Bicyclists as Consumers: Mode Choice and Spending Behavior in Downtown Davis, CA

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ABSTRACT

This paper explores the role of bicyclists as consumers by examining the relationship between travel mode and shopping behavior. As cities develop policies to combat congestion and reduce emissions from the transportation sector, there is often tension over how to best allocate scarce road space, particularly in denser urban cores. The challenge is to accommodate all travel modes while ensuring that local businesses are not negatively impacted by infrastructure changes. Previous studies in the US and abroad have shown that bicyclists make more frequent purchases than their car-driving and transit-riding counterparts and tend to shop at smaller businesses closer to home, but that motorists tend to spend more money on single occasions. While those studies focused primarily on consumable goods, this study examines retail expenditures. The objective of this study is to examine how shopping behavior in downtown Davis, CA varies between bicyclists and motorists – two groups that are in perpetual competition for parking spaces and other infrastructure accommodations. We conducted two cross-sectional online surveys in 2009 and 2010 with a total of 2,043 respondents that asked questions about recent shopping in downtown Davis. We found that customers who biked on their most recent trip downtown spent slightly lower amounts on average on their purchases each trip than their auto-driving counterparts, but that they made more frequent shopping trips, thus contributing comparable amounts of money to downtown establishments as customers travelling by car.

INTRODUCTION

The externalities of transportation include, but are not limited to, greenhouse gas emissions, traffic congestion, air pollution, accidents, and road maintenance costs. In developing policies to combat congestion, on one hand, and reduce emissions and other environmental effects, on the other, cities often face tension over how to best allocate scarce road space. Traditionally, priority for road space and on-street parking has gone to cars. However, communities are increasingly recognizing the importance of other modes in delivering customers to local businesses. But efforts to reallocate road space from cars to transit, bicyclists, or pedestrians often raise a strong outcry, not just from drivers but also from the businesses that the improvements may benefit. The challenge is to reallocate road space in a way that equitably accommodates all travel modes used by customers while ensuring that local businesses are not negatively impacted by infrastructure changes. Understanding the contribution of different modes to local economic activity is important for addressing that challenge.

This study aims to shed light on the relative economic contributions of customers arriving by bicycle versus car in downtown Davis, CA. Recently, the city has converted a number of on-street parking spaces to bike parking, at the same time that downtown merchants have been pushing the city to build an additional parking garage. This controversy over the use of scarce downtown space has drawn increasing attention to the trade-offs between accommodating cars and bicycles downtown. We analyze data from two cross-sectional online surveys conducted in 2009 and 2010 that asked a total of1,677 residents about recent shopping trips to downtown Davis. First, we examine differences between bicyclists and drivers with respect to socio-demographic and attitudinal characteristics. Second, we examine differences in shopping behavior for bicyclists and drivers. The results show that bicyclists are at least as important as drivers as downtown customers and thus provide support for efforts to improve bicycle access to downtown.

BACKGROUND

Globally, few studies have been conducted on the connection between mode choice and consumer spending habits; only one peer-reviewed journal articles has been published on the topic in the U.S. (*1*). Past research has found correlations between mode choice and consumer behavior, with two key patterns emerging: bicyclists tend to spend more money per capita than shoppers that use other modes, and business owners tend to underestimate the percentage of their customers who arrive by active modes. Many of these studies focused on spending on consumable goods and grocery items, whereas our study looks primarily at expenditures on retail items. Almost all previous studies on this topic were conducted via intercept surveys, while our study relies on self-reported spending from online surveys.

