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Commute quality and its implications for commute satisfaction: Exploring the role of mode, location, and other factors

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ABSTRACT

The quality of a worker's commute significantly impacts her well-being. We seek to add to the nascent literature on this topic by examining how travel mode, location, and other personal characteristics are associated with perceived commute quality and then by exploring implications for commute satisfaction. We use data from the annual Campus Travel Survey of students and employees at the University of California, Davis and focus on three dimensions of the commute experience: how stressful the commute to campus is, whether travel time is seen as wasted time, and the degree to which commuters like their travel mode. Our analysis shows that commute quality differs by residential location, commute mode, student versus employee status, and gender. Overall, bicycle commuters and train commuters report the highest quality commutes, all else equal; bus riders report the lowest quality commutes; the results for those traveling to campus by car are somewhere in the middle. We also find that all three dimensions of perceived commute quality are strongly associated with overall commute satisfaction. These results point to several different strategies for employers like UC Davis that aim to improve commute quality in order to enhance well-being: improve the quality of each mode, encourage a shift to modes offering higher quality commutes, identify "mis-matched" employees who are not using the mode that would yield the highest commute satisfaction, use social marketing techniques to change perceptions of and preferences for commute options, and increase housing near work sites to enable more commuters to live within bicycling distance.

1. Introduction

According to the 2009 National Household Travel Survey, Americans spend an average of 25.4 min per day traveling to work. Nearly 90% of commuters get to work by private vehicle, a statistic that largely explains the significant contribution of the transportation sector to greenhouse gas emissions in the U.S., not to mention air, water, and noise pollution, as well as other environmental impacts targeted by federal and state policies. Policy makers in the U.S. have also directed their attention toward to the social impacts of commuting, particularly the need to connect lower-wage workers to appropriate jobs, as well as the inefficiencies of long commutes and the economic "cost" of time lost to congestion. All of these impacts are worthy of attention owing to their implications for well-being, now and into the future.

Also worthy of attention is the quality of the commute experience itself. The commute, as a sizable portion of the average worker's day, significantly impacts well-being (Abou-Zeid and Ben-Akiva, 2014; Olsson et al., 2013). Researchers have convincingly documented strong negative impacts of the stress of commuting on physical health and psychological adjustment, with implications for job performance, job satisfaction, personal relationships, and other important aspects of well-being (Novaco and Gonzalez, 2009; Wener et al., 2005; Lyons and Chatterjee, 2008). Workers with longer commutes generally report lower well-being, all else equal (Stutzer and Frey, 2008). But researchers have also shown that commute time is not entirely bad (Redmond and Mokhtarian, 2001). Commuting can enhance well-being by providing privacy, protected time, or a buffer between home and work, for example (Novaco and Gonzalez, 2009; Friman et al., 2013).

In this study, we explore factors associated with perceived commute quality as well as the association between commute quality and commute satisfaction using data from the annual Campus Travel Survey of students and employees at the University of California, Davis. We focus on three dimensions of the commute experience: how stressful the commute to campus is, whether travel time is seen as wasted time, and the degree to which commuters like their travel mode. Our analysis shows significant differences in commute quality by residential location and commute mode, as well as student versus employee status and gender. Overall, bicycle commuters (among those living in Davis) and

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train commuters (among those living outside Davis) report the highest quality commutes, all else equal. Regression models show that the three dimensions of commute quality are strongly associated with commute satisfaction. These results point to the need for programs to improve commute quality by improving the modes themselves and encouraging a shift to higher quality modes, though mode liking must be taken into account, as well as land use policies to increase housing near campus so as to enable commuting by higher quality modes.

2. Conceptual framework

Transportation researchers have explored the concept of subjective well-being as an alternative to the concept of utility in assessing outcomes for travelers. A number of travel behavior researchers have examined the link between travel and overall well-being. Ettema et al. (2010) outline three ways that travel affects well-being: travel gets us to activities that impact our well-being, the travel experience affects the activity experience that impacts our well-being, and the experience of travel in and of itself affects our well-being.

