Economic Benefits of Capital Bikeshare: A Focus on Users and Businesses

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16. Abstract

This study investigates potential economic benefits of bike sharing on the neighborhood level. Using a sample of five Capital Bikeshare (CaBi) stations in Washington, DC, we conducted an intercept survey of 333 bikeshare users at five CaBi stations and a door-to-door survey of 140 local businesses within 0.1 miles of the five CaBi stations. We found that many CaBi riders are motivated to use the system due to travel time (73% of users) and cost (25% of users) savings. In addition, 16% of riders report making new trips because of Capital Bikeshare. Meanwhile, 23% of users reported spending more money because they used bikeshare. Income level was positively associated with new trips, spending levels, and spending during new trips. Joining CaBi to save money had a significant positive association with new trips. The business survey showed that 20% of the businesses in our sample report a positive impact of bike sharing on sales, and 70% identify a positive impact on the neighborhood. In addition, 61% would have either a positive or neutral reaction to replacing car parking in front of their business with a bikeshare station. Businesses that perceive a positive impact on sales from the bikeshare system are more likely to support the expansion of the system and the replacement of car parking with bikeshare stations. Overall, our findings suggest bike sharing may generate benefits among both users and businesses.

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2 ABSTRACT

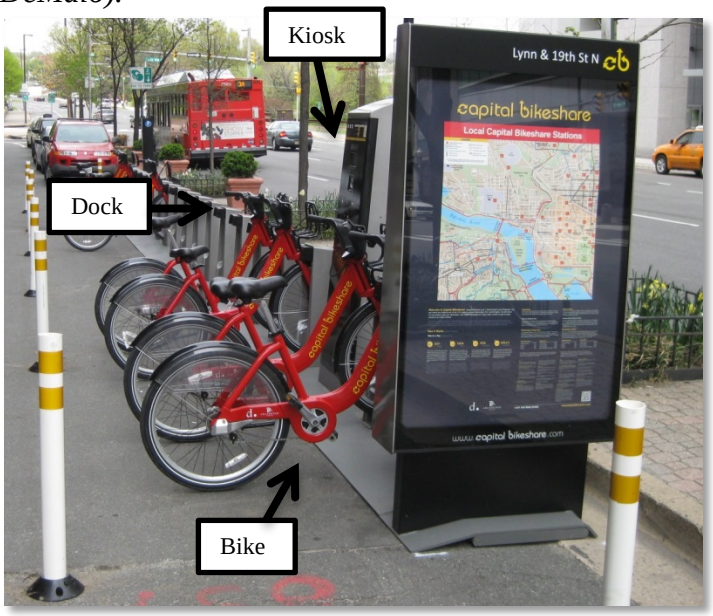
This study investigates potential economic benefits of bike sharing on the neighborhood level. Using a sample of five Capital Bikeshare (CaBi) stations in Washington, DC, we conducted an intercept survey of 333 bikeshare users at five CaBi stations and a door-to-door survey of 140 local businesses within 0.1 miles of the five CaBi stations. We found that many CaBi riders are motivated to use the system due to travel time (73% of users) and cost (25% of users) savings. In addition, 16% of riders report making new trips because of Capital Bikeshare. Meanwhile, 23% of users reported spending more money because they used bikeshare. Income level was positively associated with new trips, spending levels, and spending during new trips. Joining CaBi to save money had a significant positive association with new trips. The business survey showed that 20% of the businesses in our sample report a positive impact of bike sharing on sales, and 70% identify a positive impact on the neighborhood. In addition, 61% would have either a positive or neutral reaction to replacing car parking in front of their business with a bikeshare station. Businesses that perceive a positive impact on sales from the bikeshare system are more likely to support the expansion of the system and the replacement of car parking with bikeshare stations. Overall, our findings suggest bike sharing may generate benefits among both users and businesses.

3 INTRODUCTION

Bikesharing is a flexible form of transportation that typically offers daily, monthly, or annual bikeshare members short-term bicycle usage to and from a network of stations equipped with payment kiosks and docks (Figure 1) (ITDP, 2013; Shaheen, Guzman, & Zhang, 2012; Shaheen, Martin, Cohen, & Finson, 2012). The growth of bike sharing in the U.S. has been rapid in recent years, with 33 public program launches nationwide since 2010 (MetroBike LLC, 2014).

Capital Bikeshare ("CaBi") is a public bike sharing system in the Washington, DC area that opened in September 2010, and currently has over 2,500 bicycles at more than 300 stations in Washington, DC, as well as Arlington County and the City of Alexandria in Virginia, and Montgomery County in Maryland (Capital Bikeshare, 2014b). CaBi was the largest bike sharing system in the U.S. between its opening in 2010 and July 2013, when it was surpassed by the newly launched CitiBike system in New York City. CaBi users can pay for 1- or 3-day passes, or they can become monthly or annual members. Short-term passes and CaBi memberships provide access to the entire system and the first 30-minutes of each trip are free of charge (Capital Bikeshare, 2014b). Annual membership increased 683% between March 2011 and March 2014, from a total of 6,267 to 42,839. System-wide trips increased 262%, from 64,045 to 167,671 trips per month during the same time period (Capital Bikeshare, 2014b). Ridership fluctuates by month of the year. For example, between April 2013 and March 2014, system-wide total monthly trips ranged from a low of 114,107 in January 2014 to a high of 296,333 in August 2013 (Capital Bikeshare, 2014a).

Figure 1. Capital Bikeshare Station Components.
(Photo Credit: Paul DeMaio).



While bike sharing offers a wide range of benefits relating to air quality and congestion, public health, transit access, transportation system efficiency, and neighborhood accessibility (DeMaio, 2009; ITDP, 2013; Shaheen, Guzman, et al., 2012; Shaheen, Martin, et al., 2012), concerns have been raised regarding the repurposing of limited public space for bikeshare docking stations as well as the impact of bikeshare systems on local businesses (Fascik, 2013; Wemple, 2011). Supporters contend that bike sharing attracts new customers, while opponents argue the systems deter customers and waste valuable public space (Flusche, 2012). The purpose of this study is to investigate the economic benefits of bike sharing, with a particular focus on the neighborhood level. First, we present an overview of the literature about the economic effects of cycling. We subsequently introduce our empirical method for studying the economic effects surrounding five CaBi stations, which entailed both a user intercept survey and a door-to-door survey of local businesses. Lastly, we present our empirical analysis and results, and conclude with a discussion of our findings.

4 LITERATURE REVIEW

Interest in the economic effects of cycling is growing. A number of recent studies have investigated: 1) the relationship between mode choice and spending patterns; 2) the relationship between cycling infrastructure and spending; 3) whether bike sharing generates new travel and spending; and 4) business perceptions regarding bike sharing systems and cycling in general. This is an emerging area of research with only a few peer-reviewed publications. Table 1 presents an overview of both domestic and international sources and includes two peer-reviewed articles, four peer-reviewed conference papers, three reports for municipalities and one for a national government transportation agency, seven graduate student research papers, twelve reports for interest groups, two reports for CaBi, and a grant application.