Mode Choice and Consumer Behavior

Studies in the US and abroad have shown that bicyclists make more frequent purchases than their car-driving and transit-riding counterparts and tend to shop at smaller businesses closer to home, but that motorists tend to spend more money on single occasions (*2, 3*). Although bicyclists have been found to spend less on single shopping excursions, when the higher frequency of trips is

taken into account, they contribute more money per capita to the local economy (*1, 2, 4*). A Portland study found that bicyclists spent more money per capita than all other modes when making shopping trips downtown, although this result was contextualized by the relatively lower spending of bicyclists in other parts of the city (*2*). A survey of the East Village neighborhood in New York City found that bicyclists spent more per capita per week and visited the neighborhood more frequently than users of other modes (*3*). Together, respondents who biked, walked, or took transit as their usual mode of transportation contributed over 95% of retail dollars in the neighborhood (*3*). A New Zealand study found that bicyclists spent less than drivers but visited shops more frequently, increasing their average contributions over time (*4*). Another study demonstrated that when combining frequency and amount spent per trip, bicyclists spent more money on food and drink per month than their auto-driving counterparts (*2*).

Retailer Perceptions

Although logic suggests that bicyclists would be able to redirect savings from gas and auto insurance costs into the local economy, studies from all over the world indicate that shop owners have an inaccurate view of the travel choices of their clientele. Studies in Europe and California found that shop owners tend to underestimate the percentage of their customers that arrive by active modes and overestimate the number of customers arriving by car (*1, 4, 6, 7*). A study on the business impact of separated bike lanes in Vancouver, BC found that shop owners tended to overestimate sales losses due to bike lane construction when compared to recorded sales data (*8*). A study in Toronto, ON found that some small business owners thought increased bike infrastructure would reduce business, even though intercept surveys indicated that patrons who came by foot or bike spent the most money per month and visited the neighborhood most often (*9*). Only one study found that retailers fairly accurately estimated the mode share of their customers, but these retailers still prioritized on-street parking disproportionately to customer mode share (*5*).

A San Francisco study found that the biggest opponents of the proposed congestion pricing scheme for downtown were merchants in the area who believed the majority of their patrons arrived by car, when in reality 60% of patrons arrived by transit (*1*). The same study's survey of 1,187 shoppers revealed that transit users, pedestrians, and bicyclists shopped downtown more frequently than drivers and transit users and pedestrians spent more than drivers per capita per month (*1*). Such misperceptions may affect the level of support business owners give to proposals to increase bicycle infrastructure, potentially decreasing support over what it would be with a more accurate perception of customer mode share or outright opposing bicycle infrastructure.

Infrastructure

A number of studies focusing on infrastructure also point to the importance of bicyclists as consumers. Contrary to retailer perceptions, a study in Leicester, UK found that streets with higher traffic volumes had higher frequencies of vacant shops, a correlation that undermines the perception that more cars means more customers (*10*). A study on shopping behavior at the two main shopping avenues in Dublin, Ireland found that the street with better bike infrastructure had triple the mode share of shoppers arriving by bike and that they spent over 70 euros more per month per capita than the comparable shopping avenue with poor bike infrastructure (*4*). In Los

Angeles, sales tax revenue was higher from stores located on the portion of York Boulevard where the city reduced traffic lanes and added bike lanes compared to stores on the remainder of the boulevard where the city did not reduce traffic capacity (*6*).

Research thus points to disparities between the demonstrated economic contributions of shoppers, the perceptions of consumer behavior, and the allocation of public space. This paper aims to contribute to the growing body of research on spending behavior across travel modes in order to help transportation planners and elected officials make more informed choices for their communities.

METHODS

Setting

Davis is an interesting setting to examine the connection between mode choice and consumer behavior owing to its geographic isolation, land use patterns, and biking culture. Davis is well known for having the highest share of workers usually commuting by bicycle in the country at 19.1% (*11*). In addition to a mild climate and flat topography, the city boasts over 50 miles of on-street bike lanes and over 50 miles of off-street bike paths in an area of roughly 10 square miles (*12*). Land-use patterns also help to support bicycling for shopping trips. On one hand, Davis is surrounded by agricultural land, so that the nearest neighboring community is 10 miles away. At the same time, each of the five districts Davis (central, north, south, east, and west) has one or more neighborhood shopping centers that are easily accessed by bicycle and have good bicycle parking. Densities throughout Davis are relatively uniform, and the city is relatively compact, roughly 5 miles east-west and 3 miles north-south. Thus, nearly all residents are within 3 miles of downtown – a feasible distance to bike.

