes & Paths per sq. mi.	Bike Lanes per sq. mi.	Average State Spending per Capita on Ped/Bike (1990-99)	Population Density (people/ sq mi land)	Days of Rain (historical average)
1	Minneapolis, MN	2.63%	1.44	0.47	$0.45	6,970	116
2	Sacramento, CA	2.59	2.05	1.42	$0.09	4,189	58
3	Portland, OR	2.55	1.44	1.05	$0.94	3,939	153
4	Tucson, AZ	2.22	1.76	1.54	$0.26	2,500	53
5	Fresno, CA	1.96	0.13	0.00	$0.09	4,098	45
6	Tampa, FL	1.93	0.58	0.41	$0.58	2,708	106
7	San Francisco, CA	1.80	0.87	0.44	$0.09	16,634	68
8	Oakland, CA	1.77	0.20	0.09	$0.09	7,127	63
9	Mesa, AZ	1.64	0.37	0.36	$0.26	3,171	36
10	Anaheim, CA	1.59	0.45	0.29	$0.09	6,702	32
11	Boston, MA	1.48	0.28	0.01	$0.42	12,166	127
12	Washington, DC	1.42	0.78	0.10		9,316	113
13	Seattle, WA	1.23	0.58	0.25	$0.83	6,717	151
14	Albuquerque, NM	1.16	0.61	0.31	$1.29	2,483	61
15	New Orleans, LA	1.14	0.06	0.00	$0.29	2,684	114
16	Oklahoma City, OK	0.90	0.02	0.01	$0.45	834	83
17	Phoenix, AZ	0.87	0.48	0.38	$0.26	2,782	36
18	Buffalo, NY	0.75	0.80	0.43	$0.48	7,206	169
19	St. Paul, MN	0.69	1.93	0.65	$0.45	5,442	116
20	Long Beach, CA	0.66	1.27	0.00	$0.09	9,150	32
21	Santa Ana, CA	0.65	0.36	0.04	$0.09	12,452	32
22	Los Angeles, CA	0.63	0.34	0.25	$0.09	7,877	35
23	Philadelphia, PA	0.63	1.30	0.96	$0.21	11,234	117
24	Honolulu, HI	0.61	0.46	0.25	$0.43	4,337	97
25	Denver, CO	0.53	0.62	0.07	$0.50	3,617	89
26	Chicago, IL	0.51	0.35	0.22	$0.24	12,750	125
27	Pittsburgh, PA	0.48	0.31	0.05	$0.21	6,019	152
28	San Diego, CA	0.48	0.92	0.77	$0.09	3,772	42
29	San Jose, CA	0.42	1.02	0.74	$0.09	5,118	58
30	New York City, NY	0.42	0.64	0.40	$0.48	26,403	121
35	Houston, TX	0.35	0.43	0.32	$0.17	3,372	105
36	Raleigh, NC	0.34	0.21	0.02	$0.35	2,409	113
37	Milwaukee, WI	0.27	0.26	0.08	$0.31	6,214	126
38	Baltimore, MD	0.26	0.06	0.00	$0.42	8,058	114
39	St. Louis, MO	0.26	0.45	0.06	$0.05	5,623	111
40	Cincinnati, OH	0.25	0.16	0.06	$0.47	4,249	137
41	Riverside, CA	0.23	1.10	0.85	$0.09	3,267	32
42	Columbus, OH	0.22	0.13	0.01	$0.47	3,384	137
43	Omaha, NE	0.19	0.06	0.00	$0.80	3,371	101
45	Indianapolis, IN	0.18	0.50	0.00	$0.41	2,161	126
46	Charlotte, NC	0.17	0.12	0.01	$0.35	2,232	111
48	Wichita, KS	0.14	0.01	0.01	$0.64	2,536	86
50	Arlington, TX	0.13	0.41	0.04	$0.17	3,475	79
	Average	0.91	0.61	0.31	$0.35	6,604	93

(continued)