First, a number of studies suggest cyclists spend less per trip than drivers, but shop more frequently, and therefore spend at levels comparable to or higher than customers arriving by car.[1] For example, Clifton et al (2012) analyzed consumer spending and mode choice using intercept surveys at local businesses in the Portland, Oregon region. Overall, they found that non-driving customers spent amounts similar to or greater than customers arriving by automobile. Moreover, non-driving customers tended to visit spending locations more frequently. Stzabinski (2009) and Forkes & Smith Lea (2010) found similar results for sections of Toronto's Bloor Street. Using surveys of businesses and pedestrians, they found that non-drivers were likely to spend more per month than drivers.

Second, a number of recent studies suggest that cycling infrastructure, traffic calming, and investments in walking environments are effective at attracting customers.[2] For example, CaBi

[1] (Alliance for Biking & Walking, 2014; Bent & Singa, 2009; Bernier-Heroux & Ryan, 2012; Buis & Wittink, 2000; Clifton, Currans, et al., 2012; Clifton, Morrissey, & Ritter, 2012; Fiets Beraad, 2011; Fleming, Turner, & Tarjomi, 2013; Flusche, 2012; O'Connor, Nix, Bradshaw, & Shiel, 2011; Popovich & Handy, 2014; Sztabinski, 2009; Tolley, 2011).

[2] (Angelou Economics, 2010; Capital Bikeshare, 2011, 2013; Flusche, 2012; Forkes & Smith Lea, 2010; Meisel, 2010; NYCDOT, 2012; Smart Growth America, 2013; Sztabinski, 2009; Tolley, 2011).

collected information through surveys of its members (2011, 2013) on the relationship between the bikeshare system and patronage of local businesses and found that 83%-85% of users reported being "somewhat" or "much more" likely to patronize a business accessible by bikeshare. In addition, a study for the City of Austin, TX, estimated that the Downtown Bicycle Boulevard was likely to have a "very positive" impact on retail sales (Angelou Economics, 2010).

Third, there is evidence that bike sharing may generate new travel and spending.[3] For example, Schoner et al (2012) analyzed the economic activity associated with bikeshare stations in the Twin Cities, MN, Nice Ride system using trip data, a survey of local businesses, and a survey of system subscribers. They observed that bikeshare users often travel to spending destinations and estimated that up to about 13% of trips would not have occurred without the bike sharing system. In addition, Capital Bikeshare found that 9%-25% of users made induced (new) shopping trips over the course of a month in the Washington, DC region (2011, 2013).

Fourth, the literature suggests that businesses tend to have positive perceptions of bike sharing systems and cycling in general, mixed perceptions regarding direct impacts on sales, mixed levels of support for reallocating space to invest in bike sharing or other cycling facilities, and a tendency to overestimate the share of customers arriving by car vs. other modes.[4] For example, LoSapio (2013) conducted an analysis of the impact of Capital Bikeshare in the Dupont Circle neighborhood of Washington, DC, and found that 11% of businesses observed an increase in daily traffic and 13% perceived a positive impact on sales. In contrast, a study for the City of Vancouver indicated that some businesses attributed losses in sales and profits to newly installed bicycle lanes; nevertheless, review of a sample of sales data suggested losses were not as high as reported by businesses during the initial survey (Stantec Consulting Ltd, 2011). Schoner et al (2012) found that 17% of businesses would support replacing car parking with bikeshare stations and 8% would support using sidewalk space for bikeshare stations. Despite their general support for the Nice Ride program, the majority of businesses surveyed were not supportive of reallocating space in favor of bikeshare. This may relate to the tendency to overestimate the share of customers arriving by car observed in a number of locations (O'Connor et al., 2011; Sustrans, 2003, 2006).

Together, these studies suggest that cycling and bike sharing are associated with consumer spending and some induced travel. In addition, the literature suggests that cycling facilities can attract customers to nearby businesses. Further, businesses are generally supportive of bikeshare systems but have mixed perceptions about direct sales impacts and mixed degrees of support for the reallocation of space for cycling infrastructure. Building on this growing body of research, this present study makes a unique contribution by surveying bikeshare users at stations as well as businesses located adjacent to those same stations. To date, none of the existing literature has

[3] (Capital Bikeshare, 2011, 2013; Schoner, Harrison, & Wang, 2012).
[4] (Buis & Wittink, 2000; Drennen, 2003; Fleming et al., 2013; Lee, 2008; Losapio, 2013; McCormick, 2012; O'Connor et al., 2011; Schoner et al., 2012; Sinnett, Williams, Chatterjee, & Cavill, 2011; Stantec Consulting Ltd, 2011; Sustrans, 2003, 2006; Sztabinski, 2009; Tolley, 2011).

analyzed the impacts of a bikeshare system from both the user and business perspective at the neighborhood level.

Table 1. Overview of Literature on Economics and Cycling.

Authors	Year	Title	Publication Type	Methods, Data Source, Location	Key Findings
Alliance for Biking & Walking	2014	*Bicycling and Walking in the United States: 2014 Benchmarking Report*	Report for the Alliance for Biking and Walking	Review of local sources, reports, and peer-reviewed articles	Summarizes findings of increased spending relating to cyclists and pedestrians in New York, NY, Fort Worth, TX, Twin Cities, MN, Portland, OR, San Francisco, CA, and Austin, TX
Angelou Economics	2010	*Literature Review and Impact of the Bicycle Boulevard*	Report for the City of Austin, TX	Economic impact analysis of bicycle lanes and boulevards in Austin, TX using IMPLAN modeling, and data from the Texas Comptroller's Office and City of Austin	Austin Downtown Bicycle Boulevard estimated to have a 'very positive' impact on property values, retail sales, and quality of life ($96,000-$274,000 additional annual sales revenue due to bicycle traffic by 2020)
Bent, E. and K. Singa	2009	*Modal Choices and Spending Patterns of Travelers to Downtown San Francisco, California: Impacts of Congestion Pricing on Retail Trade*	Peer-Reviewed Article (Transportation Research Record)	Intercept surveys of a random sample of travelers over 16 years of age in San Francisco, CA on weekday afternoons & evenings in downtown retail areas (1,390 responses in downtown sample)	Transit riders, pedestrians, and cyclists spent less per trip than drivers, but visited downtown stores more frequently; Pedestrians spent the most per month of any modal group
Bernier-Heroux, L. and J. Ryan	2012	*East Village Shoppers Study: A Snapshot of Travel and Spending Patterns of Residents and Visitors in the East Village*	Report for Transportation Alternatives	Intercept surveys of a random sample of pedestrians on First and Second Avenues in East Village neighborhood of New York, NY (420 responses)	Pedestrians and cyclists visit the neighborhood more often than drivers and transit riders, and spend more on a weekly basis; Drivers account for less than 4% of retail spending in the neighborhood