Data

The data analyzed here are from two online surveys, one administered in September 2009 and a second one administered in October 2010, as described in Lovejoy, et al. (*13*). The repeated cross-sectional surveys were designed to measure changes in shopping behavior before and after the opening of a Target store, the first big-box store in Davis, in October 2009. In each year, letters were sent to a random sample of 5,000 Davis residents inviting the recipient to visit a website to complete the online survey or to contact the researchers for a paper version if they preferred. As an incentive to participate, respondents were given the option of entering a drawing for five $100 cash prizes. Reminder postcards were sent to all potential respondents a week later. The response rate was 20.4%, yielding a combined sample size totaling 2,043 respondents. For the purposes of this study, we used a subset of respondents that had used a car (either as a driver or passenger) or a bike to get downtown, for a total sample size of 1,677.

This paper makes use of the data from this survey to explore the contribution of bicyclists to the economic life of downtown Davis, although the survey was not designed for this purpose. Each survey asked respondents about their most recent visit to downtown Davis and its purpose. The survey defined downtown as bounded by particular streets and showed a map of the area. For downtown and other shopping locations (including Target in the 2010 survey), the survey asked respondents about what types of items they had shopped for (in the last year) in that location, the

typical frequency with which they shop in that location, and for the most recent occasion, a series of other questions, including what mode they had used to get there, the items purchased or browsed for, whether they purchased items, and if so how much they spent. The 17 categories of items included in the survey, shown in Table 1, were identified as the sort offered at Target. Groceries were intentionally excluded because their perishable nature means that they are not readily comparable to other retail items. The survey also included questions to measure respondents' attitudes about shopping, time use, transportation modes, and environmental issues. The surveys concluded with questions capturing socio-demographic characteristics of individuals and their households and the cross-streets near where they lived.

Analysis

We conduct a variety of analyses with these data to explore the role of bicyclists as consumers. Although other studies on the topic have examined a wider selection of modes, this analysis does not include shoppers who took transit or walked downtown because there is less competition for parking, infrastructure, and road allocation between these other modes. Mode categories (bicyclist and driver) for downtown trips were based on the mode respondents reported using to get downtown on their last trip (regardless of whether it was for shopping or other purposes).

First, we examine differences between bicyclists and drivers with respect to socio-demographic and attitudinal characteristics. We present a bivariate analysis of these characteristics, as well differences in the purpose of the most recent downtown trip. Binary logistic regression models for bicyclist versus driver identify key factors influencing mode choice, for both the most recent trip downtown for shopping and the most recent trip downtown regardless of purpose. Second, we examine differences in shopping behavior for bicyclists and drivers. We compare spending per trip, frequency of trips, and monthly spending for those who bicycle to downtown and those who drive using chi-square tests and t-tests to determine the statistical significance of differences. We then estimate linear ordinary least-square regression models for downtown spending and frequency to better understand the role of bicyclists as consumers. For all models, data from the two survey years were pooled. Data were analyzed using the statistical software packages SPSS and R.

To facilitate model development, attitudinal questions were grouped into factors. Factor scores were generated for the following five factor variables: Eco Preference, Enjoys Shopping, Prefers to Buy Local, Enjoys Biking, and Pro-Target, (Table 1). Responses to these questions were on a scale from Strongly Disagree [-2] to Strongly Agree [2] and the factors were calculated by taking the mean value of each group of questions. We then did a confirmatory factor analysis to ensure that these manually-generated factors were appropriate to the data. In addition to standard socio-demographic variables, we included in the models the number of years lived in Davis, student status, car access, employment status, work location, and distance from the respondent's home to downtown Davis. Level of car access was defined by the response to, "How much of the time do you have access to a car, either as a driver or passenger, when you are shopping for the listed products, *whether you actually choose to use it or not*?," and measured on a five-point scale from "Never" to 'Whenever I want."

