

BIKING TO WORK IN AMERICAN CITIES:  
THE EFFECT OF FEDERAL INFRASTRUCTURE FUNDING

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By

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**ABSTRACT**

Prior studies have shown that the provision of bike paths, bike lanes, and other types of bicycle-specific infrastructure is positively correlated with bicycle commuting rates in U.S. cities. This is the first study to examine the effect of federal funding for this infrastructure on urban bicycle commuting rates. Using OLS regression, this analysis models bicycle commuting rates as a function of federal spending, population density, gas price, year, and geographical location in the 51 largest cities in the United States during 2007, 2009, and 2011. The results indicate that per capita federal infrastructure spending has a positive, statistically significantly relationship with bicycle commuting, while total federal infrastructure spending does not, and that each additional dollar of bicycle and pedestrian infrastructure spending per capita will increase a city's bicycle commuting rate by 0.047 percentage points, on average and holding other factors constant. These findings suggest that federal bicycle and pedestrian infrastructure funding is most efficient when it is allocated to cities in amounts relative to their populations, but this is not evident in the sample. The analysis also estimates a statistically significant 2-percentage point increase in bicycle commuting rates in America's largest cities in 2009, at the peak of a period of recession, suggesting that commuter mode choice is sensitive to economic hardship.

For Brandon, my favorite person to ride bikes with,  
and the many others whose help and good humor  
made the research and writing of this thesis possible:

Gurkan Ay  
Ashley Begley  
Mary Jane Breinholt  
Raif Can  
Carolyn Hill  
Shinling Lim  
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Thank you.

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## 1. INTRODUCTION

“It is by riding a bicycle that you learn the contours of a country best, since you have to sweat up the hills and can coast down them. ... Thus you remember them as they actually are, while in a motorcar only a high hill impresses you, and you have no such accurate remembrance of country you have driven through as you gain by riding a bicycle.”  
—Ernest Hemingway (White 1967, 364)

Transportation policies that promote “active commuting,” or encourage people to walk or ride bicycles to and from work and school, are becoming more popular in the United States. A closer look at some other U.S. trends helps explain why.

- *Obesity rates are rising.* According to the Centers for Disease Control and Prevention, nine states had obesity rates in excess of 30 percent in 2009, and obesity now affects 17 percent of all American children (CDC 2010 and 2012).
- *Traffic congestion has persisted or worsened in several major U.S. urban areas.* One estimate put the cost of congestion in 2011 at \$121 billion, or \$818 per commuter, a \$1 billion increase over 2010 (Texas A&M 2013).
- *Concerns about climate change are becoming more real.* Transportation accounts for about a third of U.S. greenhouse gas emissions (DOT 2013), and total vehicle miles traveled continue to increase (Rodrigue 2013).

Cities are looking for creative, cost-effective solutions to these problems, and getting more people to trade car trips for bike trips seems to be a logical one. Prior studies have shown that bicycle infrastructure – e.g. signage, dedicated bike paths, on-street bike lanes, and public bikesharing programs – is positively correlated with commuter choice to bike to work (Buehler

and Pucher 2011). Over the past two decades, the federal government has provided more than \$8.5 billion in taxpayer-funded grants to states to build bicycle and pedestrian infrastructure. But MAP-21, the most recent comprehensive surface transportation legislation, has changed the way this funding is designated, spreading a smaller pool of funds across more programs and raising questions about the federal government's long-term commitment to funding bicycle and pedestrian infrastructure.

Given that bicycle commuting is good for people and the environment, and is favored as public policy by multiple levels of government, it is important to understand the effectiveness of policy interventions to support it, particularly in the face of uncertainty about long-term funding availability. It is clear that infrastructure funding drives the physical creation of bike lanes. But how does it affect actual commuting behavior? Does the amount of funding that the government dedicates to building bicycle and pedestrian infrastructure have an effect on individual commuters' preference for biking to work?

To answer this question, I analyzed bicycle commuting rates as a function of federal spending on bicycle and pedestrian infrastructure in the 51 most populous cities in America in 2007, 2009, and 2011. The results show a positive, statistically significant relationship between per capita levels of federal funding and bicycle commuting rates, when controlling for other factors that would affect a city's bicycle commuter count. Section 2 of this paper provides background on bicycle commuting in the U.S., the role of infrastructure in getting people to bike to work, and the history of federal funding for this infrastructure. Section 3 reviews the social science literature on infrastructure and bicycle commuting. Section 4 discusses basic conceptual frameworks for modeling transportation demand. Section 5 explains the data and methods used

in the analysis. Section 6 presents empirical findings. Section 7 discusses the policy implications of my results and presents ideas for future research.

## **2. BACKGROUND**

On October 5, 2009, President Barack Obama signed Executive Order 13514, establishing an Executive Branch commitment to creating a “clean energy economy.” Section 2(b) recommends that federal agencies make “accommodations for transit, travel, training, and conferencing that actively support lower-carbon commuting and travel by agency staff,” as a strategy to reduce transportation-related greenhouse gas emissions (White House 2009). In February 2013, U.S. Department of Transportation (DOT) Secretary Ray LaHood told a gathering of transportation planning officials that the Federal Highway Administration, embedded within his agency, intended to develop its own standards for bicycle and pedestrian safety for the first time in history (Snyder 2013a).

LaHood, a long-time supporter of bicycle and pedestrian infrastructure, wrote in a 2010 policy statement that investment in bike lanes and paths “can help meet goals for cleaner, healthier air; less congested roadways; and more livable, safe, cost-efficient communities,” and that “walking and bicycling provide low-cost mobility options that place fewer demands on local roads and highways” (LaHood 2010, 1). Furthermore, LaHood made plain the important role of states and cities in implementing projects that best suit their individual needs:

“DOT recognizes that safe and convenient walking and bicycling facilities may look different depending on the context — appropriate facilities in a rural community may be different from a dense, urban area. However, regardless of regional, climate, and

population density differences, it is important that pedestrian and bicycle facilities be integrated into transportation systems. While DOT leads the effort to provide safe and convenient accommodations for pedestrians and bicyclists, success will ultimately depend on transportation agencies across the country embracing and implementing this policy.” (LaHood 2010, 1)

While non-binding, these federal policy actions reflect a growing political consensus, mainly among progressives, that mode shares other than driving are important and should be supported by all levels of government. Rep. Earl Blumenauer, a Democratic congressman from Oregon, addressed the National Bike Summit in Washington, DC, in 2009, after biking to it from his Capitol Hill office. Blumenauer lamented the “wasted space” along Pennsylvania Avenue and suggested it become a bike lane. During similar remarks at the 2013 National Bike Summit, Blumenauer shared a different story: “Remember four years ago, I talked about risking my life on Pennsylvania Avenue. And I talked from a podium not unlike this and said, ‘Maybe we could just put bike lanes on Pennsylvania Avenue.’ Some of you clapped; others of you said, ‘I agree, but not in my lifetime.’ [Four] years later: It’s there, it’s a fixture, it matters to people. And it’s part of the renaissance in our nation’s capital” (Snyder 2013b).

Blumenauer was referencing the Pennsylvania Avenue “cycle track,” a two-way bicycle lane separated from traffic, that runs down the middle of Pennsylvania Avenue and connects the U.S. Capital Building to another cycle track along 15<sup>th</sup> Street NW. According to a report released by the DC Department of Transportation, the city’s cyclist count increased 200 percent after the cycle tracks were installed. Ninety percent of the people who used them said they felt safer because of the new lanes (Parks et al. 2012).

Like Washington, DC, other cities are investing in bicycling infrastructure. New York City, under the leadership of Transportation Commissioner Janette Sadik-Kahn, has aggressively

pushed to build more bike lanes and increase cyclist safety. In 2011, Sadik-Kahn said her city, and others, couldn't "wait for Washington" – meaning Congress and the President – to decide that bicycle and pedestrian infrastructure improvements were worth more federal support (Snyder 2011). Indeed, most communities know what types of infrastructure will work best for them, and are taking actions to build them. Municipalities in California, Florida, Oregon, North Carolina, Minnesota, and Illinois, among other states, have adopted "Complete Streets" policies, directing city planners to "routinely design and operate the entire right of way to enable safe access for all users, regardless of age, ability, or mode of transportation" (Smart Growth America 2010).

These ways of thinking about who uses city streets – and how they use them – defy decades of automobile-centric transportation planning, which largely disregarded the importance of making alternative transportation choices more safe, accessible, and convenient. The remainder of this chapter will situate these kinds of policies within the greater universe of commuting modes and U.S. transportation finance policy. I will explore bicycle commuting trends, how bicycle commuting compares to other commuting modes, and how pro-cycling policies have potential to impact individuals and society. I will also discuss how the federal government funds bicycle infrastructure, and how this funding may be changing.

## **2.1 Bicycling Commuting in the U.S.**

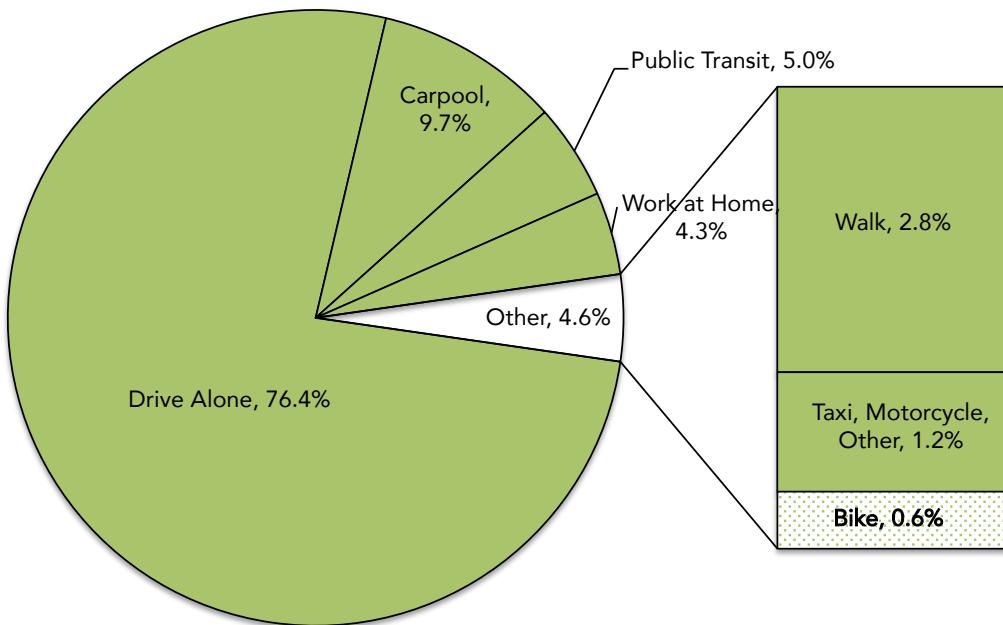
In U.S. cities, bicycling for transportation<sup>1</sup> has been on the rise in recent years. Since 2000, bicycle commuting rates in “bicycle friendly communities,” or BFCs – a designation granted by the League of American Bicyclists if a city or town meets a slate of predetermined bike-friendliness criteria – have increased 80 percent. In non-BFCs, the average increase has been 32 percent (Flusche 2012). Meanwhile, the percentage of children ages 5 through 14 who walk or bike to school has declined from 48 percent to 13 percent since 1969, largely supplanted by car trips (NCSRTS 2011). Programs like Safe Routes to School, which provides funds to communities for projects that make it safer for kids and their families to walk and ride bikes to school, are trying to reverse this trend.

Even though it has been estimated that half of all trips taken in the U.S. could be traveled on a bike in 20 minutes or less, Americans show an overwhelming preference for making these trips in their cars (MacRhodes 2011). Getting to work is no exception. As seen in Figure 1, more than 76 percent of U.S. workers over 16 commuted to work in 2011 by driving alone. The second most popular mode share was carpooling (9.7 percent). Bicycle commuters are the smallest group (0.6 percent). Almost twice as many people report taking a taxi or motorcycle to get to the office (1.2 percent) than biking. Constraining the population to workers in urban areas would likely boost the share of modes like walking, biking, and taking the bus or subway, and reduce the share of drivers.

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<sup>1</sup> This research focuses on bicycling as transportation to work or school, not recreational bicycling (e.g. specifically for fun or exercise).

**Figure 1. Aggregate U.S. Commuter Mode Shares, 2011**



Among all U.S. workers age 16 and older in 2011, bicycle commuters represented the smallest share (0.6 percent) of overall commuters. “Driving alone” represented the highest share, more than three-quarters of all commuters. Source: U.S. Census Bureau American Community Survey.