Buis, J. and R. Wittink	2000	*The Economic Significance of Cycling: A Study to Illustrate the Costs and Benefits of Cycling Policy*	Report for Vereniging van Nederlandse Gemeenten (Association of Dutch Municipalities)	Review of local sources, reports, and peer-reviewed articles	Cyclists shop more frequently than drivers, and spend amounts comparable to motorists (over time)
Capital Bikeshare	2011	*2011 Capital Bikeshare Member Survey Report*	Report for Capital Bikeshare	Online survey of Capital Bikeshare members in the Washington DC region (3,731 responses from sample of 11,100 members representing half the total approximately 22,200 members, for a response rate of 34%)	83% of users reported being "somewhat" or "much more" likely to patronize a business if it were accessible by bikeshare; 44% of users made induced trips in prior month, including 25% who made induced shopping trips
Capital Bikeshare	2013	*2013 Capital Bikeshare Member Survey Report*	Report for Capital Bikeshare	Online survey of Capital Bikeshare members in the Washington DC region (5,464 responses out of approximately 18,000 members for a response rate of 31%)	85% of users reported being "somewhat" or "much more" likely to patronize a business if it were accessible by bikeshare; 40% of users made induced trips in prior month, including 9% who made induced shopping trips
Clifton, K., K. Currans, C. Muhs, C. Ritter, S. Morrissey, and C. Roughton	2012	*Consumer Behavior and Travel Choices: A Focus on Cyclists and Pedestrians*	Conference Paper (Transportation Research Board 92nd Annual Meeting)	Intercept surveys in Portland, OR at 78 businesses (restaurants, convenience stores, and drinking establishments) on weekday evenings (1,884 total responses, 52% combined response rate for 'short' and 'long' surveys)	Pedestrians, cyclists, and transit riders visit spending locations more frequently, and spent amounts similar to or greater than drivers
Clifton, K., S. Morrissey, and C. Ritter	2012	*Business Cycles: Catering to the Bicycling market*	Peer-Reviewed Article (TR News 280)	Review of local sources, reports, and peer-reviewed articles	Summarizes findings of lower or equal spending per trip but higher trip frequency of cyclists in Portland, OR, San Luis Obispo, CA, as well as Muenster in Germany and

					Utrecht and Amsterdam in The Netherlands
Drennen, E.	2003	*Economic Effects of Traffic Calming on Urban Small Businesses*	Graduate Student Report (San Francisco State University)	Interviews in San Francisco, CA with merchants in the service, food, and retail sectors via a modified random sampling about the Valencia Street bicycle lanes (27 businesses interviewed out of a total of 122 in the study area for a response rate of 22%)	65% of businesses perceive the general impact on business and sales of the bicycle lanes has been positive; 65.4% perceive no impact on the availability of customer parking and 15.4% perceive a positive impact on its availability; 44.4% perceive a positive impact for economic revitalization; 37.0% perceive a positive impact on sales with no businesses perceiving a negative impact
Fiets Beraad	2011	*Cyclists Spend as Much in Supermarket as Motorists*	Report for Fiets Beraad	Review of local research project involving interviews of shoppers at 4 suburban supermarkets in The Netherlands	Cyclists visit the supermarket 3.2 times per week and spend about 50 euros per trip, while drivers visit 2.5 times per week and spend more than 50 euros per trip; the weekly share of customer turnover is approximately 48% cyclists and 52% drivers
Fleming, T., S. Turner, and L. Tarjomi	2013	*Reallocation of Road Space*	Report for the New Zealand Transport Agency	Survey of retailers (in-person and mail) and shoppers (offered to customers by businesses after completion of a sale) in 3 central city locations and 6 arterial shopping	Transit riders, pedestrians, and cyclists spend less per trip than drivers but shop more frequently; Cyclists spend only $4 less per trip than drivers in central city locations

				areas in New Zealand (144 retailer surveys out of 547 total shops for a response rate of 26%, 1744 shopper responses)	
Flusche, D.	2013	*Bicycling Means Business: The Economic Benefits of Bicycle Infrastructure*	Report for Advocacy Advance	Review of local sources, reports, and peer-reviewed articles	Summarizes findings relating to cycling and economic impacts, including spending and customer levels, in Chicago, IL, Hattiesburg, MN, Long Beach, CA, Memphis, TN, Portland, OR, Washington, DC, and other locations
Forkes, J. and N. Smith Lea	2010	*Bike Lanes, On-Street Parking and Business - Year 2 Report: A Study of Bloor Street in Toronto's Bloor West Village*	Report for The Clean Air Partnership	In-person surveys of businesses and pedestrians in Toronto, ON on Bloor St between Kennedy Ave and Jane St (96 businesses out of 158 in the study area for a response rate of 61%, 510 pedestrians responses)	Customers who usually do not drive to the neighborhood are significantly more likely to spend over $100 per month than customers who usually drive
Lee, A.	2008	*What is the Economic Contribution of Cyclists Compared to Car Drivers in Inner Suburban Melbourne's Shopping Strips?*	Graduate Student Report (University of Melbourne)	Intercept surveys of visitors in Melbourne, AUS near the Lygon Court Shopping Centre about spending and travel patterns (1020 responses); Public space mapping	Cyclists spend less per trip than drivers and have shorter trip durations; Authors speculation that cyclists visit study area more frequently; 67% of public space in the study area is allocated to cars, versus 3% for cyclists
Losapio, R.	2013	*Is Capital BikeShare Good for Business: Initial Evidence from the Dupont Circle Area in Washington, D.C.*	Graduate Student Report (Virginia Tech)	In-person surveys in Washington, DC at 121 businesses (retail, entertainment, and restaurant) within 0.25 miles of a Dupont Circle bikeshare station	11% of businesses observed an increase in daily traffic related to Capital Bikeshare; 13% of businesses perceived a positive impact on sales; 39.0% of

				(92% response rate from random sample of 131 businesses out of 602 businesses in study area)	businesses considered their location positive in relation to Capital Bikeshare
McCormick, C.	2012	*York Blvd: The Economics of a Road Diet*	Graduate Student Report (UCLA)	Merchant (in-person) and customer (intercept) surveys in Los Angeles, CA on York Blvd between Eagle Rock Blvd and Figueroa St on two sections (section with road diet and section without road diet) (100 businesses out of 250 in study area for total response rate of 40%, and 25 customer responses from each road section for a total of 50 responses)	Most merchants and customers in both road sections perceive neutral or positive impacts of road diet; Merchants assume more customers drive than is reflected in customer surveys
Meisel, D.	2010	*Bike Corrals: Local Business Impacts, Benefits, and Attitudes*	Graduate Student Report (Portland State University)	Online survey in Portland, OR to businesses within 0.5 blocks of a bike corral (43 responses out of 132 businesses surveyed and 248 total businesses in study area for a survey response rate of 33%)	Support for bike corrals was widespread; On average 24.8% of customers were perceived to be cyclists; Demand for bike parking appears to be increasing
Metropolitan Washington Council of Governments	2010	*A Regional Bike-sharing System for the National Capital Region*	Grant Application (USDOT TIGER II)	Review of local conditions and information sources	Cycling investments make "good economic sense as a cost effective way to enhance shopping districts and communities, generate tourism and support business."