TABLE 1 Description of Factor Variables in Models

Factor Variable	Statement as Appearing on Survey	Mean	Factor Mean
Eco Preference	I am willing to pay a little more to use a hybrid or other clean-fuel vehicle to reduce greenhouse gas emissions and improve air quality.	0.44	**0.12**
	We should raise the price of gasoline to reduce congestion and air pollution.	-0.19	-
Enjoys Shopping	*I am too busy to shop as often or as long as I would like.*	-0.25	**-0.04**
	Shopping is usually a chore for me.	0.04	-
	I like to stroll through shopping areas.	0.1	-
	For me, shopping is sometimes an excuse to get out of the house or workplace.	-0.15	-
	I am often in a hurry to be somewhere else when I am shopping.	-0.03	-
	Even if I do not end up buying anything, I still enjoy going to stores and browsing.	0.02	-
	Shopping helps me relax.	-0.44	-
Pro-Target	National chain stores do a lot of good by increasing product diversity and keeping costs down.	0.43	**0.44**
	It was a good decision to allow a Target store in Davis.	0.72	-
	I am concerned about the effect that the Target store in Davis has had on downtown Davis.	-0.08	-
	The Target store in Davis has had a negative impact on neighborhoods in East Davis.	-0.51	-
Prefers to Buy Local	I am willing to pay a little more to buy from locally owned businesses rather than national chains.	0.27	**0.19**
	It is important to me to get the lowest prices when I buy things.	0.61	-
	It's important to shop in Davis to keep the tax revenues here.	0.72	-
	When I need to buy something, I usually prefer to get it at the closest store possible.	0.38	-
Enjoys Biking	*Carrying purchases home when walking or bicycling is a hassle.*	0.58	**0.19**
	Whenever possible, I prefer to walk or bike rather than drive.	0.18	-
	I like riding a bike.	0.86	-

* Negative values of the italicized question responses were used to maintain consistent magnitude and direction of responses when generating factor variables

Methodology Limitations

The data collection process and the survey questions have a number of limitations. First, because the primary purpose of this study was to obtain information on how driving behavior changed after Target opened in Davis, the survey questions ask only about spending on categories of items available at Target (Table 2). The survey did not ask for information regarding spending on eating, drinking, or entertainment, all of which are popular downtown activities easily accessible on a bicycle. Second, college students are largely underrepresented in the sample because, given that most of them live on-campus or in relatively temporary rental situations, they were underrepresented in the commercial database from which the sample of addresses was drawn.

Third, the survey relies on recall of the most recent trip to downtown and other self-reported measures of behavior. Fourth, we classify shoppers as bicyclists or drivers based on the mode used for their last shopping trip downtown although this mode choice may not be representative of the individual's regular travel behavior. Lastly, there is no means of extracting the causal relationship between spending and mode choice; an individual's spending amount might be a consequence of the mode available at the time of the trip, and vice versa.

TABLE 2 Types of Items Included in the Scope of Shopping[1]

Bedding and bath items	Sheets, pillows, bedspreads, towels, shower curtains, soap dishes, etc.
Books or electronic media	Books, DVDs, mp3s, video games
Cleaning supplies	Mops, sponges, detergent, cleaner, etc.
Clothing for adults	Clothes, shoes, accessories for women and/or men
Clothing for children	Clothes, shoes, accessories for children and babies
Electronics	Phones, cameras, audio equipment, video game consoles, and related items
Furniture	Tables, chairs, sofas, bookcases, lamps, etc.
Garden supplies	Plants, pots, potting soil, plant food, etc.
Hardware	Hand tools, hooks, knobs and pulls, etc.
Home décor	Curtains, rugs, pictures frames, vases, etc.
Office, school, or art supplies	Paper, notebooks, pens, wrapping paper, scrapbooking supplies, etc.
Patio items	Patio furniture, barbecues, umbrellas, etc.
Small appliances	Microwaves, blenders, irons, vacuum cleaners, etc.
Sporting goods	Sports equipment, fitness equipment, camping equipment, bicycles, etc.
Storage and organization	Storage boxes or baskets, closet systems, shelving, etc.
Toiletries or cosmetics	Shampoo, soap, toothpaste, make-up, etc.
Toys or games	Character toys, stuffed animals, board games, puzzles, playhouses, etc.
1 -Respondents were asked, "Have you shopped at a store in [location] for any of the following items within the last year? (Remember we mean not just purchasing, but also browsing or gathering information about an item.")	