The last of these effects – commute well-being (Smith, 2016) – has been the subject of a growing body of work. Commute well-being is related to the concepts of commute satisfaction and commute happiness (Abou-Zeid and Ben-Akiva, 2014), and these terms are sometimes used interchangeably. The daily commute experience accumulates over time to produce a general level of commute satisfaction (Ettema et al., 2010). Contributing to commute satisfaction are instrumental factors such as travel distance, time, and cost, as well as travel time variability, but also many non-instrumental or "affective" factors (Ettema et al., 2010), or what might be called perceived commute quality.

One way that instrumental factors affect satisfaction is through their influence on one of the important dimensions of perceived commute quality: commute stress (Abou-Zeid and Ben-Akiva, 2014). Commute stress has physiological indicators but also psychological indicators (Wener et al., 2005). Psychologically, it is related to the difficulty commuters experience in moving from home to work and back (Schaeffer et al., 1988), also called subjective impedance (Novaco et al., 1990). Studies show that factors such as crowding, control, flexibility, predictability, and time urgency contribute to commute stress (Abou-Zeid and Ben-Akiva, 2014; Ettema et al., 2013; Novaco et al., 1979; Schaeffer et al., 1988; Lucas and Heady, 2002; Evans et al., 2002). One study found control to be "the most powerful predictor of commuting stress" (Sposato et al., 2012). In this study, we focus on commute stress as one of three dimensions of perceived commute quality.

Enjoyment is another important dimension of commute quality that may influence commute satisfaction (Abou-Zeid and Ben-Akiva, 2014). Travel behavior researchers have examined the role of different concepts that relate to enjoyment, including pleasure, pleasantness, and arousal (Gatersleben and Uzzell, 2007; Mokhtarian et al., 2015), as well as the "fun" factor (Eriksson et al., 2013). Closely related is the concept of "liking," both for travel in general and for modes specifically (Ory and Mokhtarian, 2005). Enjoyment is also related to the concept of positive travel utility, the idea that travelers derive some benefit from travel beyond the benefit of reaching their destinations (Redmond and Mokhtarian, 2001). This benefit may stem from enjoyment of travel in and of itself, or from the enjoyment of activities conducted while traveling (Mokhtarian et al., 2001). The perception that commute time has value other than getting to work leads to increased satisfaction (St-Louis et al., 2014). These results suggest that the opposite perception – that commute time is wasted time – would detract from enjoyment of commuting and thus from commute satisfaction. In this study, we consider both mode liking and wasted time as dimensions of commute enjoyment, which itself is a dimension of perceived commute quality.

Stress and enjoyment, though distinct concepts, are intertwined. As studies show, stress and the ability to use time productively while commuting contribute to liking of commuting (Ory et al., 2004), while activities conducted during travel (that reduce the sense that travel time is wasted) can be a coping mechanism to reduce stress (Abou-Zeid and Ben-Akiva, 2014). Some evidence suggests that enjoyment has a more important influence on satisfaction than does stress, though studies show that both play an important role (Abou-Zeid and Ben-Akiva, 2011).

Because the underlying factors that influence stress and enjoyment differ by mode, stress and enjoyment vary by mode, and thus overall commute satisfaction varies by mode (Gatersleben and Uzzell, 2007; Friman et al., 2013; Olsson et al., 2013; Chng et al., 2016; Páez and Whalen, 2010; St-Louis et al., 2014; LaJeunesse and Rodríguez, 2012; Smith, 2016; Ory and Mokhtarian, 2005; Wener and Evans, 2011; Rissel et al., 2016; Ye and Titheridge, 2017; Sprumont et al., 2017). In this study, we explore differences in stress and enjoyment by mode, residential location, and other demographic factors, using one measure of commute stress and two measures related to enjoyment. We then test the association between these dimensions of commute quality and overall commute satisfaction.

3. Methods

3.1. Setting

The City of Davis and the UC Davis campus are unusual from a transportation perspective: unlike most places in the U.S., bicycling in Davis is both safe and commonplace, owing to the city's flat topography, mild weather, and extensive network of bicycle infrastructure (Buehler and Handy, 2008). Another unusual feature of the city is its strong urban edge: through a suite of growth management policies, the city has maintained a compact form and is surrounded by a band of agricultural land that separates it from neighboring cities.