TABLE 2 (*continued*) Cities and Data Used in the Analysis

Rank	City	Percent College Students	Avg. Gas Price (state, with taxes)	Avg. No. of Vehicles per Household	Median Household Income
1	Minneapolis, MN	8.14%	1.52	1.34	$40,471
2	Sacramento, CA	9.83	1.62	1.54	$37,216
3	Portland, OR	6.88	1.63	1.53	$38,807
4	Tucson, AZ	10.27	1.51	1.50	$30,248
5	Fresno, CA	8.34	1.62	1.43	$29,934
6	Tampa, FL	5.73	1.49	1.46	$34,194
7	San Francisco, CA	9.81	1.62	1.15	$57,417
8	Oakland, CA	7.93	1.62	1.41	$45,251
9	Mesa, AZ	7.17	1.51	1.65	$39,719
10	Anaheim, CA	5.67	1.62	1.92	$46,540
11	Boston, MA	12.23	1.57	.98	$42,117
12	Washington, DC	7.56	1.50	.90	$41,162
13	Seattle, WA	11.34	1.60	1.43	$44,954
14	Albuquerque, NM	8.33	1.49	1.72	$37,235
15	New Orleans, LA	7.17	1.43	1.16	$27,496
16	Oklahoma City, OK	5.55	1.38	1.62	$34,660
17	Phoenix, AZ	5.49	1.51	1.60	$40,003
18	Buffalo, NY	8.02	1.57	1.07	$27,361
19	St. Paul, MN	7.41	1.52	1.49	$45,944
20	Long Beach, CA	8.85	1.62	1.42	$35,220
21	Santa Ana, CA	5.19	1.62	1.83	$38,258
22	Los Angeles, CA	7.29	1.62	1.50	$35,611
23	Philadelphia, PA	6.65	1.50	0.93	$29,721
24	Honolulu, HI	9.76	1.75	1.43	$46,776
25	Denver, CO	6.99	1.54	1.57	$42,060
26	Chicago, IL	7.01	1.56	1.15	$38,295
27	Pittsburgh, PA	7.91	1.50	1.03	$30,352
28	San Diego, CA	9.71	1.62	1.66	$47,088
29	San Jose, CA	9.28	1.62	2.07	$72,173
30	New York City, NY	7.12	1.57	.63	$39,686
35	Houston, TX	5.28	1.41	1.51	$36,073
36	Raleigh, NC	11.08	1.47	1.65	$46,763
37	Milwaukee, WI	6.25	1.55	1.31	$34,375
38	Baltimore, MD	6.03	1.49	0.95	$30,579
39	St. Louis, MO	6.61	1.42	1.22	$27,213
40	Cincinnati, OH	8.49	1.50	1.23	$28,116
41	Riverside, CA	8.13	1.62	1.84	$41,555
42	Columbus, OH	8.71	1.50	1.52	$37,041
43	Omaha, NE	7.65	1.50	1.64	$37,756
45	Indianapolis, IN	5.60	1.44	1.62	$41,009
46	Charlotte, NC	7.40	1.47	1.59	$44,371
48	Wichita, KS	7.15	1.42	1.77	$40,345
50	Arlington, TX	8.25	1.41	1.79	$48,617
	Average	7.80	1.54	1.44	$39,297

A series of regression models were estimated with various combinations of independent variables. The results from the best model, based on model and variable significance, are shown in Table 3 as Model 1. The model includes 42 of the 43 cities. State spending information was not available for Washington, D.C., so that city was excluded. The adjusted R^2 for the model is 0.34, indicating that the variables explain more than one-third of the variation in the dependent variable. The most significant variable in the model is the infrastructure variable—miles of Class II lanes per square mile—which is positively associated with bicycle commuting. The results also indicate that vehicle ownership and the number of days of rain are negatively related to bicycle commuting, as expected. The coefficient for the state spending variable is positive, as expected. Omitting the infrastructure variable reduces the adjusted R^2 to 0.06 (Model 2). This indicates that the number of bike lanes per square mile explains a large share of the variation bicycle commuting rates.

The model includes a dummy variable for New York City—which is often considered an outlier in transportation-related research owing

TABLE 3 Results of Regression Models

	Census 2000 Supplemental		Census 2000 April 1st	
	Model 1	Model 2	Model 3	Model 4
Constant	2.083 (0.03)	2.678 (0.02)	1.953 (0.01)	2.407 (0.00)
Type 2 lanes per square mile	0.992 (0.00)		0.757 (0.00)	
State spending per capita on bike/pedestrian	0.853 (0.06)	0.871 (0.10)	0.643 (0.06)	0.657 (0.10)
Vehicles per household	-0.890 (0.07)	-0.932 (0.10)	-0.719 (0.05)	-0.751 (0.08)
Days of rain	-0.006 (0.11)	-0.008 (0.06)	-0.006 (0.03)	-0.008 (0.02)
Percent of workers in farming, forestry	24.218 (0.04)	18.761 (0.16)	2.582 (0.76)	-1.580 (0.87)
New York City dummy variable	-1.203 (0.10)	-1.104 (0.20)	-0.912 (0.10)	-0.836 (0.20)
Adj-R^2	0.340	0.071	0.323	0.038
F-statistic	4.526 (0.00)	1.628 (0.18)	4.264 (0.00)	1.327 (0.27)
n	42	42	42	42