RESULTS

Factors Influencing Mode Choice

Characteristics of Downtown Travelers by Mode

First we compare socio-demographic characteristics of the sample across modes and to the city of Davis (Table 3). Respondents who rode their bikes downtown are on average younger than drivers, tend to have a higher level of education, are less likely to be female, and have a lower income than those who drove. Differences in age, percent female, and income were statistically significantly different at the 5% level across travel modes, and bicyclists were more likely to have graduate degrees than car-users.

Note that the sample as a whole is much older than the Davis population, given that the sample includes only adults and likely because college students are underrepresented in the sample. The sample also had higher-than-average income and education levels, most likely reflecting the sampling method (as described in more detail in Lovejoy, et al. (*13*).

TABLE 3 Socio-demographic Characteristics of Downtown Travelers by Mode

		Bicyclists	Drivers	Total	Davis (2010)
N*		256	1421	1677	65,622
Median Age		47	54	53	25.2
% Female		45.1%	56.2%	53.5%	52.5%
Mean Income**		$83,371	$94,769	$92,982	$81,863
Education***	High school or less	1.3%	2.0%	1.9%	11.7%
	Some college	4.5%	8.6%	8.0%	13.7%
	Associate's Degree	6.3%	4.4%	4.7%	5.3%
	Bachelor's Degree	17.0%	25.0%	23.8%	30.2%
	Some graduate school	11.7%	11.0%	11.1%	N/A
	Graduate degree(s)	59.2%	49.0%	50.5%	39.1%
*Sample size for each variable differs owing to missing data					
**Survey sample incomes are based on midpoint values of five categorical ranges; for those reporting incomes greater than $125,000, an average of $150,000 was assumed					
***Education levels were based on sample over aged 25 to be comparable to Davis census					

Binary Logit Models for Bicycling or Not

To identify key factors associated with the choice to bicycle downtown rather than drive, we estimate two binary logit models (Table 4). The dependent variable for the first model is whether the respondent biked on his or her last trip to downtown for any purpose. The second model looks specifically at whether the respondent biked on his or her last *shopping* trip downtown. In order to control for purchases that are categorically infeasible on a bicycle, the shopping trip model includes a dummy variable, "bulky item", which indicates whether the individual purchased an item from any of the following categories: patio, furniture, garden, storage, or small appliances.

Predictably, the farther away that someone lives from downtown, the less likely they are to bike for shopping or other trip purposes. Interestingly, income is not significant for biking downtown in general, but is significant at the 1% level for biking to shop. This inverse relationship may be indicative of the generally higher costs of downtown purchases. The longer an individual has lived in Davis, the less likely he or she is to bike downtown, perhaps reflecting a transition from biking to driving as incomes increase. Student status was not a significant determinant in an individual's likelihood to bike downtown. Note that the sample includes relatively few students, however. Level of car access is negatively correlated with biking downtown and significant in both models at the 10% level, though the effect is small. Notably, 92.5% of this sample indicated they have access to a car at all times. Individuals who work in Davis are also significantly more likely to bike downtown for both errands and shopping trips, although we do not have specific information on distance from work location to downtown. Individuals that live with at least one child under 16 are less likely to bike downtown, although there was no effect for biking downtown to shop.