There are several reasons why the bicycle commuting rate is not higher. First, the distance between work and home has grown since the early 20<sup>th</sup> century. Land use policies that increase the separation of residential and commercial areas have made commuters more dependent on cars to get from home to work and recreation at ever-increasing distances (Cervero 1996). In addition, the increase in property and land values in densely populated urban areas, where many job opportunities are located, has pushed many people to cheaper housing in suburbs, lengthening commute times and distances and reinforcing automobile dependence. Between 1990 and 2000, the average one-way commute time of American workers increased

from about 22 to 26 minutes; in 2009, it was around 25 minutes (McKenzie and Rapino 2011).

Working from home has also increased across all sectors since 2005 (Telework Research Network 2013).

There may also be a cultural preference for driving among Americans. This is certainly a stereotype, supported by the prevalence of cars and trucks on American roads; the history of the automobile and how U.S. policy led it to dominate all other modes during planning and construction of the Interstate Highway System; and the large number of short trips made by car, even though in many parts of the country they could be cheaply and quickly made with other modes. Other cultures do not necessarily share these values. In 2009, less than 10 percent of native-born American commuters carpooled to work, while 16 percent of non-native commuters carpooled. In addition, non-native commuters used public transportation at twice the rate of native-born commuters. The U.S. Census Bureau suggests that this may have less to do with cultural preferences and more to do with socioeconomic trends, however, as non-native commuters were more likely to have incomes at or below the poverty line and/or to live in families that did not have access to a car (McKenzie and Rapino 2011).

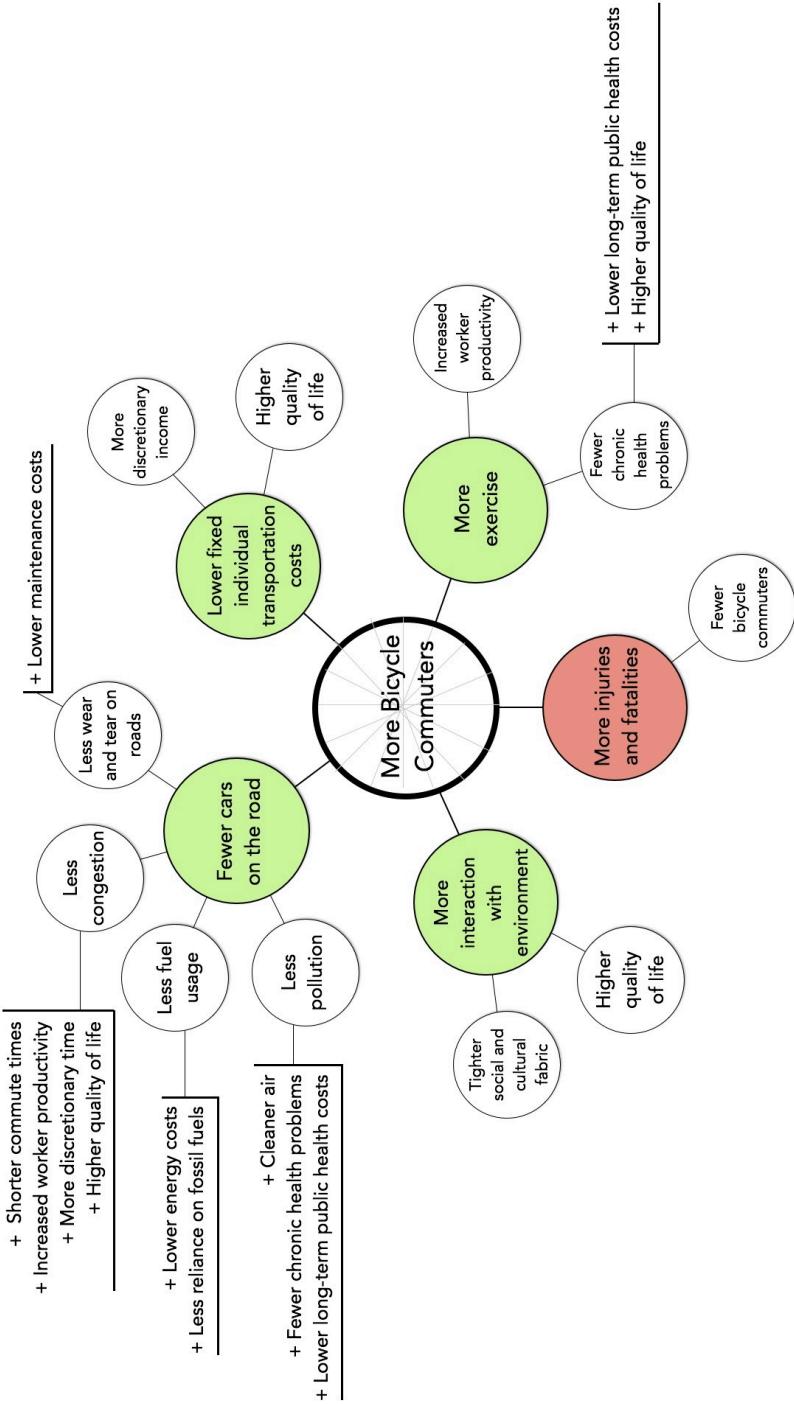
Another reason why bicycle commuters are scarce is that existing built environments do not provide safe, accessible infrastructure for their use. Roads in many urban and rural areas are planned specifically for ease of use by automobiles. A growing body of literature, discussed in Section 3, has shown a link between access to bicycle infrastructure and higher rates of bicycle commuting.

## 2.2 Policy Impacts of Bicycle Commuting

Bicycle commuting has many benefits. In general, increasing transportation choices gives people more flexibility and freedom to get around in time- and cost-efficient ways. More choice also increases overall system efficiency by more evenly distributing commuters among mode shares. It also increases transportation equity, particularly considering that driving and car ownership are not accessible to young, old, disabled, or low-income people. Beyond these general benefits, getting more people to use bicycles for transportation could also be a cost-effective way to address a wide variety of non-transportation policy problems. Figure 2 maps these plausible policy impacts and how they may have ripple effects on individuals, governments, the private sector, and society at large.

**Fewer cars on the road.** In theory, more bike commuters would lead to fewer cars on the road. This would reduce traffic congestion – benefitting all commuters, including those still in cars, who would enjoy shorter travel times – and result in less fuel usage, reducing individual transportation costs and society’s overall dependence on fossil fuels. Furthermore, it would reduce costly wear-and-tear on roads and highways caused by heavy cars and trucks. The American Society of Civil Engineers estimates that America’s decaying roads cost \$32 billion in annual travel delays and \$97 billion in annual vehicle operating costs (Halsey III 2011). In 2010, the American Association of State Highway and Transportation Officials (AASHTO) estimated that between now and 2025 the U.S. will fall \$189 billion short of funds needed to maintain urban roads, and \$375 billion short of being able to “significantly improve” them (AASHTO 2010).

**Figure 2. Map of Impacts of Bicycle Commuting Policies**



As policies encourage more people to bike to work, five broad and plausible impacts – represented by the colored circles – result.  
Each has sub-impacts of its own, represented by the smaller white circles and accompanying text, where appropriate.

**Environmental and public health gains.** Other benefits, like environmental quality and public health, are closely related. Fewer vehicle miles traveled means fewer carbon emissions – a benefit to society as a whole – and cleaner air, a benefit to people who live in urban areas or suffer from asthma and other respiratory ailments.

Active commuters get more exercise, reducing the risk of obesity and associated chronic diseases. Daily car commuting has been linked to weight gain, even if car commuters engage in regular recreational exercise (Kennedy 2013). Bauman, Allman-Farinelli, Huxley, and James (2008) suggest that, given 60-90 minutes of daily exercise is needed to maintain a healthy weight, it may be unrealistic for most people to get enough exercise through leisure-time activities like recreational cycling or going to the gym. Active transportation could fill the gap.

Employers also benefit from healthier employees. Bicycle commuters have been shown to take fewer sick days and are more alert, healthy, and productive workers than their non-active commuting peers, most likely as a result of increased physical fitness (McLaren 2010).

**Cost savings.** Many impacts of bike commuting policies lead to saving money. Car ownership is expensive. The average cost of owning and operating a car in the U.S. in 2012 was \$8,946<sup>2</sup> (Pritchett 2012). People who trade more car trips for bike trips will also spend less money on gasoline. More ambitious urban commuters could situate themselves so as to not need a car at all, eliminating monthly insurance payments and routine car maintenance costs. Greater cost savings could result from the public health impacts, reducing health care spending for both individuals and employers.

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<sup>2</sup> Estimate assumes ownership of a sedan and travel distance of 15,000 miles per year.

**Higher quality of life.** Less tangible, but certainly plausible, benefits involve higher quality of life for individuals. Less time spent in bumper-to-bumper traffic means more discretionary time to spend with one's family or on other pursuits, a benefit available even to drivers who can't, or choose not to, bike to work, but still enjoy reduced overall traffic congestion. More time spent on a bicycle, observing and interacting with the street-level community, could lead to higher appreciation of one's city and its neighborhoods. As Jane Jacobs observed, "Most of [public interactions with strangers are] ostensibly utterly trivial but the sum is not trivial at all. The sum of such casual, public contact at a local level – most of it fortuitous, most of it associated with errands, all of it metered by the person concerned and not thrust upon him by anyone – is a feeling for the public identity of people, a web of public respect and trust, and a resource in time of personal or neighborhood need" (Jacobs 1961, 56).

It is also plausible that as the number of bicycle commuters increases, the incidence of cycling-related injuries and fatalities may rise. American roads and driving culture do not expressly support regard for bicyclists, although bikes are considered vehicles and are legally allowed to share the entire road with cars in all 50 states and the District of Columbia (League of American Bicyclists 2013a). Lack of bicycle infrastructure is one major issue. Minimal public education around driver-cyclist interactions is another. Drivers are not taught or encouraged to look before opening their car doors to keep from clipping bicyclists and possibly throwing them into traffic, a common danger. Meanwhile, many cyclists follow traffic laws selectively, or not at all, assuming they even know that road rules – and rights – apply to them. As a result, dominant themes in the driver-cyclist relationship are hostility, disrespect, and dehumanization on both sides. Research has shown this hostility could be exacerbated by emotional and psychological

assumptions formed about other kinds of commuters, based on isolated experiences with only one member of another group (Saksa 2012). Others frame the conflict as a clash of values among elites; on one side are people who see bicycles as utilitarian and environmentally friendly, and on the other are drivers who see them as “childish” and “un-American” (O’Rourke 1987).

Given the potential benefit that bicycle transport could provide low-income and underserved populations, and the high risk of injury or death posed by driver-cyclist collisions, these cultural misunderstandings underscore why any policy to encourage active commuting, by bicycle or otherwise, should not exist in a vacuum. Ideally, it should be accompanied by infrastructure modifications, public education campaigns, and robust enforcement of existing laws.

## **2.3 Funding for Bicycle and Pedestrian Infrastructure**

Bicycle infrastructure – for the purposes of this paper, “infrastructure” – includes off-road bike paths, on-street bike lanes or cycle tracks, or “sharrows” (arrows painted on roads to designate cyclists’ right to share roads with drivers), to name some common examples. Infrastructure could also take more innovative forms. Some cities, including Washington, DC, and New York City, have invested in bike-sharing programs that allow paying members to rent bikes for short trips. Making these kinds of infrastructure available is one way to make city cycling safer, more visible, and less intimidating, a major barrier for many people who consider the option of riding a bike for transportation (BTS 2004).