New York City Department of Transportation	2012	*Measuring the Street: New Metrics for 21st Century Street*	Report for the New York City Department of Transportation	Review of a cross-section of recent street design projects in New York, NY to achieve 3 goals (design for safety, all users, and great public spaces)	49% fewer commercial vacancies, compared to 5% more borough-wide, in Union Square North; 172% increase in retail sales, compared to 18% borough-wide, in Pearl Street area; 71% increase in retail sales, compared to 23% borough-wide, on Fordham Road
O'Connor, D., J. Nix, S. Bradshaw, and E. Shiel	2011	*Report on Shopper Travel Behaviour in Dublin City Centre*	Conference Paper (Irish Transport Research Network 2011 Proceedings)	Intercept survey of pedestrians in Dublin, IRE on Grafton and Henry Streets in the Dublin City Centre (1009 total responses); In-person survey of store managers (60 total from the study area)	Pedestrians and cyclists spender lower amounts per trip but visit the area more often than drivers; Businesses over-estimate the share of customers arriving by car
Popovich, N. and S. Handy	2014	*Bicyclists as Consumers: Mode Choice and Spending Behavior in Downtown Davis, CA*	Conference Paper (Transportation Research Board 93rd Annual Meeting)	Online surveys in Davis, CA, in 2009 and 2010, of residents regarding spending behavior (total of 2,043 responses for a response rate of 20.4%; subset of 1,677 responses used in the analysis)	Cyclists spent lower amounts per trip but shopped more frequently than drivers, leading to comparable spending across the two groups
Rowe, K.	2013	*Bikenomics: Measuring the Economic Impact of Bicycle Facilities on Neighborhood Business Districts*	Graduate Student Report (University of Washington)	Analysis of retail sales data based on case studies in Seattle, WA of Greenwood Ave North and NE 65th Street Neighborhood Business Districts after installation of bicycle facilities	Bicycle facilities and loss of automobile travel lanes and car parking did not result in negative impact regarding retail sales

Schoner, J., R. A. Harrison, and X. Wang	2012	*Sharing to Grow: Economic Activity Associated with Nice Ride Bike Share Stations*	Graduate Student Report (University of Minnesota)	Trip data for all 116 Nice Ride stations in the Twin Cities, MN, as of 2011, and surveys of businesses (in-person) and users (online) (29 businesses out of 68 businesses affiliated with Nice Ride and/or in station areas identified in a spatial sample for a response rate of 43%, 1197 users out of 3693 total surveyed for a response rate of 32%)	Station activity is positively associated with food-related businesses and job accessibility; Businesses have generally positive attitudes toward Nice Ride; Users often travel to spending destinations; Some new trips likely occur due to Nice Ride
Sinnett, E., K. Williams, K. Chatterjee, and N. Cavill	2011	*Making the Case for Investment in the Walking Environment: A Review of the Evidence*	Report for Living Streets	Review of local sources, reports, and peer-reviewed articles	Investments in walking environments have significant economic impacts; Economic contributions of pedestrians has been underestimated; Study in Bristol, UK showed businesses underestimated share of shoppers arriving by transit, cycling, and walking
Smart Growth America	2013	*Benefits of Complete Streets: Complete Streets Stimulate the Local Economy*	Report for Smart Growth America	Review of local sources, reports, and articles	Investments in transit, walking, and cycling can stimulate local economies; Summarizes findings from Dallas TX, Cleveland OH, Chicago IL, New York NY, San Francisco CA and others; Cites "green dividend" concept of local spending due to money saved from less driving

Stantec Consulting Ltd	2011	*Vancouver Separated Bike Lane Business Impact Study*	Report for the City of Vancouver, BC and Additional Partners	Stakeholder surveys of businesses regarding economic impacts in bike lane corridors and adjacent comparison corridors in Vancouver, BC (total response rate of 32%); Exit surveys of customers	Businesses attributed losses in sales and profits to bike lanes, but minimal sales data provided by businesses indicated losses were not as high as reported; Most customers did not change their shopping patterns as a result of the bike lanes
Sustrans	2003	*Traffic Restraint and Retail Vitality*	Report for Sustrans	Review of local sources, reports, and peer-reviewed articles	Reference to studies in Graz, Bristol, Leicester, and Edinburgh on tendency for businesses to overestimate share of customers arriving by car and correspondingly support increased car parking
Sustrans	2006	*Shoppers and How They Travel*	Report for Sustrans	Overview of study of business impacts of VIVALDI "showcase" bus routes in Bristol, UK, comprised of interviews with 126 retailers and 840 customers	Retailers overestimated share of customers arriving by car; Retailers attributed losses in business to bus routes, but most customers reported no change in shopping patterns; Investments in the walking environment should be effective at attracting customers
Sztabinkski, Fred	2009	*Bike Lanes, On-Street Parking and Business: A Study of Bloor Street in Toronto's Annex Neighborhood*	Report for The Clean Air Partnership	In-person surveys of businesses and pedestrians in Toronto, ON on Bloor St between Spadina Ave and Bathurst St (61 businesses out of 110 in the study area for a response rate of 55%, 538 pedestrians responses)	Customers arriving by walking and cycling shop more frequently and spend more per month than customers arriving by automobile or public transport

Tolley, R.	2011	*Good for Business: The Benefits of Making Streets More Walking and Cycling Friendly*	Discussion Paper (National Heart Foundation of Australia)	Review of local sources, reports, and peer-reviewed articles	Traffic calming and facilities for pedestrians and bicyclists are associated with increased retail spending, higher visitation frequencies, and longer dwell times
Wang, X., G. Lindsey, J. Schoner, and A. Harrison	2012	*Modeling Bike Share Station Activity: The Effects of Nearby Businesses and Jobs on Trips to and from Stations*	Conference Paper (Transportation Research Board 92nd Annual Meeting)	Trip data for all 116 Nice Ride stations in the Twin Cities, MN, as of 2011 (mean annual trips per station of 3,749)	Station activity positively associated with food-related businesses and employment, but not general retail establishments

5 METHODS

To investigate the economic benefits of bike sharing at the neighborhood level, we collected primary data from CaBi users and businesses in five Washington, DC neighborhoods. Our empirical strategy entailed selecting a sample of bikeshare stations, designing and implementing the user and business surveys, and conducting a quantitative analysis.

CAPITAL BIKESHARE STATION SELECTION

The following criteria guided our sampling of CaBi stations. First, we sought to generate a sample representing different neighborhoods of the city. Second, we sought to control for the effect of proximity to MetroRail by including both a station near MetroRail as well as additional stations outside the typical MetroRail walkshed. Third, we sought to focus on areas with many businesses close to bikeshare and many bikeshare drop-offs and pick-ups. Our sample included the following stations (see also Figure 2).

- **Dupont Circle** (Massachusetts Ave & Dupont Circle)
- **Georgetown** (C&O Canal & Wisconsin Ave NW)
- **Logan Circle** (14th St NW & Rhode Island Ave NW)
- **Adams Morgan** (Adams Mill Rd NW & Columbia Rd NW)
- **H Street** (13th St NE & H St NE)

The Dupont Circle bikeshare station has been the busiest in the system, including the highest level of activity during the 2nd Quarter of 2013, is located next to a MetroRail station, and was studied by LoSapio (2013) in her analysis of the economic impacts of bikeshare on businesses. Because of the high volume of bikeshare usage at this station, we anticipated a high yield for survey responses.

In addition, the other four stations were chosen from a sub-sample of CaBi stations outside the typical MetroRail walkshed, estimated to be a 10-minute (or 0.5-mile) walk based on the existing street network and a pace of three miles per hour. This walkshed measure fits within relevant estimates that vary from one-fifth to one-half mile (O'Sullivan & Morrall, 1996; Weinstein Agrawal, Schlossberg, & Irvin, 2008). We chose stations outside the typical MetroRail walkshed to control for the presence of MetroRail and its effect on local businesses.