TABLE 4 Binary Logit Model for Bicycled or Not

	Last Trip Downtown			*Last Shopping Trip Downtown*		
Independent Variables	**Estimate**	**Significance**		**Estimate**	**Significance**	
(Intercept)	0.611	0.480		0.588	0.527	
Age	-0.014	0.117		-0.006	0.537	
Female	0.361	0.066	.	-0.090	0.693	
Household Size	-0.049	0.672		0.102	0.434	
Household Income	-0.017	0.834		-1.273	0.000	***
Children in Household	-0.589	0.042	*	-0.095	0.289	
Employed (part or fulltime)	-0.335	0.246		-0.175	0.607	
Student (part or fulltime)	-0.217	0.509		-0.534	0.147	
Distance from Home to Downtown	-0.410	0.000	***	-0.430	0.001	***
Works in Davis	0.716	0.003	**	0.684	0.016	*
Time Lived in Davis	-0.088	0.415		-0.204	0.084	.
Level of Car Access	-0.228	0.055	.	-0.254	0.037	*
Enjoys Shopping	-0.195	0.164		-0.095	0.554	
Enjoys Biking	1.744	0.000	***	1.959	0.000	***
Prefers to Buy Local	0.326	0.033	*	0.093	0.588	
Eco Preference	0.090	0.371		0.073	0.531	
Purchased Sporting Goods	n/a	n/a		0.928	0.006	**
Purchased Bulky Item	n/a	n/a		-1.656	0.021	*
Model Summary						
N		*1255*			*1255*	
Log likelihood (EL)		*-869.84*			*-869.84*	
Log likelihood (MS)		*-566.79*			*-467.22*	
Log likelihood (model)		*-379.78*			*-296.73*	
Rho-Squared (EL base)		*0.56*			*0.66*	
Rho-Squared (MS base)		*0.33*			*0.36*	
Adjusted Rho-Squared		*0.54*			*0.64*	

Significance codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Respondents who reported they like biking are more likely to bike to shopping destinations and to downtown in general. As expected, bulky purchases are negatively associated with biking to shop, although this model might underestimate the effect of large item purchases because this variable uses item category as a proxy for item size, as we do not know the exact item purchased. Interestingly, the purchase of sporting goods is positively correlated with biking to shop, although no other "non-bulky" item category was significant in the model. Lastly, a preference for local goods is significant for biking downtown, but not for shopping downtown.

Downtown Shopping Behavior

Characteristics of Downtown Trips by Mode

Respondents were asked what they did on their last trip downtown and were given the option of checking multiple activities. Respondents arriving downtown by bike have a distribution of activities remarkably similar to the distribution for those arriving by car (Figure 1). A greater portion of bicyclists than drivers reported participating in five of the seven activity categories, all but one of which (studying or reading) are revenue generating. Differences in participation rates were statistically significant for eating or drinking and for reading or studying, but not for the other activity categories.

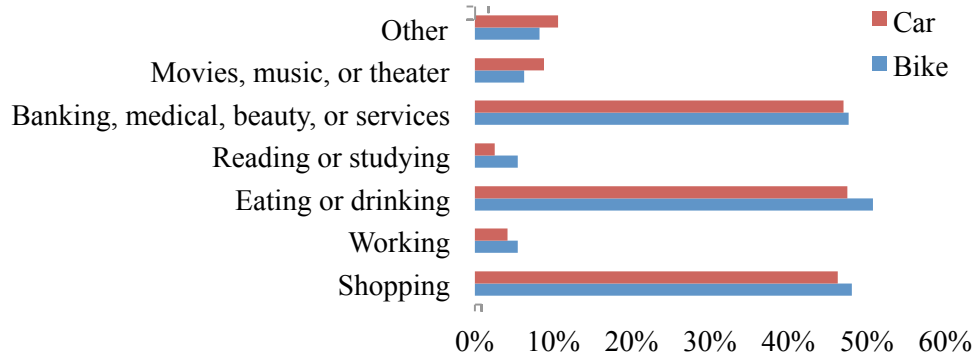

FIGURE 1 Downtown trip purpose by mode.