Financing bicycle infrastructure is also an extremely cost-effective way to promote bicycle commuting. Portland, Oregon, Mayor Samuel Adams once told a reporter that his city,

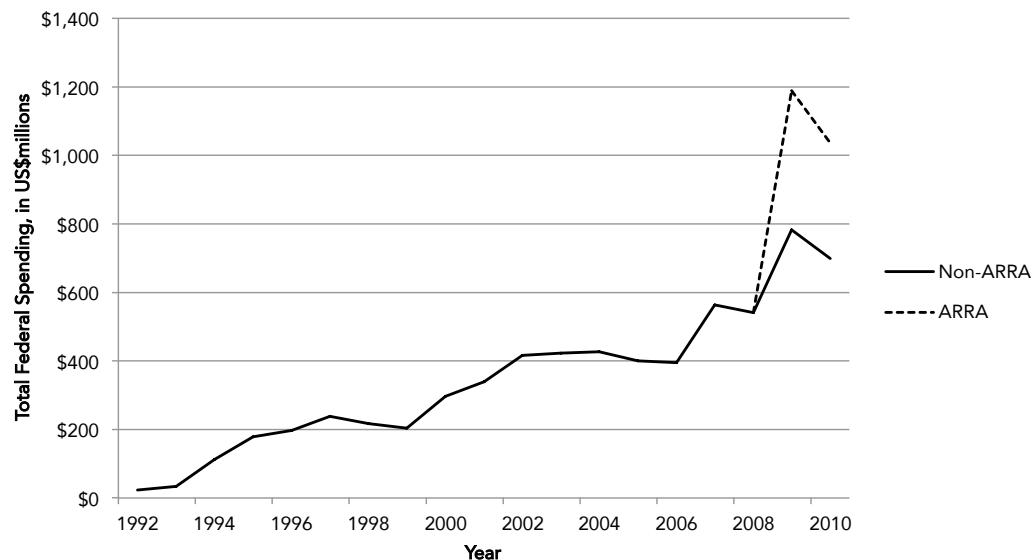
one of the nation's most bike-friendly places, built an entire city-wide bicycle transportation network for \$60 million, the same cost to build one mile of a four-lane highway (Politifact.com 2011). Unlike highways, bike projects are smaller and can be completed in less time, so the investment payback period begins sooner. In many places, bike lanes can be "built" simply by adjusting traffic patterns and painting stripes on existing roads.

Bicycling infrastructure projects also create jobs. Garrett-Peltier (2011) analyzed the job-creation impacts of 58 road, bicycle, and pedestrian projects in 11 U.S. cities, finding that bicycle projects were the best for the money. Every \$1 million invested in bicycle infrastructure created 11.4 jobs, compared to 10 for pedestrian projects and 7.8 for road-only projects. A study of bicycling's impact on the local economy in Portland, Oregon, found that every \$1 million invested in paved bicycle or multi-use trails created 65 jobs, whether through construction or spurring economic development around finished projects (Blumenauer 2009).

## **Federal Funding Policies**

Since 1992, cities and states have received varying amounts of federal funding for bicycle and pedestrian infrastructure. The Transportation Enhancements (TE) program, created under the Intermodal Surface Transportation Act (ISTEA) of 1991, has been a major source. TE provides a dedicated pool of federal funding, carved out of the U.S. Highway Trust Fund, for bicycle and pedestrian infrastructure in cities and towns across America. The TE program was extended in 1998 via passage of TEA-21, the Transportation Equity Act for the 21<sup>st</sup> Century, and in 2005 by passage of SAFETEA-LU (Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users).

**Figure 3. Annual Federal Spending on Bicycle and Pedestrian Infrastructure, 1992–2010**



The solid line represents annual federal bicycle and pedestrian spending in millions of dollars across all programs since 1992, when TE was created as part of the Intermodal Surface Transportation Efficiency Act (ISTEA). The dotted line represents the amount of bicycle and pedestrian spending in 2009 and 2010 that was authorized as part of the American Recovery and Reinvestment Act (ARRA). Source: Federal Highway Administration.

The TE program has funded more than \$8.5 billion worth of bicycle and pedestrian infrastructure over its lifetime (Slone 2012). Other federal grant programs, like Congestion Mitigation and Air Quality Improvement (CMAQ), have provided funding for bicycle and pedestrian infrastructure as way to reinforce the link between transportation planning and air quality (FHWA 2013). The Safe Routes to School Program, institutionalized by Congress in 2005, also funds bicycle and pedestrian infrastructure. Figure 3 graphs annual federal funding for bicycle and pedestrian infrastructure across all programs between 1992 and 2010.

Bicycle and pedestrian infrastructure funding amounts increased substantially during 2009 and 2010, following the passage of the American Recovery and Reinvestment Act

(ARRA). ARRA's primary goal was to create jobs and stimulate economic growth, not to increase bicycle commuting rates. But transportation infrastructure projects are seen as "shovel ready" – in other words, once money is dedicated, people can get to work relatively quickly. Following ARRA's passage in Congress, state transportation departments committed more than \$734 million of ARRA funding to bicycle and pedestrian infrastructure projects (League of American Bicyclists 2013b). More than half of the grants from a second economic stimulus program, TIGER (Transportation Investment Generating Economic Recovery), funded projects that included "significant non-motorized components" (Slone 2012).

Bicycle and pedestrian infrastructure represents a small fraction of overall transportation spending. Under MAP-21 – the most recent surface transportation bill, signed into law in July 2012 – TE and other bicycle and pedestrian funding programs were consolidated under an umbrella program called Transportation Alternatives (TA). Total TA funding for fiscal year 2013 is \$809 million<sup>3</sup> (FHWA 2012). This is only 2 percent of \$37 billion in total projected transportation spending. Figure 4 illustrates how this funding flows from the federal government to states and cities.

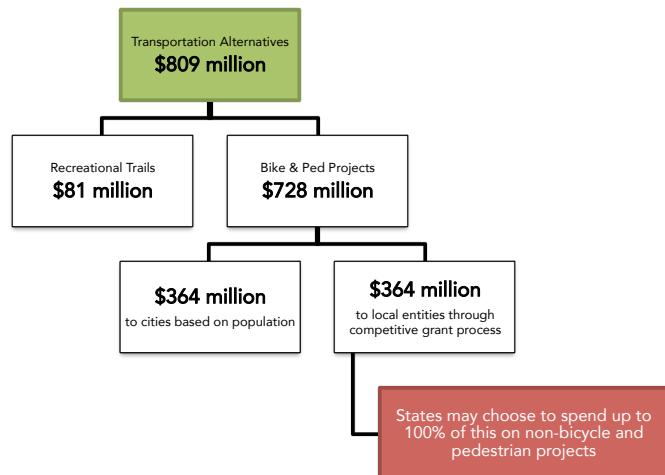
### **Vulnerability of Federal Spending Programs**

The future of federal funding for bicycle infrastructure is not clear. Figure 5 shows the breakdown of total MAP-21 allocations for 2013. Under MAP-21, current bicycle and pedestrian

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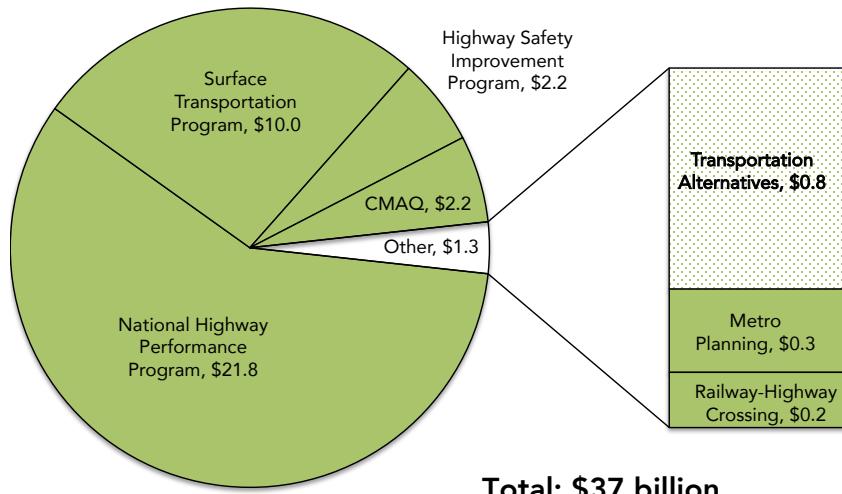
<sup>3</sup> \$809 billion is the aggregate amount; states receive portions based on prior funding levels (FHWA 2012).

**Figure 4. FY2013 Bicycle and Pedestrian Funding Under MAP-21**



Each state's Department of Transportation (DOT) receives a formula-determined share of money for bicycle and pedestrian projects from a total pot of \$809 million. After Recreational Trails funding has been set aside, state DOTs distribute half of the remaining funding among cities, based on population. The remainder is made available for local projects through a competitive grant process. States may choose to divert up to 50 percent of their funds for bicycle and pedestrian infrastructure to other transportation projects (Advocacy Advance 2013).

**Figure 5. MAP-21 Pre-Formula Funding Allocations, FY2013\***



Under MAP-21, bicycle and pedestrian funding programs are consolidated under the Transportation Alternatives program, which represents 2 percent of the \$37 billion in federal spending authorized for transportation projects in fiscal year 2013 (Federal Highway Administration 2012).

\*in billions of dollars; figures do not add exactly to \$37 billion, due to rounding

infrastructure spending through the TA program is 33 percent lower than it was in 2012, under SAFETEA-LU. Furthermore, a new provision in MAP-21 allows states to divert up to 50 percent of their annual bicycle and pedestrian infrastructure funding to other types of transportation projects. Previously, the cap for “opting out” was 10 to 15 percent (Snyder 2012a). If all states took advantage of this opt-out in its entirety, post-2012 bicycle infrastructure spending would be significantly reduced.

What is clear is that the U.S. Highway Trust Fund – the principal source of all federal infrastructure funding – is running out of money. The fund has relied for decades on federal gas tax revenue, which has steadily declined as cars have become more fuel-efficient. Furthermore, as a cents-per-gallon tax, the gas tax has not kept pace with inflation. The Congressional Budget Office predicts that cash infusions from general government revenue will keep the fund solvent through 2014, when MAP-21 expires (Puro 2013). After that, the picture is murky. Prior transportation bills, like ISTEA, were authorized for much longer periods, providing more certainty for states, cities, and bicycling advocates about the state of future funding. A recent survey found that 60 percent of mayors in the U.S. think a lack of funding for bicycle and pedestrian projects is a major issue that stands in the way of increasing bicycle commuting rates (U.S. Conference of Mayors 2011).

Given the possibility of large departures from established bicycle infrastructure funding policy in the future, it is important to understand how recent historical federal infrastructure spending has impacted bicycle commuting rates in the U.S. That is the goal of this study.

### **3. LITERATURE REVIEW**

Prior studies focus on the empirical link between bicycle commuting rates and bicycle infrastructure, without specific regard to the effect of infrastructure funding. I attempt to build on this work by analyzing the relationship between bicycle commuting and funding for bicycle infrastructure. Although the federal government has historically used formulas to distribute much of its transportation infrastructure funding among states, and states use formulas to distribute a portion of what they receive among cities, some funding is allocated through competitive grant processes, and federal-level politics plays a large role in all funding policy decisions. Therefore, there are likely unique and unobserved forces – e.g. politics, enthusiasm for cycling, or strong advocacy – that determine a city’s funding levels and would not necessarily determine infrastructure type or quantity.

Some studies of infrastructure have found a “if you build it, they will bike” phenomenon. Buehler and Pucher (2011) observed a strong, positive relationship between bicycle commuting rates and amounts of bicycle infrastructure present in the 90 largest U.S. cities, when controlling for safety, weather, gas price, sprawl, and the amount of students and households without cars. Earlier research by Dill and Carr (2003) found similar results in a smaller sample of 35 cities, when controlling for occupation, availability of other transportation modes, weather, land use, socioeconomic status, and public support for bicycling. Bicycle transportation research is a relatively new discipline, however, and a lack of data exists to support it. As a result, findings of most multiple-city studies come with caveats.

A growing body of research focuses on single cities to learn about how cyclists make route choices within a network that includes bicycle infrastructure. In Minneapolis, researchers

found that bicyclists, on average, traveled 67 percent longer than necessary in order to include a particular bike trail on their route (Krizek et al 2007). A 2008 study in Portland used GPS technology to trace the riding and route choice habits of 164 adult cyclists. The results showed that bicyclists most often rode for utilitarian purposes, rather than recreation, and that more than half (52 percent) of the miles rode in the study took advantage of existing cycling infrastructure. Furthermore, the researchers found that the cyclists would often go out of their way – adding unnecessary miles to their trips – to use cycling infrastructure and travel on low-traffic streets (Dill and Giesebe 2008).

Other studies (Parkin et al. 2008; Douma and Cleaveland 2008) find that although “build it and they will bike” applies in some cities, contextual factors – like land use policies, publicity about new infrastructure, and overall connectivity of a city’s bike lane network – are crucial to the success and widespread use of new bicycle facilities. Cities with “a supportive environment,” including the funding and political will to build specialized infrastructure, are more likely to have higher rates of bicycling for transportation purposes (Dill 2009, 105). Pucher, Buehler, and Seinen (2011) point out that the cities with the most growth in cycling have not relied on bike lanes alone, but have consciously created comprehensive packages of programs, advocacy, and infrastructure.