These land use characteristics lead to distinctly different sets of potential modes to campus depending on whether students and employees live within the city or live outside of the city (Table 1). Within the city, driving, walking, bicycling, and bus are all feasible, depending on how far one lives from campus. Given the compact form of the city, most residents are within three miles of campus. UC Davis runs

Table 1
Mode characteristics for UC Davis commuters.

	Living in Davis	Living outside Davis
Walking	Less than 10% live within 1 mile	–
Bicycling	85% live within 3 miles; most streets have bike lanes; several off-street bike paths connect to campus	90% live at least 10 miles away; route to campus via two-lane roads and/or bike path parallel to freeway
Drive alone	$42-$51 per month for parking	$42-$51 per month for parking; unpredictable congestion on freeways
Ride with others	$13-$21 per month for carpool parking; limited Uber, Lyft, and taxi availability	$13-$21 per month for carpool parking; priority parking spaces; emergency ride home program; ride matching service; no carpool lanes on freeways
Bus	Unitrans bus service; free for undergraduates, $1 per ride for others	Yolobus service from cities in Yolo County; limited service from other counties; discounted bus passes through UC Davis
Train	–	Capitol Corridor service from Sacramento and from Bay Area; discounted tickets through UC Davis; 15 trains per day each direction

Unitrans, a local bus system that links all parts of the city to the campus; undergraduate students pay for the service through their fees but graduate students and employees pay a $1 fare. For those living outside of Davis, the primary modes are driving alone or in a carpool, or taking a regional bus or train. Yolo County operates bus service from neighboring cities. The Amtrak-operated Capitol Corridor train links Davis to Sacramento to the east and to the Bay Area to the southwest. A small number of hardy commuters living outside Davis commute by bicycle on occasion or in part. Students and employees driving to campus, regardless of where they live, must pay to park. Given the limited options, the characteristics of each mode, other than distance, are similar for all commuters in each location.

3.2. Survey administration

Our analysis uses data from the 2017–18 UC Davis Campus Travel Survey (CTS), an annual online survey of students, staff, and faculty. The survey provides university administrators with data on travel to campus for planning purposes and for estimating annual greenhouse gas emissions for the campus. The 2017–18 survey included questions on the quality of commutes to campus and on overall commute satisfaction.

On Monday, October 23, 2017, the university distributed an invitation to participate in the CTS via email to a stratified random sample of 19,796 students, faculty, and staff. A reminder email was sent out one week later, followed by a second reminder after one more week. As an incentive, participants were offered the opportunity to compete for one of 30 $50 Visa gift cards and one Amazon Fire tablet. During the three weeks that the survey was live, 4412 valid cases were recorded, about 22% of those invited. It is possible that commuters with lower quality commutes were more likely to respond to the survey, seeing it as an opportunity to voice their concerns to the university. If so, our results may overstate negative feelings about the commute relative to the entire campus population. Because the focus of our analysis is on identifying factors associated with perceptions about commute quality rather than generalizing perceptions to the population, any such bias should not be a significant concern.

3.3. Variables

The variables representing perceived commute quality come from a series of Likert-style questions with a five-point agree-disagree scale (Table 2). The first statement, “traveling to campus stresses me out,” was designed to capture the stress associated with the commute itself rather than the stress associated with arriving on campus, though these things may be difficult to separate for some participants. The second statement, “travel time is generally wasted time,” is not specific to commuting, but given that the survey otherwise focused on commuting and commuting makes up a significant share of travel, we assume that respondents were largely considering their commute in answering this question. Finally, three statements gauge enjoyment of travel modes: “I like biking,” “I like driving,” and “I like using public transit.” These statements did not refer to the use of these modes for the commute specifically, but we can examine the degree to which commuters like their chosen mode. For participants who drive alone, ride the bus or train, or bicycle to campus, we created a single “mode liking” variable from these questions reflecting their liking of their commute mode. The “wasted time” and “mode liking” variables are related to the concept of commute enjoyment.