To determine how frequently respondents shopped downtown, we extrapolated an average monthly frequency based on their responses to the two survey questions, "How often did you shop there in the last year?" and "When was the most recent occasion?" Extrapolated monthly shopping trips ranged from a minimum of none (did not shop there at all last year) to a maximum of 15.21 (shopped once a week or more and most recent visit was within the previous two days). Average spending and frequencies are shown in Table 5.

TABLE 5 Downtown Shopping Frequency and Spending by Mode

		Bicyclists	Drivers	*p*-value
N		256	1421	-
Mode Share	*Any activity*	14.8%	76.5%	-
	Shopping	15.2%	77.2%	-
Trip Distance	*(miles)*	1.86	2.35	-
Shopping Frequency	*Trips per month*	3.55	3.28	0.367
Spending	*Average spending for all visitors*	$55.05	$55.83	0.923
	Percent of shoppers who made purchases	88.7%	92.4%	-
	Average spending for purchasers	$62.08	$60.45	0.855
	Monthly spending (freq. times last trip amount)	$224.66	$168.00	-

Although participants were asked about all categories of activities for their trip purpose, spending amount was only collected for purchases that fell under the categories of Table 2. For survey purposes, "shopping" included browsing as well. Bicyclists as a group spent a slightly lower amount on their most recent downtown shopping trips on average than drivers. However, for those people that did make purchases, bicyclists spent more money than drivers, though the differences were not statistically significant (Table 5). Monthly spending was calculated based on extrapolated monthly shopping frequency multiplied by the amount spent for purchases on the last downtown trip. Because bicyclists shopped downtown more frequently than drivers, their estimated average monthly spending was higher than that of drivers, consistent with previous studies.

In addition, an analysis of purchases in other parts of Davis shows that people who biked downtown spent a larger share of their total spending downtown. Using the extrapolated shopping frequency to determine monthly spending at locations outside of downtown, bicyclists spent an average of $427.29 per month, while motorists spent $443.42, a difference that is not statistically significant. On average, downtown purchases accounted for 58.1% of bicyclists' spending versus 45.4% of motorists' spending, a difference that is statistically significant at the 1% level. This relationship suggests that, although motorists may spend higher amounts at other Davis locations, bicyclists do a bigger share of their shopping downtown.

Linear Regression Models for Downtown Spending and Shopping Frequency

To test whether bicyclists differ from car-users in their spending and trip frequency after accounting for other variables, we estimated linear regression models (Table 6). These models include only individuals who indicated that they purchased an item listed in Table 2; purchases of other types and spending in bars, restaurants, entertainment, or services are not included. Contrary to the bivariate results (Table 5), this model indicates that shoppers who arrived downtown by bicycle spent more money than car-users after accounting for other factors, although the effect was not statistically significant even at the 10% level. As expected, income is a significant, but fairly small, determinant of downtown spending. We might expect income to play a larger role in the general population, but given the relatively wealthy sample, this low correlation is plausible. Student status, once again, was not found to be significant. Whether an individual enjoys shopping or biking was not found to be significant in explaining downtown spending amounts. Indeed, the most significant determinant of the amount an individual spends downtown is a preference to support local businesses. Lastly, individuals that reported a concern about protecting the environment spent less money downtown, perhaps reflective of their propensity to minimize unnecessary consumption.

Note that the R-square for this model is only 0.02, suggesting that spending on the last downtown trip is not well explained by these variables. With the exception of mode, the explanatory variables are measured for the individual rather than last trip; it is likely that spending across trips varies considerably for any one individual.

The model for shopping frequency explains more of the variation among the respondents. Although biking as a mode of travel to downtown on their last trip was not significant, respondents who "enjoyed biking" did travel downtown significantly more frequently than those who did not. Respondents who enjoy shopping and prefer to shop at small and local businesses,

predictably, made more frequent downtown shopping trips. The longer an individual has lived in Davis, the less frequently he or she shops downtown. However, age had the opposite effect.