Four stations were chosen from among the CaBi stations outside the MetroRail walkshed based on high levels of bikeshare activity and a high number of businesses within 0.1 miles of the station, as well as locations within different Washington, DC neighborhoods. In particular, we identified these stations using trip data for CaBi from the 2nd Quarter of 2013 along with the ReferenceUSA business database and the North American Industrial Classification Codes 44 (Retail Trade), 71 (Arts, Entertainment, and Recreation), and 72 (Accommodation and Food Services). We chose to include stations with high commercial activity, as opposed to those located in residential areas, in order to generate a sample suited to investigating the effects of bikeshare on local businesses at the neighborhood level.

Figure 2. Capital Bikeshare Station Sample in Relation to Streets and MetroRail Stations.

USER SURVEY

We designed the 2013 Virginia Tech Capital Bikeshare User Survey to create profiles of CaBi users, find out about motivations for using CaBi and understand the spending patterns of CaBi riders in relation to neighborhood businesses surrounding CaBi stations. We worked with Virginia Tech graduate students enrolled in a Fall 2013 studio class to design and conduct a 23-question intercept survey. The graduate students conducted the surveys in 2-4 hour shifts over four weekends (Friday afternoon through Sunday) in October 2013 at the five CaBi stations described above by approaching users as they returned bikes to the stations. The survey focused on spending after the most recent CaBi trip taken. In order to target individuals who frequent spending destinations, we chose to survey on weekends, when commute trips were less likely and discretionary trips were more likely. Moreover, we expected a higher participation rate from non-commuters who were less time-constrained, and a higher share of CaBi users going to spending destinations – the main target group for our study.

BUSINESS SURVEY

We designed the 2013 Virginia Tech Capital Bikeshare Business Survey to understand the impacts of the CaBi system on local businesses. Again, we worked with Virginia Tech graduate students enrolled in the studio class to design and conduct a 22-question in-person paper-based survey. The graduate students conducted the surveys over five weeks in October and November 2013 at businesses located within 0.1 miles of the five CaBi stations discussed above. We obtained a list of 326 businesses in this radius from the ReferenceUSA database using the North American Industrial Classification codes 44 (Retail Trade), 71 (Arts, Entertainment, and Recreation), and 72 (Accommodation and Food Services). Respondents included business owners, managers, and other staff. With the survey, we sought to collect information from businesses about their perceptions of the impact of the bikeshare system.

6 RESULTS

USER SURVEY

A total of 333 users completed our survey after dropping off a bicycle at one of the five CaBi stations. Our response rate was at least 50% per station and shift. In general, our sample had a demographic profile that was similar to the most recent Capital Bikeshare Member Survey (2013), as summarized in Table 2.

Table 2. Demographics of Capital Bikeshare Annual Members and Virginia Tech User Survey Sample.

Variable	Annual Members (Capital Bikeshare, 2013)	Virginia Tech Sample
Age	63% under 35; 20% age 35-44; 11% age 45-54; 6% age 55+	67% under 35; 20% age 35-44; 9% 45-54; 4% age 55+
Gender	57% Male; 43% Female	65% Male; 35% Female
Household Income	8% less than $35,000; 31% $35,000-$74,999; 30% $75,000-$124,999; 31% $125,000+	10% less than $35,000; 29% $35,000-$74,999; 33% $75,000-$124,999; 28% $125,000+
Education	5% less than 4-year degree; 39% 4-year degree; 41% Master's degree; 15% Doctorate	6% less than 4-year degree; 41% 4-year degree; 37% Master's degree; 16% Doctorate

The majority of the users in our sample were under the age of 35 (67%) and male (65%). About half of respondents (53%) reported having attained a master's degree or higher and nearly all respondents (94%) had a bachelor's degree. Only 10% of respondents reported a household income less than $35,000 and over a quarter reported a household income above $125,000. Approximately 66% of respondents were annual members of Capital Bikeshare, while another 23% were 24-hour members.

Large segments of our sample shared several motivations for choosing CaBi. In particular respondents cited the following reasons for choosing CaBi for the most recent trip: shorter travel times (73%), enjoyment (42%), exercise (41%), and lower travel costs (25%). In addition, 66% of users reported traveling to a destination associated with consumer spending (e.g. food-related, retail, or entertainment). Of those users, 65% planned to spend between $10-$49 and 29% planned to spend over $50. Most users traveling to spending destinations indicated they would be spending at a business nearby the station, with 34% reporting spending would occur within 2 blocks of the station and an additional 45% indicating spending would occur within 4 blocks.

About one in six respondents (16%) indicated they would not have made their trip to the neighborhood without the presence of the CaBi station, while 78% indicated they would have made the trip regardless of CaBi and 6% reported being unsure. Of those respondents who reported making an induced trip, 19% would have stayed home and not traveled to another neighborhood.

Overall, 23% of users indicated they were likely to spend more during the trip because of arriving by CaBi and not another mode, and 67% indicated they were likely to spend the same amount or were unsure. Table 3 provides a summary of key results from the user sample.

Table 3. Summary of 2013 Virginia Tech Capital Bikeshare User Survey Results.

User Survey	**%**	**N**
Top reasons for using CaBi		
Travel Time	73%	333
Enjoyment	42%	333
Exercise	41%	333
Travel Costs	25%	333
Share of Users Traveling to Spending Destination	66%	333
Spending Less Than $10	6%	198
Spending $10-$49	65%	198
Spending $50 or More	29%	198
Spending Within 2 Blocks of Station	34%	190
Spending Within 4 Blocks of CaBi Station	45%	190
Spending Greater than 4 Blocks/Did Not Know	22%	190
Share of Users Making New/Induced Trip	16%	326
Share of Users Making a Trip Regardless of CaBi	78%	326
Share of Users Spending More Because of CaBi	23%	260

In addition to the results presented above on the user sample as a whole, we investigated the significance of a series of bivariate relationships between user characteristics and economic effects. In particular, we focused on whether new trips, trips to spending destinations, new trips to spending destinations, or spending levels varied across a series of user characteristics. Table 4 summarizes the dependent and independent variables analyzed, along with their level of measurement and definition.

Table 4. Description of Dependent and Independent Variables for User Survey Bivariate Analysis.

Variable	Description
New/Induced Trip (Dependent)	Nominal, 1/0 (New/Induced Trip v Not a New/Induced Trip)
Spending Trip (Dependent)	Nominal, 1/0 (Spending Trip v Not a Spending Trip)
Spending Level (Dependent)	Ordinal, 3 categories (Less than $10, $10-$49, $50 or More)
New Trip with Spending (Dependent)	Nominal, 1/0 (New/Induced Trip to Spending Destination v Not a New Trip to Spending Destination)
Annual Member (Independent)	Nominal, 1/0 (Annual Member v Daily or Monthly)
Cyclist Type (Independent)	Nominal, 4 categories (Strong, Moderate, Curious, Not a Cyclist)
Education (Independent)	Nominal, 1/0 (Bachelor's Degree & Higher v Less than Bachelor's)
Gender (Independent)	Nominal, 1/0 (Male v Female)
Income Level (Independent)	Ordinal, 4 categories (<$35K, $35K-$74,999, $75K-$124,999, >$125,000)
Joined for Fun (Independent)	Nominal, 1/0 (Joined for Fun v Did not Join for Fun)
Joined to Save Money (Independent)	Nominal, 1/0 (Joined to Save Money v Did not Join to Save Money)
Number of CaBi trips (Independent)	Interval-Ratio, Number of CaBi trips in previous month
Station (Independent)	Nominal, 5 stations (Adams Morgan, Dupont Circle, Georgetown, H Street, Logan Circle)
Trip by CaBi b/c Cost (Independent)	Nominal, 1/0 (Made trip by CaBi because of cost v Did not Make Trip Because of cost)
Trip by CaBi b/c Speed (Independent)	Nominal, 1/0 (Made trip by CaBi because of Speed v Did not Make Trip because of speed)

We performed statistical tests[5] to evaluate the significance of the bivariate relationships, and also calculated appropriate measures of bivariate association to evaluate the strength and direction of the relationships.[6] Table 5 summarizes the results of our analysis of these bivariate relationships.