The literature links infrastructure with other key cyclist preferences, including safety, and shows that it reduces the fear that inexperienced cyclists face when considering the prospect of biking in motor vehicle traffic. The availability of bike infrastructure is highly correlated with both rates of biking and cyclists’ perceptions of personal safety while biking. Hunt and Abraham (2007) found that time spent cycling in mixed traffic is perceived as more arduous than time

spent cycling on bike lanes and bike paths. A 2004 survey by the Bureau of Transportation Statistics found that 17 percent of people who rode bikes in places with no bike paths or lanes said they had felt threatened or unsafe at least once in the prior month. Where bike lanes and paths were available, however, only 10 percent of respondents said they had felt threatened or unsafe (BTS 2004). Buehler and Pucher (2011) found that a 10 percent increase in the cyclist fatality rate is associated with 3.7 percent fewer bicycle commuters for every 10,000 people. Park et al. (2011) found that the availability of segregated bike lanes shortened the time it took for recreational cyclists to become commuter cyclists.

Many studies have studied the effects of biking on health, and the effects of infrastructure on cycling rates. De Hartog, Johan, Boogaard, Nijland, and Hoek (2010) found that, on average, the increased physical activity from switching commuting modes from driving to cycling provided substantially higher health benefits than costs from increased exposure to air pollution. In cities with infrastructure sufficient to provide a safe, convenient transportation network for cyclists, commuters are likely to get their daily recommended level and duration of exercise by biking to and from work and to run errands (Dill 2009).

Generally, the literature indicates that bicycle infrastructure is a good way to get people to make more trips by bike. In turn, people who use bicycles for transportation will enjoy better health and assume reduced risks when sharing the road with cars. If we assume that infrastructure will be built in direct proportion to how much funding is dedicated to it, we must also assume that decreases in funding will result in less bicycle infrastructure, and fewer bicycle commuters. This analysis will aid policy makers in evaluating the decision to increase or decrease funding based on policy goals and expected effects on bicycle commuting rates.

## 4. CONCEPTUAL FRAMEWORK

### 4.1 Transportation Demand Models

In 1955, H. J. Casey developed the gravity model, based on Newton's gravitational law, to estimate the expected number of trips, T, from an origin  $i$  to a destination  $j$ :

$$T_{ij} = \alpha \frac{O_i D_j}{c_{ij}^2}$$

In Casey's model, seen above,  $T_{ij}$  is directly proportional to the number of people leaving one destination ( $O_i$ ) and arriving at another ( $D_j$ ) and inversely proportional to the square of the costs of that travel (Bierlaire 1996, 13). This model recognizes that trips taken are consumer choices made in consideration of supply-side inputs like cost, time, distance, and accessibility. The result is a measure of transportation demand.

In 1996, Landis used this theoretical framework to create a practical model for estimating bicycle infrastructure demand, and, by extension, helping cities and towns make decisions about how to allocate infrastructure funding. Landis's Latent Demand Score (LDS) method uses probabilistic gravity modeling to analyze the proximity and likelihood that an "activity center," such as a public park, would generate new trips in a bicycle network. Using geographic information system (GIS) data and calculations in a spreadsheet, transportation planners can use the model to generate latent demand scores for individual road segments. Segments with high scores are considered to have high latent demand – that is, the highest potential for use by bicyclists if infrastructure is added – and would be considered a high priority for funding (FHWA 1999).

The LDS can be coupled with a supply-side method, known as the Interaction Hazard Score (HIS), to evaluate the quality of existing roadways. This is an important control factor, as the literature indicates that poor quality of existing infrastructure would deter people from choosing to bike more often. In Landis's framework, which is recommended by a Federal Highway Administration guidebook, roadways with both high LDS scores and low supply-side level of service scores would be considered of highest funding priority (FHWA 1999).

Instead of predicting latent demand, my analysis reinterprets this framework – and borrows from Casey – to model actual demand (the bicycle commuter rate) as a function of federal spending, which influences infrastructure supply.

## 4.2 Hypothesis

I hypothesize that the bicycle commuting rate is directly related to federal infrastructure spending. As more money is allocated to bicycle infrastructure projects in a city, that city's bicycle commuting rate will increase proportionally to funding received, other factors held constant. I expect this relationship because spending is acting as a supply-side measure of, or proxy for, the infrastructure itself, and infrastructure has been linked to higher levels of cycling in at least two prior studies (Buehler and Pucher 2011; BTS 2004).

Furthermore, funding is an expression of political priority. When funds are allocated to a particular policy goal, that goal is seen as sanctioned and worthy of achievement. When funds are lessened or taken away from a policy objective, its supporters feel a loss of both morale and momentum. I hypothesize that higher amounts of bicycle infrastructure funding will result in more infrastructure, which will raise awareness about bicycling and send signals to communities

that bicycling is important, leading to more enthusiasm for it. When less funding is awarded, less infrastructure is built, and a community's awareness and valuation of bicycling will decrease. In turn, bicycle commuting rates will stagnate or decline.

## **5. DATA AND METHODS**

The ideal data set for this analysis would be a panel including all major metropolitan areas of the United States with observations since the early 1990s, cataloguing populations, number of workers, and the percentage of workers who commute to work by bike, as well as detailed amounts of federal funding received by each metropolitan area for bicycle and pedestrian infrastructure each year. This ideal data set would also include key control variables such as population density, average commute times, average gas price, and measures or indicators of existing bicycle infrastructure.

Unfortunately, this ideal data set does not exist in the wild. But I was able to approximate it by gathering relevant data from separate sources. These sources, as well as the variables and their summary statistics, are described in detail in the first part of this section. The subsequent parts discuss limitations of the data and how I specified models for my analysis.

### **5.1 Data Sources**

The data originate from three primary sources: the U.S. Census Bureau's American Community Survey (ACS), the Federal Highway Administration (FHWA), and the Energy

Information Administration (EIA). The ACS is an annual survey providing demographic information that local, state, and federal agencies often use when making funding decisions. The FHWA, via its Fiscal Management Information System, provides by request detailed information on programs and funding to states and cities for transportation infrastructure. The EIA is the data and analytics arm of the U.S. Department of Energy. Data were also drawn from the biannual Alliance for Biking & Walking (ABW) City Survey. The ABW is a nonprofit coalition of pedestrian and bicycling advocacy groups. Their survey measures amounts of bicycle infrastructure and local government support for cyclists and pedestrians, and includes data from ACS and FHWA, as well as qualitative data that ABW uses to write its periodic Benchmarking Reports (ABW 2012).

## 5.2 Analysis Sample

My hybrid data set is a panel that includes observations from the years 2007, 2009, and 2011. The unit of analysis is cities. To the extent possible, I wanted to drill down to commuting rates and population numbers within city limits, not within entire metropolitan statistical areas (MSAs), so the city labels in the sample correspond to individual Federal Information Processing Standards (FIPS) city codes used by the U.S. Census Bureau.

My sample is small ( $N = 51$ ). More observations could have plausibly been included had the unit of analysis been states, not cities. But individual commuting mode choice decisions are made on a local level, not a state level. A city can be considered a distinct local unit, while an entire state cannot.

In addition, my sample is not randomly selected. The cities in the sample are the most populous in the U.S. This is partially deliberate – larger cities are likely to have traffic congestion issues, making alternative commuting choices such as walking, biking, and public transportation more attractive (and likely more widely available) to citizens – and partially because this project’s scope and timeline limited me to working with readily available data. The ABW City Survey creators had saved me a great deal of time by already requesting and disaggregating the FHWA funding numbers for the 51 cities that ultimately ended up in my sample.<sup>4</sup> The time periods observed were chosen primarily because they were the only three for which near-complete sets of observations were available for each city in the sample.

Because my sample size was constrained to avoid large amounts of missing data, there are only four missing values. One is a missing bicycle commuting rate observation for Kansas City, Missouri, in 2009, which was not reflected in the ACS data. The other three are missing gas price observations for Washington, DC, in each year in the panel. The EIA data included average gas prices for the 50 U.S. states; not being a state, Washington, DC, was excluded, and I chose not to impute the missing data. The missing values are indicated in the summary statistics table below.

### 5.3 Discussion of Variables

Table 1 displays summary statistics of the key policy and control variables in my sample by year. Each variable is discussed in detail below.

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<sup>4</sup> I confirmed that ABW’s numbers were accurate reflections of actual FHWA data (Douwes 2012).

**Table 1. Summary Statistics of Key Policy and Control Variables**

	Mean	Std. Dev.	Minimum	Maximum	N
<b>Bike commuting rate</b> <i>(percentage)</i>					
<b>2007</b>	0.85	0.86	0.00	3.91	51
<b>2009</b>	1.12	1.12	0.02	5.81	50
<b>2011</b>	1.19	1.22	0.06	6.29	51
<b>Population</b> <i>(thousands)</i>					
<b>2007</b>	918.58	1,222.69	239.12	8,274.53	51
<b>2009</b>	960.82	1,240.12	354.85	8,391.88	51
<b>2011</b>	947.99	1,214.28	360.74	8,244.91	51
<b>Population density</b> <i>(Population per square mile, 1,000s)</i>					
<b>across all years*</b>	5.18	4.55	.97	26.40	51
<b>Total spending</b> <i>(millions of dollars)</i>					
<b>2007</b>	\$1.05	\$1.73	\$0	\$10.05	51
<b>2009</b>	\$3.30	\$5.45	\$0	\$33.85	51
<b>2011</b>	\$2.10	\$2.94	\$0	\$11.11	51
<b>Spending per capita</b> <i>(dollars)</i>					
<b>2007</b>	\$1.29	\$1.78	\$0	\$7.87	51
<b>2009</b>	\$4.86	\$7.31	\$0	\$35.35	51
<b>2011</b>	\$3.21	\$5.27	\$0	\$21.68	51
<b>Average gas price</b> <i>(dollars)</i>					
<b>2007</b>	\$1.44	\$0.05	\$1.38	\$1.59	50
<b>2009</b>	\$1.14	\$0.07	\$1.07	\$1.39	50
<b>2011</b>	\$1.37	\$0.08	\$1.30	\$1.69	50

\*2010 Census Bureau estimates

## **Dependent Variable: Bicycle Commuting Rate**

To create this variable, I took the number of workers age 16 and older in each city who reported commuting by bicycle on the American Community Survey and divided it by the city's total number of workers over 16.<sup>5</sup> The resulting dependent variable, *bike* (from here, referred to as "bicycle commuting rate"), is a percentage, so coefficient interpretations will be percentage point changes, not percent changes in the number of workers who commute by bike.

Bicycle commuting rates in my sample are low, but high relative to the national rate seen in Figure 1. Portland, Oregon, a city well known for its efforts to build a comprehensive network of bike lanes, has the top rate each year (3.91 percent in 2007, 5.81 percent in 2009, and 6.29 percent in 2011), but two-thirds of the 152 observations in the data set are less than 1 percent. However, bike commuters increased in the sample over time. The mean bicycle commuting rate increased from 0.85 percent in 2007 to 1.19 percent in 2011. Because these are small numbers, even fractional percentage point changes in a city's bicycle commuting rate could have a noticeable effect on the total number of bicycle commuters in that city.

## **Policy Variable of Interest: Federal Bicycle and Pedestrian Infrastructure Spending**

To analyze the effect of federal infrastructure spending on bicycle commuting rates, I used FHWA data from the 2012 ABW Benchmarking Report dataset to create two funding variables, *fedbp* and *fedpc*. The *fedbp* variable, referred to from now on as "total spending," is the annual amount of federal funding that was received by cities in the sample across all types of grants and programs that was earmarked specifically for bicycle and pedestrian infrastructure

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<sup>5</sup> These data are contained in Table B08006, "Sex of Workers by Means of Transportation," of the ACS database (U.S. Census Bureau 2011).

projects.<sup>6</sup> It is expressed in millions of U.S. dollars. The *fedpc* variable, referred to throughout this paper as “per capita spending,” is the annual amount of federal funding per person across all grants and programs that was earmarked specifically for bicycle and pedestrian infrastructure projects. It is expressed in U.S. dollars. The two variables are different ways of expressing how much federal money went annually toward building bicycle and pedestrian infrastructure in the cities in my sample.

Total spending varies quite a bit in the sample, both across cities and from year to year. The mean in 2009 (\$3.3 million) is substantially higher than the means in 2007 (\$1.1 million) and 2011 (\$2.1 million), a reflection of the spike in this type of funding that was authorized by ARRA, the emergency economic stimulus bill, in 2009. In each year, several cities in the sample received no funding of this type. The most funding disbursed, \$33.8 million, went to Dallas, TX, in 2009. The lowest non-zero amount, \$19,282, went to Sacramento, CA, in 2007.

I cannot observe factors that may explain the variation in funding amounts from one city to another (e.g., strength of lobbying efforts, or political clout of policy actors), but I expect that there is a direct relationship between funding amounts and infrastructure.