Overall commute satisfaction is measured as the average of six statements related to general feelings about the commute. These statements, which also use a five-point agree-disagree scale, were adapted from those used by de Vos in his study in Belgium (De Vos and Witlox, 2017). We recentered the scale to a range of −2 (strongly disagree on all six items) to 2 (strongly agree for all six items) for the analysis.

We use several explanatory variables (Table 2). Gender is categorized as female or not female (male and other). Campus role is defined by four categories: undergraduate student, graduate student, faculty, and staff. Role is correlated with age (especially for students) and is also related to time flexibility (with faculty having the mode flexible schedules) as well as disposable income (with faculty having higher incomes than staff); previous studies of commuting to universities show a significant effect of role (e.g. Sprumont et al., 2017).

Commute mode is expected to have a strong association with perceived commute quality. Although the survey asks about all modes used on each day of a specified week, we use the usual commute mode as reported by participants. The survey also asked respondents what modes are available to them for commuting. We used this question to create a variable reflecting a constrained mode choice: respondents with only one mode available were classified as “mode constrained” while those with two or more modes available to them were classified

Table 2
Variable definitions.

	Values	Survey question and responses
Commute satisfaction	−2.0 to 2.0	Average of six statements on a 5-point Likert scale,[1] recentered around 0: “I am satisfied with my commute trips to campus” “When I recall my commute trips, the positive aspects outweigh the negative ones” “I do not want to change anything about my commute trips” “My commute trips give me positive feelings” “My commute trips mostly go well” “My commute trips are the best I can imagine”
Commute stress	1–5	“Traveling to campus stresses me out” on a 5-point Likert scale[1]
Wasted time	1–5	“Travel time is generally wasted time” on a 5-point Likert scale[1]
Like driving	1–5	“I like driving” on a 5-point Likert scale[1]
Like transit	1–5	“I like using transit” on a 5-point Likert scale[1]
Like biking	1–5	“I like biking”on a 5-point Likert scale[1]
Mode liking	1–5	Value for *Like Driving* if driving alone is usual mode; value for *Like Biking* if biking is usual mode; value for *Like Transit* if train or bus is usual mode
Female	0, 1	“I identify as…” 1 = female; 0 = male or other
Role	–	“What is your primary role at UC Davis?” undergraduate student; graduate student (including post-doctoral scholar and visiting scholar; staff; faculty
Mode	–	“What means of transportation do you usually use to travel to campus for school or work?” walk; bike (including e-bike and skateboard; drive alone (including motorcycle; carpool (including vanpool, someone drives you, taxi, Uber/Lyft); bus; train; other
Mode constrained	0, 1	1 if only one mode available for the commute; 0 if 2 or more modes available.
Location	–	“Where do you live now?” in Davis (but not on campus); outside Davis
Commute miles	0.4–228	Miles from intersection near home to central point on campus via the road network, one-way

[1] 1 = strongly disagree; 2 = somewhat disagree; 3 = neither agree nor disagree; 4 = somewhat agree; 5 = strongly agree.

as “mode unconstrained.”

Home location is characterized in two ways. First, participants reported whether they live on-campus, off-campus but within Davis, or outside of Davis. Because on-campus residents have short commutes, we focus on the latter two categories and analyze them separately in light of the very different sets of modes available (see Table 1). Second, participants reported an intersection near their home. We geo-coded these intersections and calculated distances to a central point on the campus on the road network or an expanded network consisting of the road network as well as off-street paths, depending on mode, using ArcGIS. The distance variable has many missing values because many respondents did not provide intersections and in some cases we were not able to geo-code the intersections they provided. The sample size for our analysis after taking out on-campus residents and respondents who did not provide information on their residential location is 2703.

3.4. Analysis

We analyzed the survey data using the R statistical programming language (R Core Team, 2017). We began with cross-tabulations to identify important patterns among the explanatory variables and between the explanatory variables and the measures of commute quality. We estimated a Bayesian linear regression model (for background on Bayesian modeling, see McElreath, 2015) for commute satisfaction, a continuous variable, by using the *rstan* package (Stan Development Team, 2016), which uses Hamiltonian Monte Carlo (HMC) sampling. To capture non-linear effects of distance, we included both distance and the square of distance in the model. We included an interaction term for location and bus mode to capture the differences between the two bus systems that serve the campus. Commuters who walk to campus were excluded from the model because the mode-liking variable is limited to those who bicycle, use transit, or commute by car. We tested the correlations among the explanatory variables and found that they were not large enough to present problems of multicollinearity. We present the mean coefficient values and the associated standard deviations from across the 1000 HMC samples. The model exhibits acceptable goodness of fit, with a R-square value well within the usual range for individual-level studies of travel behavior. The model shows the degree to which each dimension of commute quality is associated with commute satisfaction while accounting for the other explanatory variables.