[5] All of our dependent variables were either measured on the nominal or ordinal level of measurement. Thus, chi-square tests are appropriate. In a few instances, cell frequencies were small, casting doubt on the reliability of Chi^2 tests. In these instances, we also used Fisher's Exact Tests. However, the outcomes of the statistical tests did not vary between Chi^2 and Fisher's Exact Tests in any of those instances. Thus for brevity, we report all Chi^2 p-values in Table 4, even though some are based on Fisher's exact test.

[6] Cramer's V for the nominal dependent variables and proportional reduction in error ("PRE") measures for the ordinal dependent variable (spending level). Specifically, we used Lambda for

Income level had statistical significance across three of the four dependent variables. There were also positive measures of association between income level and new trips, spending trips, spending levels, and new trips with spending. Joining CaBi to save money had a significant positive association with new trips. New trips varied significantly by station area, with the Dupont Circle and Georgetown stations reporting the highest shares of new trips and H Street reporting the lowest share. For spending trips, we found a significant association with station area, with Georgetown and H Street reporting the highest shares of spending trips and Logan Circle reporting the lowest. Joining CaBi for enjoyment and taking the trip by CaBi because of cost had a significant association with spending level. Finally, new trips with spending had a significant association with station area, with Dupont Circle and Georgetown having the highest shares and H Street the lowest. Appendix 1 presents detailed frequency tables for the user survey bivariate relationships found to be significant.

Table 5. Summary of User Survey Bivariate Relationships.
(Note: significant p-values (<.1) in bold).

Independent	**Dependent Variable**			
	Chi^2 p-value			
	New/Induced Trip	Spending Trip	Spending Level	New Trips With Spending
Annual Member	>0.10	>0.10	>0.10	>0.10
Cyclist Type	>0.10	>0.10	>0.10	>0.10
Education	>0.10	>0.10	>0.10	>0.10
Gender	>0.10	>0.10	>0.10	>0.10
Income Level	***0.060***	>0.10	***0.019***	***0.017***
Joined for Fun	>0.10	>0.10	***0.070***	>0.10
Joined to Save Money	***0.025***	>0.10	>0.10	>0.10
Number of CaBi trips	>0.10	>0.10	>0.10	>0.10
Station	***0.049***	***0.000***	>0.10	***0.033***
Trip by CaBi b/c Cost	>0.10	>0.10	***0.099***	>0.10
Trip by CaBi b/c Speed	>0.10	>0.10	>0.10	>0.10

BUSINESS SURVEY

A total of 140 businesses completed the business survey out of the initial list of 326 total businesses for an overall response rate of approximately 40%. Response rates varied across station areas, from approximately 24% in Adams Morgan to 51% in H Street, as well as business

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the nominal independent variables and Gamma for the ordinal and interval/ratio independent variables.

type, from 17% for non-food and non-retail businesses to 51% for food-related businesses and 63% for retail businesses.

The vast majority of respondents were aware of the CaBi system (88%), and 32% reported having experience using the system. However, most businesses did not know if CaBi had any effect on customer traffic levels. Nevertheless, approximately 10% perceived an increase in customer traffic because of CaBi. One in five businesses perceived that CaBi has positively impacted their sales while another 79% reported a neutral impact or were unsure and 1% perceived a negative impact. In addition, most businesses (70%) indicated CaBi has had a positive effect on the neighborhood, while another 29% reported a neutral impact or were unsure.

Further, 69% described the location of their business in relation to CaBi as favorable, and 59% indicated they would like more CaBi stations to be added. Regarding public space tradeoffs, 22% of businesses indicated they would have a positive reaction to replacing sidewalk space with a CaBi station, while an additional 26% would be neutral and 52% would have a negative reaction. Finally, 29% would have a positive reaction to replacing car parking with a CaBi station, while an additional 32% would be neutral about removing car parking in favor of a bikeshare station and 39% would have a negative reaction. Table 6 provides a summary of key results from the business sample.

Table 6. Summary of 2013 Virginia Tech Capital Bikeshare Business Survey Results.

Business Survey	**%**	**N**
Impact of CaBi on Overall Customer Traffic		
Increased	10%	133
No Change	28%	133
Decreased	1%	133
Unsure	61%	133
Impact of CaBi on Overall Sales		
Positive	20%	133
Neutral	36%	133
Negative	1%	133
Unsure	43%	133
Impact on the Neighborhood		
Positive	70%	133
Neutral	7%	133
Negative	2%	133
Unsure	22%	133
Would Like CaBi to		
Install New Stations	59%	138
Remove Existing Stations	1%	138
Neither Install Nor Remove Stations	27%	138
Unsure	13%	138
Reaction to Replacing Sidewalk Space With CaBi		
Positive	22%	138
Neutral	26%	138
Negative	52%	138
Reaction to Replacing Car Parking With CaBi		
Positive	29%	136
Neutral	32%	136
Negative	39%	136

In addition to the results presented above on the business sample as a whole, we investigated the significance of a series of bivariate relationships to identify correlates of perceived economic effects. In particular, we focused on whether business perceptions of CaBi's impact on sales, perceptions of overall sales, support for installing more CaBi stations, and support for replacing car parking with CaBi stations varied across a series of business characteristics. Table 7 summarizes the dependent and independent variables analyzed, along with their level of measurement and definition.

Table 7. Description of Dependent and Independent Variables for User Survey Bivariate Analysis.

Variable	Description
CaBi Impact on Sales (Dependent, Independent)	Nominal, Perceived Impact of CaBi on Sales (Positive, Neutral, Negative, Don't Know)
Overall Sales (Dependent)	Nominal, Perceived Change in Overall Sales in Previous 12 months (Increased, No Change, Decreased, Don't Know)
Install More CaBi Stations (Dependent, Independent)	Nominal, 1/0 (Interested in seeing more CaBi stations installed v Interested in seeing stations removed or neither removed/installed)
Car Parking Change (Independent)	Nominal, 1/0 (Perceive replacing car parking for CaBi positively v Perceive replacing car parking for CaBi negatively or neutrally)
Station (Independent)	Nominal, 5 stations (Adams Morgan, Dupont Circle, Georgetown, H Street, Logan Circle)
Business Type (Independent)	Nominal, 3 categories (Retail, Food-Related, Other)
Business Size (Independent)	Ordinal, 4 categories (1-9 workers, 10-19 workers, 20-29 workers, >30 workers)

We performed statistical tests[7] to evaluate the significance of the relationships, and also calculated appropriate measures of association to evaluate the strength and direction of the relationships.[8] Table 8 summarizes the results of our analysis of these bivariate relationships.