## Control Variables

Many factors affect commuter mode choice. To isolate the effect of funding and to control for other relevant factors, my model includes population density, year, and whether a city is located in Texas or California, two large states that are proportionally overrepresented in the

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<sup>6</sup> The *fedbp* values for 2009 include bicycle and pedestrian infrastructure funding that was authorized by ARRA for 2009. ARRA also authorized a second year of funding in 2010, which is excluded from this study.

sample. Because driving represents such a large share U.S. commutes, I also include a variable to control for the average price per gallon of gasoline. These variables, and their relationship to bicycle commuting rates, are explained in more detail below.

**Population density.** Data for my population density variable (*density*), defined as thousands of people per square mile, come from the 2000 U.S. Census.<sup>7</sup> Year 2000 Census data were the most recent observations available. However, these data do not vary much by year, and I do not expect that population density varied much between 2000 and 2009, or over the short time periods in my sample.

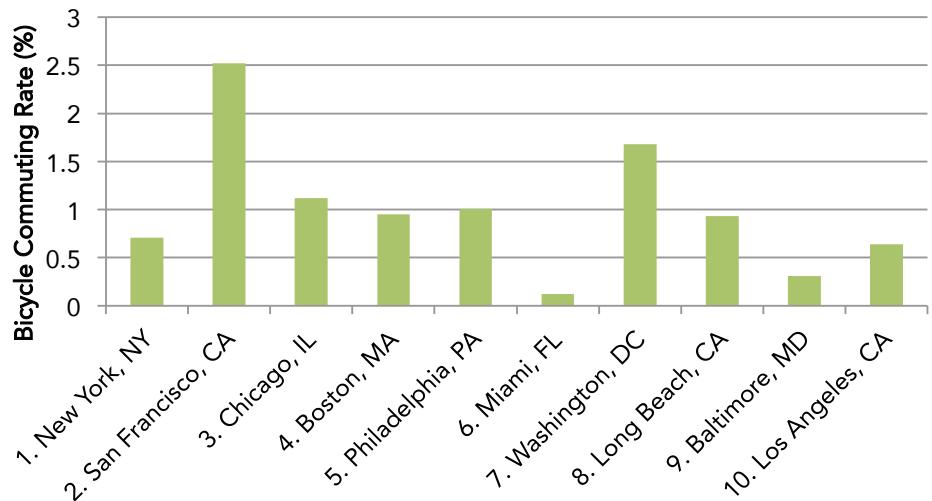
It is important to control for population density, because more densely populated urban areas – where many people live very close together, leading to scarce or expensive parking spaces, traffic congestion, and other disincentives to commute by car – could be expected to have higher rates of biking, walking, and public transit ridership. In my sample, the minimum density is Jacksonville, FL, with just shy of 1,000 people per square mile. The maximum, New York City, has more than 26,000 people per square mile; the next most densely populated city is San Francisco, CA, with 16,634 people per square mile. The sample mean is 5,180.

Population density rankings in the sample track somewhat with bicycle commuting rates. Figures 6 and 7, below, graph the bicycle commuting rates and population densities, respectively, of the cities with the 10 highest rankings of the opposite factor. Although the groups of cities are not identical, the patterns of the graphs are similar, and we can observe a downward sloping trend in both density and commuting rates as the rankings decrease. I expect

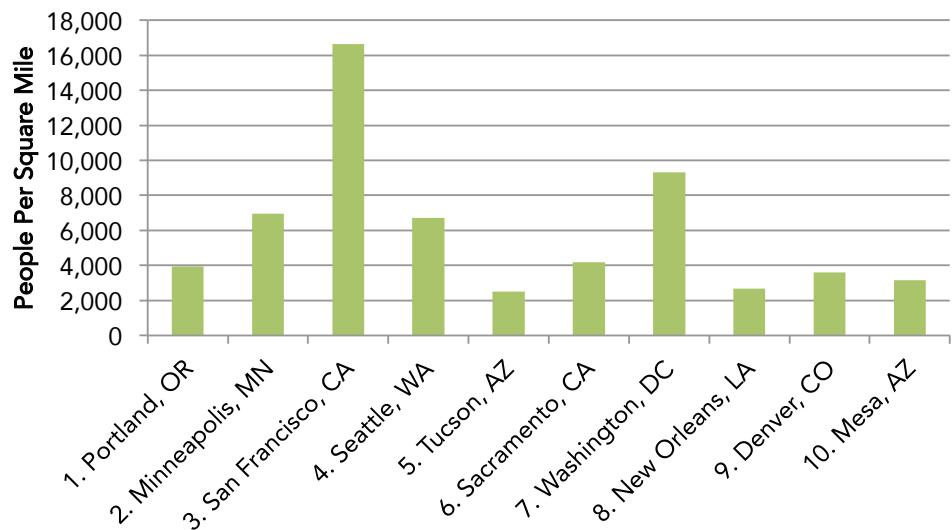
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<sup>7</sup> These data can be found in Census Table GCT-PH1, “Population, Housing Units, Area, and Density: 2000 - State - Place and (in selected states) County Subdivision, Census 2000 Summary File 1 (SF 1) 100-Percent Data” (U.S. Census Bureau 2000).

**Figure 6. Bike Commuting Rates in 10 Most Densely Populated Cities, 2007**



**Figure 7. Densities of Cities with 10 Highest Bike Commuting Rates, 2007**



that population density will have a direct relationship with bicycle commuting rates in my quantitative analysis.

**Real price of gasoline.** The majority of U.S. workers commute by car. I expect that increases in gasoline prices suppress gasoline consumption, and, by extension, lead more workers to substitute other, cheaper modes for driving, possibly including bicycle commuting. Failing to control for this effect would likely bias my funding coefficients. In addition, because my sample includes a period of recession in the United States, including this variable allows me to assess the effect of gas prices on commuter behavior during a time of economic hardship.

City-level data were not available, so I created my *gasprice* variable by taking EIA's state-level monthly weighted average price of gasoline<sup>8</sup> (the total revenue from the sale of gasoline during the reference month divided by the total volume sold, then deflated with a CPI that includes energy prices); calculated the averages for 2007, 2009, and 2011 for each state in my sample; and then assigned the annual state averages to the appropriate cities.

**Year.** In 2007, the U.S. was entering a period of recession. In 2009, the recession was at its peak. In 2011, a slow recovery had begun. The pre-recovery period included policy interventions like ARRA, which greatly – albeit temporarily – increased federal bicycle and pedestrian infrastructure spending. To control for the unique circumstances of these time periods, and to isolate the effects on bicycle commuting rates in the sample, my models include indicator variables for 2009 and 2011. Their coefficients will allow me to compare these years to the pre-recession baseline year of 2007.

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<sup>8</sup> Data available in EIA Table 782, “Survey, Gasoline Prices by Formulation, Grade, Sales Type” (EIA 2011).

**Texas and California.** Of the 51 cities in the sample, seven are in Texas (Arlington, Austin, Dallas, El Paso, Fort Worth, Houston, and San Antonio) and eight are in California (Fresno, Los Angeles, Long Beach, Oakland, Sacramento, San Diego, San Francisco, and San Jose), while all other states in the sample have only one, two, or three (Arizona only) cities represented. I created an indicator variable to flag if a city is in Texas or California to control for this imbalance and isolate any effects it may have. For example, since Texas and California are big states with many Congressional representatives, they are likely already receiving higher amounts of all types of funding, whether by formula, politics, or otherwise.

## 5.4 Limitations of Data

The American Community Survey, one of the few sources of multi-year data on U.S. commuter mode choice, asks respondents how they got to work most often in the prior week. Surveyors only record the most frequently used mode of transportation. Someone who biked to work two days and drove three days, for example, would be considered a driver in the dataset, while someone who biked one mile and then took a bus or train three miles each day would be considered a public transit-taker, whether or not the past week was an accurate depiction of his or her traditional commuting habits. Therefore, the actual number of people who biked to work may be overstated or understated in this data.

In addition, I used ACS 1-year estimates for this analysis. ACS 1-year estimates are less precise than ACS 3-year or 5-year estimates because they examine a smaller sample size and only account for 12 months of data. As such, ACS 1-year estimates serve researchers who are more interested in currency than precision, which holds true here.

The funding data also come with caveats. Bicycle and pedestrian infrastructure funding data for 2011 were requested, but could not be obtained in time for inclusion here. Data for 2010 were available and have been used as a proxy for 2011 in the data set. Also, the raw FHWA data include negative dollar values, which represent funding amounts that were initially authorized, but later de-authorized (i.e. never disbursed for use). These negative values have been adjusted to \$0 in the dataset to reflect the actual amount of disbursed funds for bicycle and pedestrian infrastructure projects.

Another limitation of the data set is that it does not include variables for existing bicycle infrastructure. As the literature indicates, the presence of infrastructure is a driver of bicycle commuting mode choice. Including measures of what is available to commuters in a given city (e.g., miles of existing bike lanes and paths; the presence of painted “green lanes,” bike boxes, or other innovative types of infrastructure to enhance driver awareness of cyclists; whether a city has a bicycle and pedestrian master plan, or sponsors education initiatives for responsible cycling or driver awareness campaigns; or whether a city has installed a public bikeshare system) would improve the model. Furthermore, I would expect that public officials in cities with more infrastructure may be more intrinsically dedicated to making their cities bike-friendly. This dedication is hard to measure and likely correlated with both funding received and bicycle commuting rates. Including a variable that quantifies infrastructure – a measurable, plausible proxy for this dedication – would reduce the likelihood of omitted variable bias.

However, standardized and comprehensive infrastructure data is limited. The best resource is the ABW City Survey. The survey was sent to bicycle and pedestrian advocacy

groups in 51 of the largest cities in America in 2007, 2009, and 2011.<sup>9</sup> The surveys asked respondents to report data on bicycle and pedestrian funding, staffing, public education, and specific infrastructure measures from the prior two-year period. By combing through replies to three years' worth of survey responses, I initially created several variables for cycling infrastructure by hand. Ultimately, these variables were too incomplete to include in a scientific analysis, mainly due to inconsistent or incomplete reporting by respondents. Contacting transportation planning officials in individual cities to retrieve missing data fell out of the time scope of this project.<sup>10</sup>

Finally, because the data set is limited to the largest 51 cities in the United States, it is not possible in this analysis to estimate the more general effects of funding on bicycle commuting. Expanding the sample to include more cities would produce results applicable to cities smaller than those analyzed here.

## 5.5 Model Specification

To investigate my research question, I estimate two OLS regression models, including indicator variables for the years 2009 and 2011<sup>11</sup> and a flag to indicate whether a city is in Texas or California. Both models are described below, followed by a discussion of outliers, heteroskedasticity, and tests of the models.

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<sup>9</sup> Initial hopes of including this data were a major driver of research design for this analysis.

<sup>10</sup> Buehler and Pucher (2011) report using ABW infrastructure data in some form for their empirical analysis of the effects of infrastructure on bicycle commuting rates in 90 cities in America. A request to use these data was not returned in time to be considered for this analysis (Newhall 2012).

<sup>11</sup> Stata's "xi" command is used to stratify the data by year in the OLS regression analysis.

Model (I) estimates a city's bicycle commuter rate, *bike*, as a function of total federal spending on bicycle and pedestrian infrastructure (*fedbyp*), population density (*density*), and the state's average real price of gasoline (*gasprice*). Model (II) removes the total spending variable, *fedbyp*, and replaces it with *fedpc*, spending per capita (total federal spending divided by population), to measure the funding-commuting rate relationship in another way.

### **Model (I): Total Spending with Controls**

$$\begin{aligned} bike_i = & \beta_0 + \beta_1(fedbyp_i) + \beta_2(density_i) + \beta_3(gasprice_i) \\ & + \beta_4(ca\_tx) + \beta_5(2009) + \beta_6(2011) + u_i \end{aligned}$$

### **Model (II): Per Capita Spending with Controls**

$$\begin{aligned} bike_i = & \gamma_0 + \gamma_1(fedpc_i) + \gamma_2(density_i) + \gamma_3(gasprice_i) \\ & + \gamma_4(ca\_tx) + \gamma_5(2009) + \gamma_6(2011) + \eta_i \end{aligned}$$

To determine the effects of different years in my panel, I include the indicator variables *2009* and *2011*. The first set of observations in my panel comes from 2007, before the onset of the Great Recession, and serves as a baseline for the analysis. The observations from 2009 reflect elevated funding levels in some cities after passage of ARRA. The observations from 2011 reflect the sample immediately after recession-related policy interventions.