4. Results

Before turning to our analysis of commute quality, it is important to consider associations among the explanatory variables. First, consistent with considerable differences in the feasible modes for those living in Davis and those living outside of Davis, the distribution of modes differs for these two groups in this sample (Table 3): driving alone is the dominant mode for those living outside of Davis (79%), while biking is the most common mode for those living in Davis (50%). Davis residents are far less likely to be mode constrained (3%) than those living outside of Davis (27%). Second, home location and commute mode are strongly correlated with campus role: undergraduate students are more likely to live in Davis and they ride the bus to a far greater degree than the other groups (not shown). Third, women are less likely to bicycle than men: 42% of women living in Davis bicycle to campus compared to 58% of men (not shown). It is important to consider these patterns when interpreting the impact of these factors on commute quality.

4.1. Commute stress

Our first measure of commute quality is agreement with the statement “Traveling to campus stresses me out.” Over a quarter of all participants agree (somewhat or strongly) with this statement, and nearly half disagree, suggesting that commutes to UC Davis are not especially stressful (Table 4). Those commuting from outside Davis are more likely to report stressful commutes (41%) than those living in Davis (30%). Women are more likely to feel stressed by their commutes (37%) than men (24%), and commute stress also differs significantly by role, with undergraduates the most stressed (41%) and faculty the least stressed (14%).

The high level of stress among undergraduates is tied to their high bus mode share: bus riders are the most likely of all commuters (excluding other) to report that their travel to campus stresses them out (42%). Those walking and bicycling, most of whom live in Davis, are least likely to report stressful commutes (27% and 23%, respectively). Train commuters are more likely to report stressful commutes than bikers and walkers but less likely than drivers. Among drivers, fewer of those living in Davis report stressful than those living outside Davis commutes (31% versus 40%; not shown). Driving with others is comparable to driving alone in its stressfulness. Commuters who are mode constrained are more likely to report being stressed out by their commutes than those who aren’t.

Table 3
Gender, role, mode, and commute length by location.

	Davis	Outside Davis	Total	n
Total	77.1%	22.9%	100.0%	2702
Not female	33.5%	33.4%	33.5%	905
Female	66.5%	66.6%	66.5%	1797
Undergrad	55.5%	25.3%	48.6%	1312
Grad student	27.6%	25.8%	27.2%	734
Faculty	11.0%	19.8%	13.0%	352
Staff	6.0%	29.0%	11.3%	304
Walk	3.3%	0.3%	2.6%	71
Bike	50.2%	0.5%	38.8%	1049
Drive alone	15.6%	79.4%	30.2%	817
Drive with others	3.7%	8.7%	4.9%	132
Bus	26.6%	3.7%	21.4%	577
Train	0.0%	7.1%	1.7%	45
Other	0.4%	0.3%	0.4%	11
Mode constrained	3.1%	26.8%	8.5%	230
Mode unconstrained	96.9%	73.2%	91.5%	2472
Average commute miles	2.0	27.1		

4.2. Wasted time (commute enjoyment part 1)

Our second measure of commute quality is agreement with the statement “Travel time is generally wasted time,” a component of commute enjoyment. UC Davis commuters are more likely to agree (somewhat or strongly) that travel time is wasted time (49%) than they are to disagree (29%) (Table 4). Men are more likely to agree that time is wasted, and undergraduates are more likely to feel that travel time is wasted time than other groups, with staff the most likely to disagree.