We did not find significant variation regarding business perceptions of CaBi's impact on sales across station areas, business type, or business size. Perceptions regarding overall sales significantly varied across station areas, with the highest share of businesses perceiving increased sales in Georgetown and the lowest share in Dupont Circle. We found a significant and positive relationship between support for installing more CaBi stations and perceived impact of CaBi on sales. Finally, we found a significant and positive association between support for replacing car parking with CaBi and perceived impact of CaBi on sales (at the 10% level) as well as support for installing more CaBi stations. Appendix 2 presents detailed frequency tables for the business survey bivariate relationships found to be significant.

[7] All of our variables were either measured on the nominal or ordinal level of measurement. Thus, chi-square tests are appropriate. As was the case with the user survey, in a few instances, cell frequencies were small and we used Fisher's Exact Tests in addition to Chi^2. Similar to the user survey, the outcomes of the statistical tests did not vary between Chi^2 and Fisher's Exact Tests in any of those instances. We report all Chi^2 p-values in Table 7 even though some are based on Fisher's exact test.

[8] Cramer's V for the nominal dependent variables. CaBi impact on sales and overall sales were treated as nominal (rather than ordinal) to account for the "don't know" category.

Table 8. Summary of Business Survey Bivariate Relationships.
(Note: significant p-values (<.1) in bold).

Independent	**Dependent Variable**			
	Chi^2 p-value			
	CaBi Impact on Sales	Overall Sales	Install More CaBi Stations	Car Parking Change
Station	>0.10	***0.064***	>0.10	>0.10
Business Type	>0.10	>0.10	>0.10	>0.10
Business Size	>0.10	>0.10	>0.10	>0.10
CaBi Impact on Sales	NA	>0.10	***0.023***	***0.078***
Install More CaBi Stations	NA			***0.030***

7 DISCUSSION AND CONCLUSIONS

Our analysis of five Capital Bikeshare station areas suggests that bikeshare stations may have significant economic benefits at the neighborhood level, based on the intentions and perceptions of users and businesses surveyed in this study. The results of our survey suggest that users incur both monetary and non-monetary benefits in terms of lower travel costs and time savings. We found that most users (73%) were motivated to use CaBi because cycling was faster than other modes for that particular trip, while 25% were motivated because using the system offered monetary savings compared to other modes. The results of our business survey suggest that businesses perceive both monetary and non-monetary benefits in terms of increased customer traffic and sales, as well as positive impacts on the neighborhood. Our business survey indicated 20% of businesses perceived a positive impact on customer sales, while 70% reported a positive impact on the neighborhood.

Our user survey suggests that the CaBi stations are encouraging new trips to the station areas and new spending at nearby businesses. The results of our business survey mirror this finding, as 10% of businesses perceive increases in customer traffic and 20% perceive increases in customer sales. While many of these effects are likely redistributive in nature, we found evidence to suggest that a portion of these outcomes relate to new trips and new spending in the area. Our results suggest 16% of users made new trips because of the presence of the CaBi station, and 19% of those traveling to the neighborhood regardless of CaBi reported increased spending due to their use of CaBi. Therefore, it is likely that at least a portion of the travel cost and time savings incurred by CaBi users is spent at businesses surrounding stations.

The bivariate analysis of our user survey suggests there is no difference in new trips, spending trips, spending at various levels, and new trips to spending locations based on annual membership status, cyclist type, education, gender, number of recent CaBi trips, or the influence of speed in choosing CaBi for the most recent trip. Economic theory suggests that income is associated with spending patterns, and we found this holds for CaBi users as well, with

household income positively associated with new trips, spending at higher rates, and new trips with spending at the neighborhood level.

The bivariate analysis of our business survey suggests there is no significant difference across station areas, business types (e.g. retail, food, other), and business size in perceived impacts of CaBi on sales, support for the installation of more CaBi stations, or support for replacing car parking with CaBi stations. Moreover, we found that businesses with a perception of positive impacts on sales support expansion of the CaBi system and reallocation of space toward CaBi. Similarly, businesses that support expansion of the system were more likely to support reallocation of space away from car parking and toward CaBi. Together, these findings suggest that bikeshare operators seeking to expand their bikeshare system should start near businesses that perceive positive impacts on sales, and operators seeking to replace car parking with CaBi stations may find this most feasible near businesses that support expansion of the system as a whole.

While caution should be taken in directly comparing the magnitude of our overall sample findings to those of prior studies, due to such differences as sampling design, geography, and demographics, our findings are largely consistent with those presented in other recent studies. Our findings regarding top motivations for joining CaBi are slightly lower, but largely consistent with the most recent CaBi annual member surveys (73% in our sample vs. 85%-91% of annual members for travel time, 42% in our sample vs. 64%-76% of annual members for enjoyment, 41% in our sample vs. 4%-57% of annual members for exercise, 25% in our sample vs. 46%-52% of annual members for travel costs) (Capital Bikeshare, 2011, 2013).

Our study also lends support to the recent findings that indicate cycling facilities attract customers to nearby businesses. We found that 66% of users reported traveling to spending destinations and of those 63% planned to spend $10-$49. This is higher than the $7-$14 estimated spending per trip found by Schoner et al (2012), and may be related to the higher cost of living and higher incomes in the Washington, DC area compared to the Minneapolis/St. Paul area, as well as the focus on weekend spending in the present study, which could be more discretionary in nature. In addition, our finding that a high share of users traveling to spending destinations intended to visit establishments nearby bikeshare stations (34% within 2 blocks and another 45% within 4 blocks) is consistent with the annual membership survey, which indicated 83%-85% of users were more likely to patronize businesses near bikeshare stations (Capital Bikeshare, 2011, 2013).

Our findings regarding new travel and new spending in relation to bike sharing are consistent with other recent estimates. About 16% of users in our sample reported making new trips, which is higher than the upper range of 13% given for various business types by Schoner et al (2012) but squarely within the range of 9%-25% found by Capital Bikeshare (Capital Bikeshare, 2011, 2013). A future study could further investigate the factors that influence the relationship between bikeshare and new travel and spending.

In terms of business perceptions, this study is consistent with prior findings of overall positive perceptions of bike sharing and cycling, but mixed perceptions regarding impacts on sales and mixed support for reallocating space toward bike sharing. Both Schoner et al (2012) and the

present study found more support among businesses for replacing car parking with bikeshare stations than for replacing sidewalk space. However, we found a higher level of support in our five Washington, DC neighborhoods than was found for the Minneapolis/St. Paul area (29% in our study vs. 17% in their study for car parking and 22% in our study vs. 8% in their study for sidewalk space). One possible explanation is that businesses in Washington, DC are more accustomed to non-driving customers, given the larger and more extensive public transport system in the region. This finding may also relate to the relatively high traffic congestion levels in Washington, DC, which could discourage driving to spending destinations. Our results were also largely comparable to LoSapio's (2013) analysis of the Dupont Circle neighborhood, where we found 10% of businesses perceived increases in daily traffic and 20% perceived increases in sales compared to her findings of 11% and 13% respectively.

Our bivariate analysis found a positive correlation between perceived impact of CaBi on sales and support for both system expansion and the replacement of car parking with bikeshare. Future studies could further investigate factors that influence support for the reallocation of space toward bike sharing; it could be that more accurate perceptions by businesses of the travel patterns of their customers could lead to greater support for bike sharing and cycling in general.