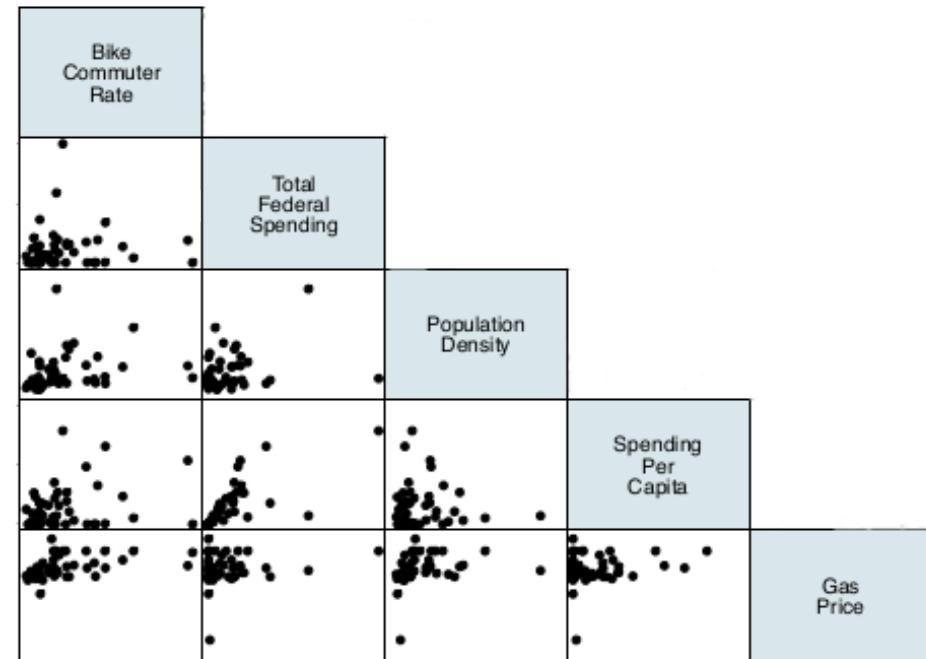
In the final analysis, I also include an indicator variable to flag if a city is in Texas or California (*ca\_tx*) to control for these states being overrepresented in the sample.

## **Outliers and Influencers**

The panel data used in this analysis cover three years, all within a five-year period. Bicycle commuting rates are not expected to have changed drastically during this period, although on average in the sample they do increase over time. However, other variables – notably funding levels – do vary a good deal in the sample, and it is important to understand how these relate to population density and other variables. Figure 8, below, plots the relationship between the dependent variable, bike commuting rate, and the covariates of interest from both main models.

Outliers exist in almost all plots of the relationship of the dependent variable with other variables, but further investigation shows that they are not all the same city (or cities). The case of funding and commuting rates is an instructive example. In 2007, San Diego, California, received almost twice as much federal funding for bicycle and pedestrian infrastructure as the second-highest recipient, New York City. That same year, however, two cities with bicycle commuting rates nearly three times as high as San Diego's, Portland, Oregon, and Minneapolis, Minnesota, received only 20 percent of the amount of funding that San Diego received. This may be because cities with higher bicycle commuting rates might have not needed or requested funding for infrastructure at the rates requested by cities whose bike commuter rates remain low during this time, or perhaps these cities had fewer shovel-ready projects that made good candidates for ARRA funding. In subsequent years, Portland remains an outlier on the commuting rate axis, but other cities (e.g., Dallas, Texas, in 2009, and a larger mix of cities in 2011) move out on the funding axis. This reinforces the earlier observation that there is a substantial degree of variation among funding levels across both cities and years.

**Figure 8. Matrix of Key Variable Relationships**



Each plot's x axis corresponds to the shaded box above it. Each plot's y axis corresponds to the shaded box to its left. By starting at two shaded boxes and simultaneously working left and down, the intersecting box plots the relationship between two key variables.

Plots of the relationship between population density and total federal spending in 2007 include two major outliers, New York City and San Diego. New York City remains an outlier in 2009 and 2011, mainly because its population density is so much higher than the other cities in the sample, but San Diego becomes less of a funding outlier (as mentioned above) in subsequent years.

## Heteroskedasticity

Because of the varying sizes of cities included in the sample, it is likely that the variance of the residuals is not homogenous. Thus, heteroskedasticity is present.<sup>12</sup> This is a cause for concern with my OLS regression models because standard errors based on heteroskedastic variances will not generate valid confidence intervals or *t* statistics (Wooldridge 2006), thereby compromising the accuracy of any conclusions I could draw from my results. I use robust standard errors in the final analysis to correct for heteroskedasticity.

## Testing Explanatory Power

I used joint significance tests to evaluate the explanatory power of both main models, as well as the value of the indicator variables for Texas and California.

A test of the entire model, in both cases, showed that both groupings of variables were jointly statistically significant at the 99 percent confidence level. The *F* statistic on Model (2) (*fedpc, density, gasprice, ca\_tx*) was higher than the *F* statistic on Model (1) (*fedbp, density, gasprice, ca\_tx*).

The two indicator variables *ca* and *tx* were not jointly statistically significant when included in Model (II) but the combined *ca\_tx* flag, indicating if a city is in Texas or California, was statistically significant at the 95 percent confidence level. As a result, I decided to include the single combined flag in my final models.

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<sup>12</sup> Stata's "hettest" post-estimation command confirmed the presence of heteroskedasticity in both of my main model specifications.

## 6. EMPIRICAL RESULTS

My analysis results show that per capita federal spending leads to small but statistically significant increases in bike commuting rates in cities in my sample, while the total amount of federal spending does not. Table 2 displays coefficients and standard errors from my two model specifications. These results are discussed in more detail below, followed by a discussion of results related to the control variables included in both models.

### Funding Variables

**Regression results.** The coefficient on total federal spending predicts that, on average, each \$1 million increase in federal infrastructure funding a city receives will increase that city's bicycle commuting rate by 0.0346 percentage points. These results generally support my hypothesis that funding has a direct relationship with commuting rates, but this coefficient is not statistically significant ( $P = 0.2$ ).

The coefficient on federal spending per capita is higher in both magnitude and statistical significance ( $P = 0.003$ ). Model (II) predicts that, on average, a \$1 increase in spending per capita will increase a city's bicycle commuting rate by 0.0473 percentage points, holding gas price, population density, year, and geographic location constant. To see what effect these results would have on the average city in my sample, I returned to the data and identified the mean values for population, workers over age 16, number of bicycle commuters, and bicycle commuter rate. In 2009, "Averagetown" would have had 960,820 residents and 442,534 workers over age 16. Of those workers, 4,417 would have biked to work, a rate of 1.12 percent. The model

**Table 2. OLS Estimation of Average Effects of Spending, Population Density, Gas Price, Year, and Geographical Location on Bicycle Commuting Rate**

	(I) <i>Bicycle Commuting Rate</i>	(II) <i>Bicycle Commuting Rate</i>
<i>Total spending (millions of dollars)</i>	0.0346 [0.0269]	
<i>Spending per capita (dollars)</i>		0.0473 *** [0.0156]
<i>Population per square mile (1,000s)</i>	0.0286 [0.0202]	0.0337 * [0.0194]
<i>Gas price (dollars per gallon)</i>	6.482 *** [2.060]	6.325 *** [1.927]
<i>2009</i>	2.176 *** [0.658]	2.044 *** [0.621]
<i>2011</i>	0.786 *** [0.278]	0.722 *** [0.272]
<i>CA or TX</i>	-0.435 ** [0.201]	-0.393 ** [0.186]
<i>Constant</i>	-8.570 *** [2.864]	-8.406 *** [2.675]
N	148	148
<i>R</i> <sup>2</sup>	0.220	0.257
Adjusted <i>R</i> <sup>2</sup>	0.186	0.226

Standard errors in brackets

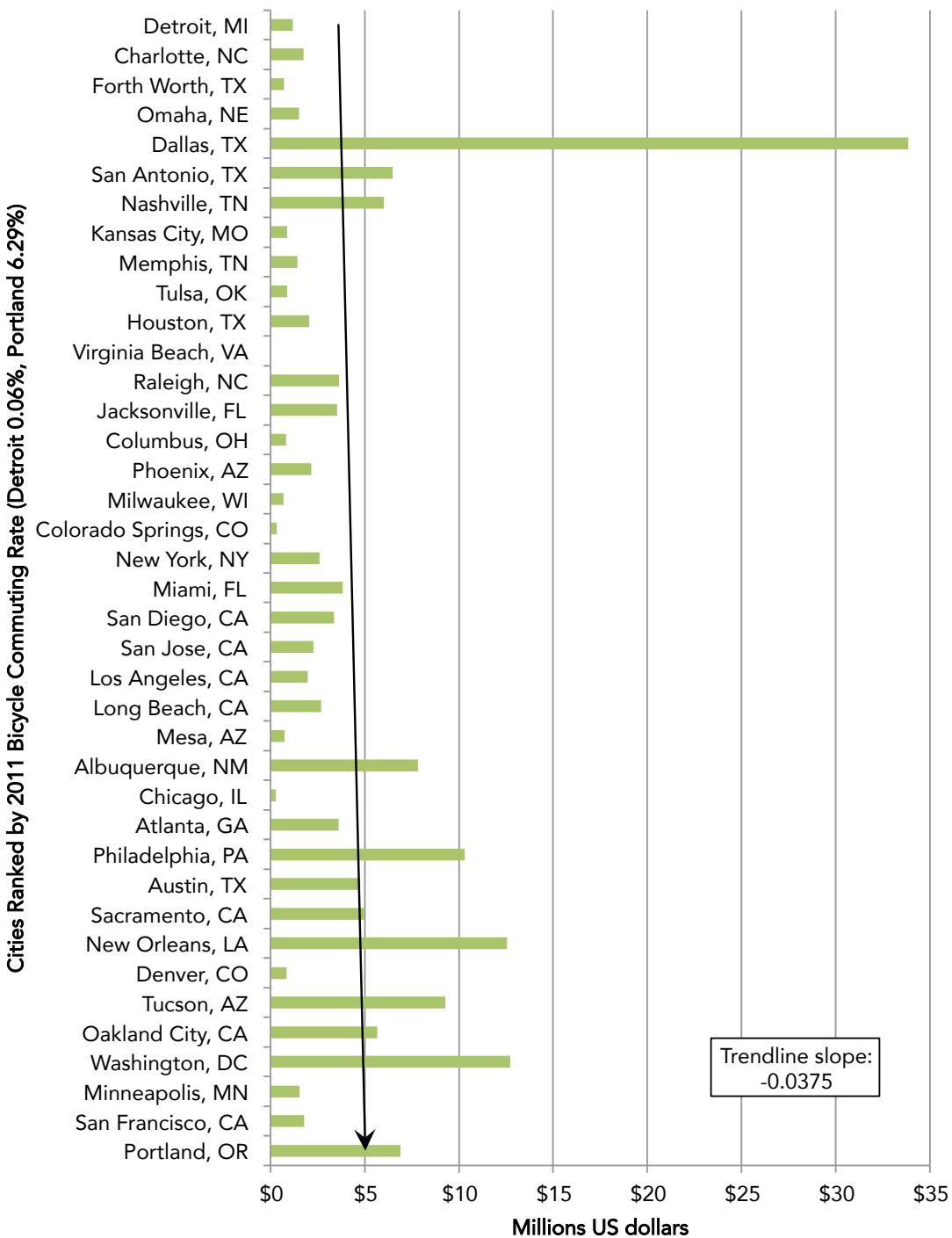
\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

predicts that a \$1 increase in per capita spending on bicycle and pedestrian infrastructure – a \$960,820 increase in total spending, holding other factors constant – would increase the bicycle commuting rate by 0.0473 percentage points. The policy intervention would generate 749 new bicycle commuters, a 17 percent increase in the total number of people who bike to work.