Dependent Variable: Percentage of workers commuting by bicycle
Beta-coefficient is shown in each cell. Level of significance is shown in parentheses.

to its high amount of transit use and population density. New York City may also be unique in terms of bicycling. Pucher et al. (*5*) suggest that New York could be a leading bicycling city, with its flat terrain and close destinations. However, obstacles such as heavy traffic, poor pavement, poor links on bridges, vehicle exhaust, lack of secure bicycle parking, and theft likely discourage high levels of bicycle commuting. This theory is supported by the negative coefficient in the model. Including the New York City dummy variable increased the explanatory power of the model and increased the significance of several variables. The percentage of workers in farming, fishing, and forestry occupations is also significant and positively associated with bicycle commuting. The share of workers in these occupations was significantly higher in Fresno, California (more than 5%), than in all other cities (all under 1%). This finding may explain the high rate of cycling in that city, considering the lack of extensive infrastructure. Gasoline price, although significantly and positively correlated with bicycle commuting, was not included in the models presented. When it was included in models, the variable was not significant.

The results from Model 1 indicate that for typical U.S. cities with a population more than 250,000, each additional mile of Class II bike lanes per square mile is associated with a roughly one percentage point increase in the share of workers commuting by bicycle. The magnitude of the relationship between bike infrastructure and bike commuting in our model is less than that found by Nelson and Allen (*9*). When our model is run using the same infrastructure variable (miles of Class I and II bikeways per 100,000 population), the coefficient is 0.023, about one-third that found by Nelson and Allen (0.069). Our model with this variable does not perform as well overall, with a lower adjusted R^2 and fewer significant variables. The model is also not as strong using miles of Class I plus Class II bikeways per square mile as a variable. This indicates that Class I facilities (separated bike paths) are not as strongly associated with commuting as are Class II facilities. This is consistent with the fact that many bike paths are built in parks and greenbelts, intended for recreational cyclists, and do not connect to major employment locations.

Increasing Class II bike lane mileage by 1 mi per square mile is substantial—about four times the current average of 0.31 mi per square mile. However, increasing the share of workers commuting by bicycle by one percentage point would more than double the average share of bicycle commuters for many of these cities. Of course, as noted by Nelson and Allen (*9*) and Pucher et al. (*5*), the strong association between the existence of bike lanes and levels of bicycle commuting does not certify a cause–effect relationship. It does, however, imply that commuters will use bicycle lanes if they are provided.

In a regression analysis that includes only 42 cities, one city can influence the results significantly, as shown with the New York City flag. Therefore, it is also worth looking at the data for other anomalies and possible explanations. For example, Fresno, California, is ranked fifth, with 1.96% of the workers commuting by bicycle, yet the city has few bicycle lanes or paths. However, as noted, nearly 6% of the workers are employed in the farming, fishing, or forestry occupations, more than 10 times the rate in any of the other cities. Baltes (*10*) had found that the percentage of the population employed in agriculture is positively related to bicycle commuting at the MSA level. Boston also has a high level of bicycle commuting (1.48%) and a low number of bicycle lanes and paths. The city also has the highest share of residents who are college students and a low rate of vehicle ownership—just less than one vehicle per household. The high density in Boston also indicates that destinations are closer than in many cities. These possible explanations do not apply to New Orleans, another city with a relatively high level of bicycle commuting (1.14%) and little infrastructure. One possible explanation is income; the median household income in New Orleans is more than $10,000 less than the average for the 43 cities. However, income in general was not significantly correlated with bicycle commuting across all 43 cities and, when included in regression models, was not a significant variable. At the other end of the list, there are some cities with higher than average bicycle infrastructure, but lower than average bicycle commuting—San Diego, San Jose, and Riverside, California, for example. All three cities have low rainfall, which should be conducive to bicycling. They also have lower than average densities and higher than average automobile ownership rates. This finding might imply that providing bicycle lanes and paths in more automobile oriented cities may not correlate well with increased bicycle commuting. However, Sacramento, California, and Portland, Oregon, have similar population densities and higher than average vehicle ownership rates, yet much higher bicycle commuting and infrastructure.