There are important limitations to our study design and the generalizability of our findings. First, we collected data during a single time period, so our data are not designed to capture changes over time. It could be that both user and economic development effects will change as more stations are added to the CaBi system, more on-street cycling facilities are added throughout Washington, DC, and more people become members of CaBi. In addition, spending patterns may differ significantly between the 2nd Quarter (when our study was conducted) and other times of the year. Second, our station selection criteria provided us with a sample characterized by high commercial activity. As a result, our findings are likely not applicable to the CaBi system as a whole or to Washington, DC as a whole. In addition, our surveying of users on weekends intentionally focused on discretionary trips rather than commute trips; a future study could compare user spending in relation to discretionary versus commute travel. Third, as is typical of primary data collection efforts, our results depend on the comprehension of our survey respondents, both in terms of our survey questions and in terms of their behavior and perceptions. Fourth, our surveys captured stated spending behavior from users and perceived impacts from businesses, rather than actual spending at businesses or behavior by bikeshare users. Future studies could attempt to measures these outcomes more directly. Fifth, our methodology was not designed to directly capture spending information across modal groups. Future studies could build on the literature regarding spending levels and mode choice by incorporating bike sharing and other modes in one study. Moreover, future studies could focus on questions regarding public space tradeoffs from both the user and business perspective. This could inform comparisons across bike sharing systems and provide a deeper understanding of the factors influencing local debates. Another area for consideration could be further study of the generative and redistributive impacts of bike sharing in terms of trip levels and spending.

Overall, we find evidence that bike sharing offers benefits to both users and businesses by enabling new trips and spending. In particular, we found evidence to suggest users and businesses perceive both monetary and non-monetary benefits from bikeshare, and that a significant share of users are likely to spend money at businesses located near CaBi stations. In

addition, we found mixed support for the reallocation of public space among businesses, but a majority (61%) that would react positively or neutrally to the replacement of car parking with a CaBi station. Our study may inform ongoing debates surrounding the effects of bike sharing in relation to local businesses.

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9 APPENDIX 1. DETAILED TABLES FOR USER SURVEY BIVARIATE ANALYSIS

Table 9. Frequency Tables for New Trips, Spending Trips, Spending Levels, and New Trips With Spending in Relation to Income Level.

	Income Level				
	<$35,000	$35,000 - $74,999	$75,000 to $124,999	$125,000 or More	Total
New Trip	2	9	21	17	49
	7%	11%	23%	22%	18%
Not a New Trip	27	72	70	62	231
	93%	89%	77%	78%	83%
Total	29	81	91	79	280
	100%	100%	100%	100%	100%
Less than $10	0	5	3	1	9
	0%	9%	5%	2%	5%
$10-$49	6	39	40	25	110
	60%	74%	70%	50%	65%
$50 or More	4	9	14	24	51
	40%	17%	25%	48%	30%
Total	10	53	57	50	170
	100%	100%	100%	100%	100%
New Trip With Spending	0	8	19	15	42
	0%	15%	32%	28%	23%
Not a New Trip With Spending	14	47	41	39	141
	100%	85%	68%	72%	77%
Total	14	55	60	54	183
	100%	100%	100%	100%	100%

Table 10. Frequency Tables for Spending Levels in Relation to Joining CaBi for Enjoyment.

	Joined Capital Bikeshare for Enjoyment		
	No	Yes	Total
Less than $10	2	9	11
	3%	7%	6%
$10-$49	41	88	129
	59%	69%	65%
$50 or More	27	31	58
	39%	24%	29%
Total	70	128	198
	100%	100%	100%

Table 11. Frequency Tables for Spending Levels in Relation to Joining CaBi to Save Costs.

	Joined Capital Bikeshare to Save Money		
	No	Yes	Total
New Trip	16	37	53
	11%	20%	16%
Not a New Trip	128	145	273
	89%	80%	84%
Total	144	182	326
	100%	100%	100%

Table 12. Frequency Tables for New Trips, Spending Trips, and New Trip With Spending in relation to Station Area.

	Station Area					
	Georgetown	Adams Morgan	Dupont Circle	Logan Circle	H Street	Total
New Trip	26	3	16	8	0	53
	20%	10%	22%	10%	0%	16%
Not a New Trip	102	27	56	74	14	273
	80%	90%	78%	90%	100%	84%
Total	128	30	72	82	14	326
	100%	100%	100%	100%	100%	100%
Spending Trip	105	15	50	38	11	219
	80%	50%	67%	46%	79%	66%
Not a Spending Trip	26	15	25	45	3	114
	20%	50%	33%	54%	21%	34%
Total	131	30	75	83	14	333
	100%	100%	100%	100%	100%	100%
New Trip With Spending	25	2	12	6	0	45
	20%	7%	17%	7%	0%	14%
Not a New Trip With Spending	103	28	60	76	14	281
	80%	93%	83%	93%	100%	86%
Total	128	30	72	82	14	326
	100%	100%	100%	100%	100%	100%

Table 13. Frequency Table for Spending Level in relation to Motivation to Make Trip by CaBi due to Cost.

	Trip by Capital Bikeshare due to Cost		
	No	Yes	Total
Less than $10	5	6	11
	3%	11%	6%
$10-$49	96	33	129
	66%	62%	65%
$50 or More	44	14	58
	30%	26%	29%
Total	145	53	198
	100%	100%	100%

10 APPENDIX 2. DETAILED TABLES FOR BUSINESS SURVEY BIVARIATE ANALYSIS

Table 14. Frequency Tables for Overall Sales in Relation to Station Area.

	Station Area					
	Georgetown	Adams Morgan	Dupont Circle	Logan Circle	H Street	Total
Increased	22	5	5	8	13	53
	52%	50%	23%	50%	46%	45%
No Change	4	0	4	2	10	20
	10%	0%	18%	13%	36%	17%
Decreased	10	3	8	2	2	25
	24%	30%	36%	13%	7%	21%
Unsure	6	2	5	4	3	20
	14%	20%	23%	25%	11%	17%
Total	42	10	22	16	28	118
	100%	100%	100%	100%	100%	100%

Table 15. Frequency Tables for Support for Expanding CaBi and Support for Replacing Car Parking in Relation to CaBi Impact on Sales.

	Capital Bikeshare Impact on Sales				
	Positive	Neutral	Negative	Unsure	Total
Support Installing New Stations	22	23	0	34	79
	81%	48%	0%	60%	59%
Do Not Support or Unsure	5	25	1	23	54
	19%	52%	100%	40%	41%
Total	27	48	1	57	133
	100%	100%	100%	100%	100%
Support Replacing Car Parking	11	8	0	20	39
	42%	17%	0%	36%	30%
Neutral on Replacing Car Parking	10	16	0	15	41
	38%	33%	0%	27%	31%
Oppose Replacing Car Parking	5	24	1	21	51
	19%	50%	100%	38%	39%
Total	26	48	1	56	131
	100%	100%	100%	100%	100%

Table 16. Frequency Table for Support for Replacing Car Parking with CaBi in Relation to Support for CaBi Expansion.

	Capital Bikeshare Expansion		
	Support Installing New Stations	Do Not Support or Unsure	Total
Support Replacing Car Parking	29	10	39
	36%	18%	29%
Neutral on Replacing Car Parking	27	17	44
	33%	31%	32%
Oppose Replacing Car Parking	25	28	53
	31%	51%	39%
Total	81	55	136
	100%	100%	100%