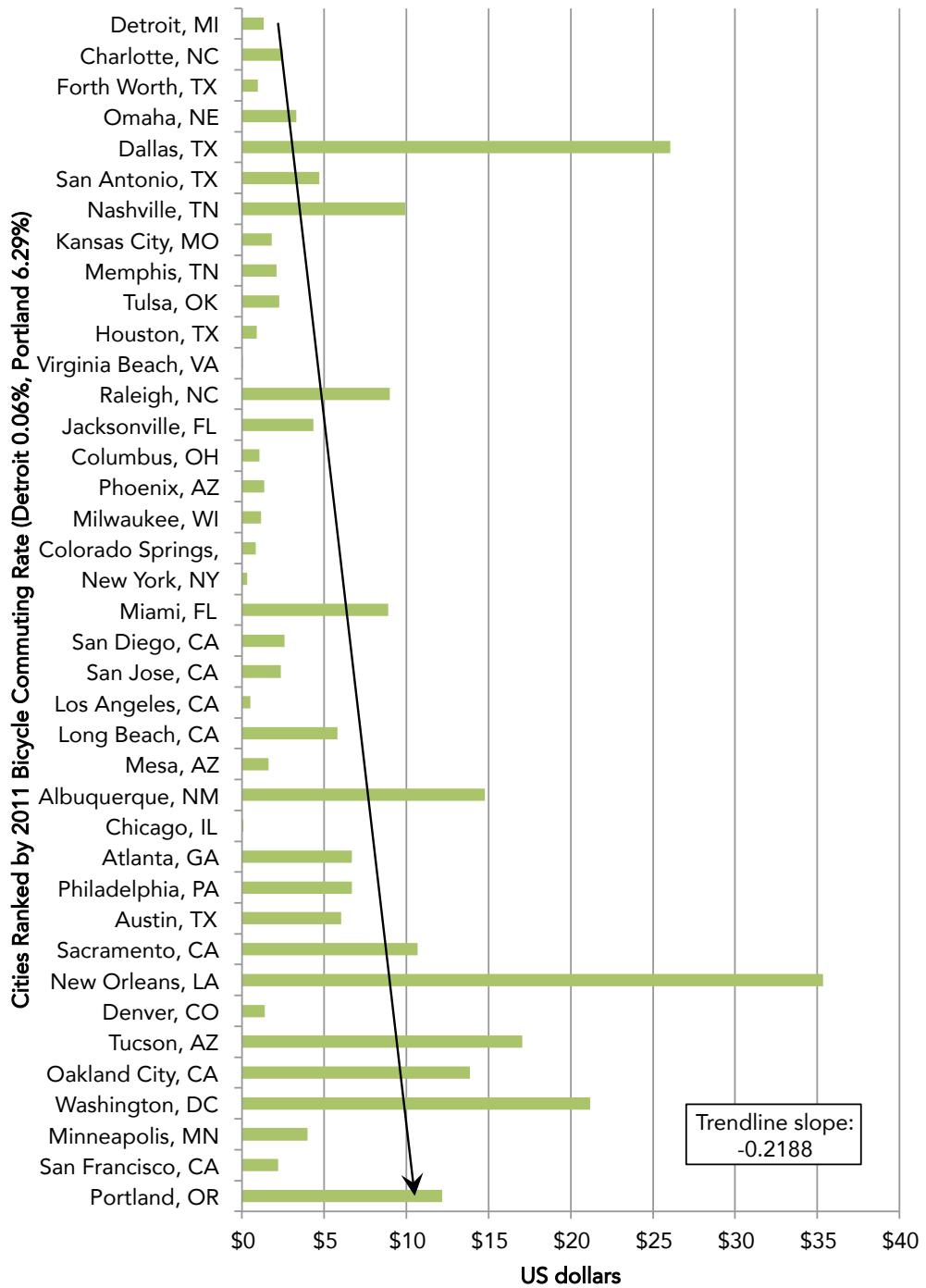
**Lagged graphs.** Figures 9 and 10, below, show the effect of federal funding on bike commuting rates in isolation, outside the context of regression analysis. In Figure 9, cities that received funding in 2009 are ranked along the left-hand axis by their bike commuting rates two years later in 2011, when conceivably enough time had passed for infrastructure to be built and commuters to respond. The graph shows how much funding each city received in millions of dollars. Figure 10 is identical, but graphs per capita spending (in dollars) instead of total spending.

The only indication of bicycle commuting rates is how the cities are ordered in the graph (lowest at the top, highest at the bottom). Detroit, at the top of both graphs, had the lowest 2011 bicycle commuting rate (0.06%); Portland had the highest (6.29%). Using an Excel command, I calculated the slope of trend lines placed over the graphs. Both lines show a consistent, positive relationship between funding and commuting rates. However, the total spending trend line is a great deal steeper than the per capita trend line, showing a stronger relationship between per capita funding and bicycle commuting rates cities that received federal funding in 2009. These visuals support my hypothesis and are consistent with the results of my regression analysis.

**Figure 9. Total 2009 Funding by City, Ranked by 2011 Bike Commuting Rates**



**Figure 10. Per Capita 2009 Funding by City, Ranked by 2011 Bike Commuting Rates**



## Control Variables

**Population density.** I hypothesized that increases in population density would lead to increases in bicycle commuter rates. The results bear this out, although the coefficients are not highly statistically significant ( $P = 0.158$  in Model (I);  $P = 0.084$  in Model (II)). This suggests that population density is not a major determinant of bicycle commuting rates in my sample, which represents major U.S. urban areas, and on balance does not likely represent the full variance of population densities across all cities in the United States.

**Gas price.** Gas price has a large and highly statistically significant effect on bicycle commuting rates in both models. Model (1) predicts that a \$1 increase in the average real per-gallon price of gasoline will increase a city's bicycle commuting rate by nearly 6.5 percentage points, holding funding, year, and geographic location constant. In Model (2), this prediction rises to 6.9 percentage points ( $P = 0.000$ ). This supports my hypothesis that increases in gas prices will cause some urban car commuters to switch to other, lower-cost modes, including bicycling.

**Year.** The coefficients on 2009 and 2011 are highly statistically significant in both models. The results show that the 2009 percentage point increase (over 2007 baseline levels) in bicycle commuting was twice as large as the 2011 increase. Returning to Averagetown, which had a 2007 bicycle commuting rate of 0.83 percent, the effect of being in the year 2009 would have been an increase in the bicycle commuting rate to 2.87 percent, based on Model (II)'s prediction when we hold other factors constant. The effect of being in 2011 would be a boost to 1.55 percent.

**CA or TX.** The “Texas or California” flag had small but statistically significant effects on bicycle commuting rates in the sample, adjusting for the effects of being located in one of these two large states. In Model (I), being in Texas or California deducted 0.435 percentage points from an average city’s bicycle commuting rate ( $P = 0.032$ ); in Model (II), being in Texas or California deducted 0.393 percentage points ( $P = 0.036$ ).

### Sum of Average Effects

Table 3 lists the predicted average bicycle commuting rate – the sum of effects of federal spending (total in Model (I), per capita in Model (II)), population density, gas price, year, and geographical location, plus the constant from each model – in 2007, 2009, and 2011, and in either Texas or California. The values were calculated by plugging the sample means for each variable into the regression results functions below, and then adding the resulting products of sample means and coefficients together:

### Model (I): Total Spending with Controls

$$\widehat{bikе}_i = -8.570 + 0.0346(fedb_{pi}) + 0.0286(density_i) + 6.482(gasprice_i) \\ -0.435(ca\_tx) + 2.176(2009) + 0.786(2011) + \varepsilon_i$$

### Model (II): Per Capita Spending with Controls

$$\widehat{bikе}_i = -8.406 + 0.0473(fedpc_i) + 0.0337(density_i) + 6.325(gasprice_i) \\ -0.393(ca\_tx) + 2.044(2009) + 0.722(2011) + \varepsilon_i$$

Using Table 3, we can quickly identify the predicted average bicycle commuting rate in a given year and geographical area, including all factors controlled for in the models.

**Table 3. Predicted Average Bicycle Commuting Rate by Year and Geographical Location, Using Model Results and Sample Means**

	<b>Model (I)</b> <i>Predicted Average Commuting Rate</i>	<b>Model (II)</b> <i>Predicted Average Commuting Rate</i>
<i>2007 (baseline)</i>	0.949	0.938
<i>2007 CA or TX</i>	0.514	0.545
<i>2009</i>	1.258	1.253
<i>2009 CA or TX</i>	0.823	0.860
<i>2011</i>	1.356	1.308
<i>2011 CA or TX</i>	0.921	0.915

Table values reflect the sum of predicted effects of gas price, population density, spending, year, and geographical location on the average bicycle commuting rate. Each value is calculated using the appropriate sample means and parameter estimates and constants from the analysis models.

## **7. DISCUSSION AND CONCLUSIONS**

This study is the first of its kind to analyze the effect of federal infrastructure spending on bicycle commuting rates. Using OLS regression and sample data from the 51 largest cities in the U.S., I estimated the bicycle commuter rate as a function of federal spending, population density, gas price, year (2009 and 2011, compared to a baseline year of 2007) and geographical location. Robust standard errors were used to correct for heteroskedasticity.

My analysis results in three key findings:

- 1) Per capita federal spending on bicycle and pedestrian infrastructure has a larger and more statistically significant effect on bicycle commuting rates than total federal dollars spent.
- 2) More people biked to work in 2009 and 2011 than in 2007, suggesting a “recession effect” – my own term, discussed in more detail below – that helps explain commuter behavior in the face of economic hardship.
- 3) Commuters are highly sensitive to increases in gas prices.

These findings align with my expectations and existing literature. Their policy implications are discussed in greater detail below.

### **7.1 Policy Implications**

#### **Bicycle and Pedestrian Infrastructure Funding**

My results suggest a positive, statistically significant relationship between bicycle commuting rates and per capita federal funding of bicycle and pedestrian infrastructure. Cities in my sample that received higher amounts of funding per resident, regardless of the total amount of funding received and holding other factors constant, have higher shares of bicycle commuters.

This intuitively suggests that federal infrastructure funding may do a better job of getting people to bike to work if grant amounts are determined with respect to population (e.g., \$600,000 may be more influential in Washington, DC, population roughly 618,000, than in New York City, population in excess of 8 million).

This finding is particularly relevant to current policy. If per capita spending is important, policy makers ought to prefer policies that allocate money to cities relative to their populations. This is not evident in the sample. In Table 4, below, the 34 cities that received federal infrastructure funding in 2007 are tabulated by rank (1 received the most funding, 34 the least) and population (1 is the most populous, 34 is the least) and followed through 2009 and 2011. The columns show how much, in each year, these cities' funding rankings differed from their population rankings. In a majority of cases, the difference between a city's population rank and funding rank was more than 5 places in either direction. It may be significant that recent funding levels have not been directly proportional to population levels in these cities.

Instead, funding levels are likely influenced by politics. Federal bicycle and pedestrian infrastructure spending policy changed under MAP-21. Prior to 2012, federal transportation funding legislation included formulas to take factors like population into account. Those formulas were eliminated in 2012. Now, states receive what they got in 2009 – a share determined partially by formula, but also by what their members of Congress were able to obtain through closed-door political negotiations (Snyder 2012b). It seems reasonable to expect that allocations through 2014 under MAP-21 do not do an accurate job of funding states – or cities – based on population, but instead reflect which federal political actors were more successful at

**Table 4. Cities Ranked by Level of Funding and Population**

	2007			2009			2011		
	Funding Rank	Population Rank	Difference	Funding Rank	Population Rank	Difference	Funding Rank	Population Rank	Difference
San Diego, CA	1	8	+7	17	8	-9	27	8	-19
New York, NY	2	1	-1	19	1	-18	31	1	-30
Houston, TX	3	4	+1	22	4	-18	1	4	+3
Tucson, AZ	4	33	+29	5	33	+28	13	34	+21
Los Angeles, CA	5	2	-3	23	2	-21	21	2	-19
Indianapolis, IN	6	14	+8	40	15	-25	31	13	-18
Columbus, OH	7	17	+10	33	17	-16	31	16	-15
Washington, DC	8	26	+18	2	28	+26	8	26	+18
Minneapolis, MN	9	49	+40	26	49	+23	4	49	+45
Oakland City, CA	10	47	+37	10	45	+35	31	47	+16
Boston, MA	11	22	+11	40	21	-19	31	22	-9
Philadelphia, PA	12	6	-6	4	6	+2	6	5	-1
Atlanta, GA	13	41	+28	15	34	+19	31	41	+10
Austin, TX	14	16	+2	12	16	+4	25	14	-11
Detroit, MI	15	13	-2	29	11	-18	29	19	-10
Nashville, TN	16	24	+8	9	26	+17	23	27	+4
Seattle, WA	17	28	+11	40	24	-16	31	23	-8
San Antonio, TX	18	7	-11	8	7	-1	14	7	-7
Fresno, CA	19	36	+17	40	37	-3	30	35	+5
Chicago, IL	20	3	-17	38	3	-35	26	3	-23
Albuquerque, NM	21	34	+13	6	35	+29	18	33	+15
Baltimore, MD	22	20	-2	40	22	-18	31	25	-6
Colorado Springs, CO	23	44	+21	37	47	+10	31	42	+11
Cleveland, OH	24	42	+18	40	44	+4	31	48	+17
Kansas City, MO	25	39	+14	31	36	+5	10	38	+28
Jacksonville, FL	26	12	-14	16	14	-2	31	12	-19
San Francisco, CA	27	15	-12	24	13	-11	31	15	-16
Phoenix, AZ	28	5	-23	21	5	-16	12	6	-6
Raleigh, NC	29	48	+19	14	46	+32	22	43	+21
Milwaukee, WI	30	27	-3	36	27	-9	16	29	+13
Dallas, TX	31	9	-22	1	9	+8	2	9	+7
Virginia Beach, VA	32	40	+8	39	42	+3	31	40	+9
Miami, FL	33	50	+17	13	43	+30	5	45	+40
Sacramento, CA	34	38	+4	11	39	+28	3	36	+33

The 34 cities that received federal infrastructure funding in 2007 are tabulated by rank (1 received the most funding, 34 the least) and population (1 is the most populous, 34 is the least) and followed through 2009 and 2011. The columns show how much, in each year, these cities' funding rankings differed from their population rankings.

carving out additional funding for their states. The fact that this political maneuvering is happening at the federal level, far removed from the municipal planning officials who best understand their cities' infrastructure needs and implementation goals, is also problematic. The result may be inefficient allocation of funds.