Even with multiple significant variables and a fairly large sample size, both models have very low adjusted R-square values, indicative of the difficulty of predicting individual behavior as well as short-comings in the measurement of these dependent variables, as noted earlier.

TABLE 6 Linear Regression Models for Downtown Spending and Shopping Frequency

	Downtown Spending			***Downtown Shopping Frequency***		
Independent Variables	**Estimate**	**Significance**		**Estimate**	**Significance**	
(Intercept)	87.637	0.001	**	0.823	0.547	
Mode: Bike	11.534	0.162		-0.237	0.567	
Age	-0.011	0.961		0.031	0.008	**
Female	-12.061	0.016	*	0.496	0.050	.
Household size	-0.870	0.776		0.182	0.224	
Household income	6.056	0.006	**	0.335	0.002	**
Children in household	3.113	0.675		0.032	0.933	
Employed (part or fulltime)	-0.172	0.980		-0.945	0.007	**
Student (part or fulltime)	-4.025	0.684		0.258	0.601	
Distance from Home to Downtown	-3.186	0.201		-0.139	0.283	
Works in Davis	-1.420	0.815		0.868	0.005	**
Time Lived in Davis	0.673	0.832		-0.433	0.008	**
Car Access	-8.701	0.018	*	0.215	0.251	
Enjoys Shopping	-4.045	0.246		0.876	0.000	***
Enjoys Biking	0.246	0.939		0.625	0.000	***
Prefers to Buy Local	13.601	0.001	***	1.004	0.000	***
Eco Preference	-6.632	0.010	**	-0.169	0.211	
Pro-Target	-	-		-0.205	0.178	
Model Summary						
N	*1012*			*1117*		
Adjusted R-squared	*0.02*			*0.09*		
Residual Standard Error	*75.3*			*4.0*		

Significance codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

DISCUSSION & CONCLUSION

In line with previous studies, our results show that – after taking into account frequency of shopping trips – bicyclists spend at least as much at downtown shops as drivers and potentially more. Further analysis is needed to determine whether this pattern holds in other situations. In particular, this study focused on a limited set of goods. It is possible that the spending difference between bicyclists and drivers is greater at establishments where goods are consumed onsite (e.g.

bars, movie theaters, restaurants) for which customers arriving by bike are not limited by their carrying capacity. At the same time, spending by drivers in this study is potentially underestimated due to the exclusion of grocery trips, which tend to include longer distances and larger purchases on a single trip. In addition, this study examined spending for only the most recent trip. It would be helpful to collect detailed mode, destination, and spending data for all shopping trips over periods of time as long as a month.

Other kinds of studies would complement this effort. An intercept survey of shoppers at downtown locations would overcome the recall problem inherent in the on-line survey used here, though such surveys present other challenges. Surveys with downtown business owners would enable a comparison between their perceptions of customer behavior by mode and actual behavior as measured in the survey. Lastly, other studies have demonstrated that infrastructure influences mode choice to shopping destinations (*1, 4-6*), but before-and-after studies would provide more definitive evidence on the impact of improved bike infrastructure on mode share and shopping behavior.

This study contributes to an important and growing body of research documenting the economic contributions of bicyclists to their local communities. As municipalities increasingly encourage sustainable transportation modes, it is helpful for policymakers to understand the impact that these changes might have on economic development. Our results indicate that, even without accounting for spending on food, drink, and services, customers who travel to shop downtown by bike spend comparable amounts of money to their car driving counterparts on a per-month basis based on extrapolated frequencies and per-trip spending. Perhaps more importantly, bicyclists spend the largest share of their shopping expenditures at downtown locations compared to other locations. Although these findings may not be generalizable to other contexts, they provide support for additional investments in bike infrastructure in the downtown core.

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