The feeling that travel time is wasted time is prevalent among those who drive alone, the mode used by the vast majority of those living outside of Davis. In contrast, the commuters least likely to feel that travel time is wasted time are those riding the train from outside Davis: almost two-thirds of these commuters *disagree* with the statement. However, this effect is not universal to transit: the group most likely to feel that travel time is wasted time are bus riders, most of whom are undergraduates living in Davis. In contrast, over a third of bicyclists, most of whom live in Davis and many of whom are undergraduates, disagree that their travel time is wasted. Thus, we see wide differences in each location: between drivers and train riders living outside Davis, and between bus riders and bicyclists within Davis. Commuters who are mode constrained are more likely to agree that travel time is wasted time than those who are not constrained.

Table 4
Commute quality by gender, role, location, and mode.

	"Traveling to campus stresses me out"		"Travel time is generally wasted time"		"I like [biking, driving, using transit]"[3]	
	Disagree[1]	Agree[2]	Disagree[1]	Agree[2]	Disagree[1]	Agree[2]
All	45%	32%	29%	49%	13%	73%
Female	40%	37%	27%	51%	14%	71%
Male	56%	24%	33%	44%	10%	76%
Undergrad	37%	41%	25%	53%	13%	71%
Grad student	48%	28%	33%	49%	12%	77%
Faculty	67%	14%	37%	37%	9%	77%
Staff	49%	28%	27%	41%	15%	65%
Davis	48%	30%	31%	47%	9%	78%
Outside Davis	35%	41%	23%	56%	24%	55%
Walk	52%	27%	46%	35%	–	–
Bike	56%	23%	37%	41%	5%	89%
Drive alone	39%	37%	20%	56%	21%	59%
Drive with others	37%	38%	22%	56%	–	–
Bus	36%	42%	24%	54%	17%	62%
Train	42%	33%	62%	24%	7%	82%
Other	27%	55%	36%	27%	–	–
Mode constrained	34%	40%	25%	53%	22%	54%
Mode unconstrained	46%	32%	29%	48%	12%	74%

[1] Strongly disagree or somewhat disagree.
[2] Somewhat agree or strongly agree.
[3] Value for liking of the respondents usual commute mode.

4.3. Mode liking (commute enjoyment part 2)

A second component of commute enjoyment is the degree to which a commuter likes their commute mode. As explained earlier, we created a measure of mode liking for those who drive, use transit, or bike to campus; we do not have a measure of mode liking for those walking, driving with others, or using other modes.

Overall, over three-quarters of this subsample agree that they like their usual commute mode, with just 10% disagreeing (Table 4). However, while half of men strongly agree that they like their commute mode, only a third of women strongly agree. Graduate students are somewhat more likely than other groups to like their commute mode, but residents of Davis are far more likely to like their mode (80%) compared to those living outside of Davis (65%). The locational differences are clearly tied to differences by mode. Almost 90% of bicyclists, nearly all of whom live in Davis, agree that they like their mode, compared to 65% of those who take the bus. Sixty-five percent of those who drive alone, the dominant mode for those living outside of Davis, like their commute mode, compared to 87% of those who ride the train. Commuters who are mode constrained are less likely to agree that they like their modes than those who are not constrained.

4.4. Commute satisfaction

On average, UC Davis commuters are satisfied with their commutes. Over two thirds of respondents have satisfaction scores over 0, and the average satisfaction score is 0.35 (Table 5). But satisfaction varies considerably across subsets of commuters. Men are more satisfied than women. Faculty are far more satisfied than staff or students, and the undergraduates are the least satisfied. Walkers are the most satisfied, followed closely by bicyclists; bus riders are the least satisfied, though those who drive alone or with others do not score much higher. Commuters who are mode constrained are less satisfied than those who are constrained. Commuters from outside of Davis are neutral on average, not satisfied but not dissatisfied. These patterns are largely consistent with the patterns for the three measures of commute quality.

All three dimensions of commute quality are strongly associated with commute satisfaction, according to the linear regression model (Table 6). Higher ratings of commute stress significantly reduce commute satisfaction. Wasted time also reduces commute satisfaction, though the effect is not as strong as for stress. Mode liking, in contrast, significantly increases commute satisfaction, pointing to the importance of matching commuters to their preferred modes.