After the original analysis for this paper was performed, the Census Bureau released the long-form commute data at the city level. The use of these data for the dependent variable changes the model little (Models 3 and 4). All of the original variables are still significant and in the same direction, with one exception. The share of workers in farming, fishing, and forestry occupations is no longer significant. This is likely because the share of commuters bicycling in Fresno as indicated by the long-form April 1 Census is 0.79%, less than half the rate shown in the C2SS. This may reflect the seasonal variation in bicycle commuting, particularly for certain workers.

CONCLUSIONS

The analysis performed here affirms the results of Nelson and Allen (*9*). Higher levels of bicycle infrastructure are positively and significantly correlated with higher rates of bicycle commuting. Achieving consistent results with a larger, more uniform set of cities (e.g., no small or college towns) lends strength to this finding. Although additional variables were tested, such as income, gas prices, and transit availability, they were not significant in the regression models. However, there are still several limitations to this analysis. As already discussed, the analysis does not indicate the existence or direction of a cause–effect relationship. People may be commuting by bicycle more because there are more lanes and paths. Alternatively, because people are commuting by bicycle, the city is building more bike lanes and paths. Both relationships may be occurring to varying degrees in each city. But, as Nelson and Allen state, "This analysis confirms the hunches of public policy makers that at least some, but perhaps not an inconsequential number, of commuters will be responsive to the bicycling option if only it were made available" (*9*, p. 82). The range in rates of bicycle commuting among the 43 cities indicates that improvements can be made. However, bicycle lanes and paths alone are not likely to increase bicycle commuting. Bike lanes and paths need to connect popular origins and destinations, greater efforts should be taken to educate commuters about bicycling as an option, and commuters need adequate and safe parking at work (*4, 5*).

Additional research could overcome some of the limitations of this analysis. For example, our data were collected at the city level. A disaggregate analysis examining individuals and their proximity to bike lanes and paths may shed more light on the relationship between proximity and propensity to bicycle. Socioeconomic variables, such as income and age, might be significant at the disaggregate level. This type of analysis is possible when the Census releases data at the micro level—the public use micro sample (PUMS). Although C2SS PUMS data are available, the sample does not list the city of the household or person. In addition, the sample includes only 727 bicycle commuters, compared with 150,000 people commuting in personal vehicles. The data do include weighting factors to help reflect the data to the population as a whole. These weighted data do indicate that there are differences between cyclists and other commuters. For example, 82% of the bicycle commuters were male, and 21% were students, compared with 54% and 11% of all commuters, respectively. Bicycle commuters had lower incomes than did vehicle commuters. Only 31% of the bicycle commuters had children of their own at home, compared with 42% of all commuters. This finding may indicate that commuting parents are less likely to use bicycles because they also need to transport children. It may also indicate that cyclists are more likely to be students. Thirty-five percent of bicycle commuters lived in homes built before 1950, compared with 21% of all commuters. This finding may indicate that people living in older neighborhoods, which are more likely to have a grid street pattern, are more likely to bicycle. However, additional statistical analysis to control for other variables, such as density and income, is necessary before clear conclusions can be drawn.

Two limitations of the data involve the dependent variable—the percentage of workers that commute by bicycle. First, commuting is only one of many trip purposes. The BTS data as described indicate that more people bicycle to run errands than to commute. Personal travel surveys, such as the Nationwide Personal Transportation Survey (NPTS, now called the Nationwide Household Travel Survey) and regional surveys, would provide data on bicycling for all trip purposes. However, the NPTS does not include a large enough sample to analyze individual cities. Regional travel surveys could be used, but they are conducted at different times (ranging from every 5 to more than 10 years) and employ different methods. One advantage of the Census and C2SS is the consistency in data collection methods and that the data are all for the same year.

The second limitation pertaining to the dependent variable is that the Census asks how the person usually got to work the previous week. Therefore, only regular bicycle commuters are captured in the data. Someone who rides a bike 1 or 2 days a week will not be listed as a bicycle commuter. For this reason, some bicycle advocates feel that the Census systematically undercounts cyclists. Again, a regional or citywide travel survey could overcome this limitation. Such surveys usually involve a 1- or 2-day travel diary. With a large enough sample, occasional cyclists will be included in the data.

Additional research could more clearly explain the relationship between cycling and infrastructure by including additional variables. For example, bicycle commuting may be correlated to the distance of travel, which is not collected by the Census Bureau. In addition, changing the level of analysis (aggregate versus disaggregate) would allow for the use of variables such as sex, which do not vary by city significantly. Before-and-after studies and time-series data may help explain the direction and significance of causality.

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