## Control Variables

**Population Density.** In my sample, the effect of population density is not significantly different from zero. This may be because my sample includes only large cities with high population densities. The lack of variance leads to results that suggest population density doesn't matter as much as factors like funding, which varied more in the sample.

There may be more to the story. Pucher, Buehler, and Seinen (2011) observed a non-intuitive, bell-curved relationship between 2009 population size and bicycle mode share in an aggregate study of cycling trends in U.S. metropolitan areas. The smallest populations (less than 250,000) had bike mode shares that mirrored the largest populations (greater than 1 million). The highest bike mode shares were in the middle, between 500,000 and 1 million. The bike mode share among workers also follows a curve in the Pucher-Beuhler-Seinen study, peaking in cities with 250,000 to 500,000 people and lessening as population increases.

This suggests there may be a threshold density at which population is so high that the effects of infrastructure spending – or even the existence of infrastructure for bicycling – become irretrievably cost-ineffective. In other words, does population density get so acute that, past a certain point, commuters do not feel safe sharing congested city streets with cars, trucks, and pedestrians, even if bicycle infrastructure is available? In such a case, additional units of

infrastructure spending would have no effect on individual commuter choice, even though bicycle commuting rates may rise or fall based on effects of unrelated factors.

Levinson and Kumar (1997) do not analyze bicycle commuters, but do identify a “threshold density” at which commuter mode choice becomes driven by congestion effects. The “shortest duration auto commutes” occur at “a residential density between 7,500 and 10,000 persons per square mile (neither the highest nor lowest)” (147). This phenomenon would be an interesting topic for further study within my sample of densely populated cities.

**Gas price.** Of all factors in my models, gas prices had the greatest individual effect on bicycle commuting rates. This aligns with preexisting empirical evidence that commuter behavior is highly sensitive to changes in gas prices.

A 2012 analysis of changes in prices of gasoline and homes in urban areas of the U.S. found that each \$1 increase in the price of a gallon of gasoline reduces home values by 0.143 percent per commute mile, or \$5,191 for the average home and commute in the researcher’s sample (Blake 2012). In other words, commuters demand shorter commute times (and lower commuting costs), so when gas prices go up and driving becomes less affordable, demand for homes closer to urban cores increases, thus raising the prices of those homes and depressing the value of homes that are farther away.

More relevant is a 2012 time-series analysis of 33 U.S. cities, which showed that a 10 percent increase in gas prices would result in up to a 4 percent lagged increase in bus ridership, and up to an 8 percent lagged increase in rail ridership (Lane 2012). As gas prices rise, car commuters will opt for public transportation. Similarly in my sample, increases in gas prices push more commuters to opt for biking to work.

Such findings make a good case against the persistent cultural trope that Americans are “addicted to cars.” Instead, Americans might be addicted to affordable transportation. Gas prices in the U.S. are some of the lowest in the world, mainly because gas taxes here do not reflect the full costs of the externalities of fuel use. In some European cities, gas prices are three times as high as they are in the United States, and taxes account for up to 75 percent of the per-gallon price (Randall 2013). Policies that make gasoline – and, by extension, driving – more expensive could incentivize usage of cheaper and less carbon-intensive commuting modes, like bicycling.

**Year.** In my analysis, I observed a “recession effect” – my own term for the effect of economic hardship – on commuter behavior. More people biked to work in large U.S. cities in 2009 than in either 2007 or 2011, with the greatest percentage point change in 2009, at the height of the Great Recession. However, 2011 bicycle commuting rates in this sample were still higher than they were in 2007. During this time, many people in the cities in the sample were facing financial hardship. My results suggest that bicycle commuting became an attractive way to cut individual transportation costs.

This aligns with findings from IBM’s 2009 Commuter Pain Survey, which reported that 21 percent of respondents said the recession forced them to switch from driving alone to some other commuting mode, including carpooling and public transportation (IBM Corporation 2009). It is reasonable to expect that some drive-alone commuters chose bicycling instead. In the future, policies that promote bicycle commuting could be an effective way to help consumers save money during times of economic hardship.

**Texas and California.** In the sample, being in Texas or California meant a decrease in a city’s predicted bicycle commuter rate. This controls for these two large states being

overrepresented in the sample. It also controls for some effects of the political process on funding decisions. These two large states are typically viewed as polar political opposites: Texas is staunchly Republican, while California is fairly liberal, and at least one city in each state is an outlier in amounts of funding received during various years in my sample. Controlling for their overrepresentation may screen out some of the effects that polarized political leanings might have on the transportation infrastructure funding process, as well as portions of other unobserved factors – e.g. climate, regulatory policy, and local funding sources – that may be correlated with bicycle commuting. In the future, more data and more specialized analysis could elucidate these effects.

## 7.2 Caveats

My results come with a few general concerns about external validity. The analysis sample was limited to only the largest cities in the country, so I do not expect my results to be transferable to all cities in the U.S. In addition, given the observed differences between years in the sample, my results should be tested when additional years of data become available. Furthermore, the effects of the recession may have impacted commuter behavior in my sample in ways that would not have been observed had the economy been stable. However, these results may be transferrable to groups of large urban areas during other periods of economic hardship.

### Omitted Variable Bias

Many factors affect bicycle commuting rate variation besides those that were controlled for in my models. As discussed, measures of existing infrastructure would have improved the

analysis, as would have proxies for unobservable factors like political ideology and the nuances of the political and grant-making processes. Since both of these unobserved factors are plausibly correlated with my key policy variable of interest, federal spending, my parameter estimates may suffer from some degree of omitted variable bias.

**Infrastructure.** I would expect that cities with high levels of preexisting bicycle infrastructure would have higher bicycle commuting rates (a positive relationship). The relationship between funding and existing infrastructure is harder to predict, but for discussion's sake, I will assume that cities with higher levels of existing infrastructure will receive lower levels of funding over time, as their infrastructure needs are met (a negative relationship). Therefore, my coefficients on funding may be biased downward, diminishing the estimated effect of federal funding on bicycle commuting rates in the sample.

**Politics.** I expect that cities led by public officials with a knack for getting lots of bicycle and pedestrian infrastructure funding – or represented at the federal level by more influential senators and representatives – would have both more funding (a positive relationship) and more infrastructure (also positive). So the exclusion of this factor might be biasing my funding coefficients upward.

To address these concerns, more data are needed.

### 7.3 Future Research

Overall, my analysis is valuable despite its limitations. This study is the first of its kind with this combination of data. My results are supported by transportation demand theory and

evidence from the existing social science literature. Furthermore, I was able to estimate the effect of an economic recession on one aspect of American commuting behavior.

Given the large number of unobserved factors that could account for variation in bicycle commuting rates in cities – bicycle infrastructure levels, average commute distance, weather patterns, number of accidents involving cyclists, and the presence of cycling advocacy organizations and awareness campaigns, to name a few – I plan to repeat this analysis after collecting more data. A larger sample, more years of observations, and collection/inclusion of comprehensive infrastructure data would alleviate some endogeneity concerns and add greater explanatory power to the models. More years of data would also allow me to perform a lagged analysis, similar to Lane (2012), to observe the effects of funding amounts on commuting rates over time.

This work could be expanded in a few other ways:

**Macro vs. Micro Analysis.** This analysis uses a macro approach to investigate the relationship between federal spending and bicycle commuting. A “micro” approach, using individual bike commuters as the unit of analysis, would shed light on how individuals’ preferences for biking to work is affected by federal infrastructure spending. In this way, I could predict the effect of federal per capita spending on the likelihood that individual commuters would choose biking to work over other commuting modes, when controlling for a variety of other factors.

**Alternative Infrastructure Financing Models.** Given the uncertainty about federal funds as a future source of financing for bicycle infrastructure projects, it would be valuable to understand the cost efficacy of other financing models. I would like to investigate other types of

transportation infrastructure financing, such as municipal taxes and bonds and public-private partnerships, to see if they have an effect on project completion and bicycle commuter rates over time, as well as if the per-capita/total spending distinction holds true across financing models.

**Other Explorations of Main Findings.** Does the “per capita” versus “total outlay” funding effectiveness distinction hold true for transportation modes other than biking? Ninety-eight percent of what The U.S. Department of Transportation will spend on infrastructure in 2013 will not be for biking and walking. Given the capital-intensive nature of road construction and maintenance – and the fact that at least one study has shown bicycle infrastructure to create more jobs than road-only projects, dollar for dollar (Garrett-Peltier 2011) – it would be interesting to analyze whether federal policy makers are effectively allocating these much higher funding amounts.

## 7.4 Conclusion

My analysis shows there is demand for bicycle commuting in U.S. urban areas. Federal funding provides infrastructure, and therefore increases the supply; people will respond by biking to work more often. Researchers and policy makers should focus on making funding allocations more efficient; improving mechanisms to encourage bike commuting; increasing the safety of bicyclists; and educating the public about the individual, societal, and economic benefits of bicycle commuting.

Aside from the findings and policy implications of this analysis, it is not insignificant that the federal government’s ability and willingness to continue funding bicycle infrastructure is in question. Sweeping new policies are needed to replenish the Highway Trust Fund and ensure that

infrastructure funding remains available – not just for new infrastructure, but for crucial repairs and maintenance of what already exists. Future authorizations of comprehensive transportation financing legislation must fairly allocate funds to states – and, in turn, states must fairly allocate to cities – in ways that do not reward political power over population share and infrastructure needs. Otherwise, recent gains in bicycle commutes may stagnate or be reversed.

Given that bicycle commuters remain such a small share of total U.S. commuters, one could argue that funding infrastructure for this group is wasteful and unfair, since bicycles do not use gasoline and therefore their riders do not pay gas taxes into the Highway Trust Fund. On the contrary, many bicycle commuters own cars, participate in urban car-sharing services, or otherwise drive a motor vehicle periodically. Cyclists also pay local property taxes, which go toward road improvements and infrastructure construction in the cities and towns where they bike and live. It is not true that bicycle commuters are anti-car, or do not want the government to pay for basic maintenance of all transportation infrastructure. Biking can be one of many ways people get around a city, whether its commuting to work, running a quick errand, patronizing local businesses, or getting to a car-sharing parking lot or public transit station. Most commuters would probably agree that having many choices of how to get from A to B, and from B to C, D, and Z, is liberating and good for them, even if driving is still the simplest way to make certain types of trips.

It is also important to remember the many ways people and cities could benefit from higher shares of bicycle commuters. Dollar for dollar, bicycle infrastructure projects create more in-state jobs than road projects (Garrett-Peltier 2011). People who bike to work are more likely to get their daily recommended amount of physical activity, and are less likely to be obese and

suffer from chronic obesity-related health conditions. Making it easier for people to replace car trips with bike trips could reduce traffic congestion, lower transportation costs, and decrease wear-and-tear on stressed roadways. And fewer transportation emissions will reduce the U.S.'s contribution to climate change, which has already begun to impact weather patterns and the economy in significant ways. Last fall, for example, New York Gov. Andrew Cuomo estimated the recovery costs of Hurricane Sandy at \$71 billion (Webb 2012). State and federal governments have a responsibility to address these problems with cost-effective and well-informed transportation policies.

Informing policy makers will remain difficult, however, until public officials and the research community work together to ensure more consistent collection of data on bicycle commuting and related infrastructure levels in the United States. Today, cyclists are a small share of the total commuting population. But as a group, they have potential to grow. Building and improving infrastructure that serves this group, and increases its level of actual and perceived safety while sharing city roads with cars, could only serve to increase the cost-effectiveness of policy interventions that promote active commuting. Without comprehensive and standardized data, the effects of these policy interventions will be difficult to adequately quantify or understand.

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