Demographic characteristics are also significant predictors of commute satisfaction. Although the descriptive statistics showed that women are less satisfied on average, they are *more* satisfied on average once commute quality and other variables been taken into account. The results for role group show that faculty are far more satisfied with their

Table 5
Average commute satisfaction[1] by gender, role, location, and mode.

All	0.35
Female	0.31
Male	0.44
Undergrad	0.25
Grad student	0.38
Faculty	0.72
Staff	0.34
Walk	0.72
Bike	0.66
Drive alone	0.14
Drive with others	0.14
Bus	0.11
Train	0.30
Other	0.50
Mode constrained	0.12
Mode unconstrained	0.38
Davis	0.46
Outside Davis	0.01

[1] From -2 (strongly disagree on all statements) to 2 (strongly agree on all statements).

Table 6
Linear regression model for commute satisfaction.

	Mean coefficient	Standard deviation
(Intercept)	**0.48**	**0.10**
Commute stress	**−0.25**	**0.01**
Wasted time	**−0.09**	**0.01**
Mode liking	**0.26**	**0.01**
Female	**0.09**	**0.03**
Undergrad	**−0.19**	**0.04**
Graduate student	**−0.20**	**0.04**
Staff	**−0.14**	**0.05**
Train	0.07	0.11
Drive	−0.05	0.04
Bus	**−0.38**	**0.13**
Bus * lives in Davis	**0.25**	**0.13**
Mode constrained	**0.09**	**0.05**
Lives in Davis	0.05	0.06
Distance (miles)	**−0.01**	**0.00**
Distance^2	**0.00**	**0.00**
R^2	0.50	
N	2483	

commutes even after accounting for differences in commute quality. This finding is possibly explained by greater satisfaction in other domains (as might result from great income, job security, and intellectual fulfillment), a possibility that could be explored in future research.

If our commute quality variables fully capture the mode characteristics that influence satisfaction, the coefficients for the mode variables would be insignificant. This is the case for taking the train and driving, relative to bicycling. The coefficient for taking the bus, however, is significant and sizably negative, suggesting that something about taking the bus, beyond its contribution to higher stress and lower enjoyment, detracts from commute satisfaction. The interaction term for bus and living in Davis, which indicates use of the local bus system (see Table 1), is positive, suggesting that commuters using the regional bus system are less satisfied. Because distance is also accounted for in the model, this result might reflect the less frequent service and more limited coverage of the regional system in comparison to the local system. Commuters with mode constraints (i.e. just one mode available to them) are, surprisingly, *more* satisfied than those without mode constraints, all else equal.

Residential location is not statistically significant after accounting for commute quality and other variables. This makes sense, as the effect of residential location on commute satisfaction is likely to be mediated by commute mode and thus commute quality. In other words, we have little reason to believe that residential location in and of itself, apart from its connection to mode choice, would impact commute satisfaction. But the strong connection between residential location and mode choice means that residential location is still an important consideration in devising strategies to increase commute satisfaction, as discussed further below. Distance has a significant effect on commute satisfaction, all else equal, also pointing to importance of land use policies, housing policies in particular.

5. Discussion of results

The strong connection between perceived commute quality and commute satisfaction, the latter shown by other researchers to be connected to well-being more generally, supports a focus on commute quality and the factors that influence it, as discussed in this section, as well as strategies for increasing it, as discussed in the next section.

Commute quality is strongly tied to commute mode for UC Davis commuters. Bicyclists have the highest quality commutes: for most, the commute is not stressful for them, they do not feel that their travel time is wasted, and they like their mode. Although the sample of walkers in this study is small, they too report low stress and disagree that travel time is wasted. These findings are consistent with prior studies that show that commuting by active modes – bicycling and walking – are the least stressful and the most enjoyable, producing the highest level of satisfaction of all modes (Gatersleben and Uzzell, 2007; Friman et al., 2013; Olsson et al., 2013; Chng et al., 2016; Páez and Whalen, 2010; St-Louis et al., 2014; LaJeunesse and Rodríguez, 2012; Smith, 2016; Ory and Mokhtarian, 2005). Unfortunately, active modes are only reasonably available to those living in Davis, as the commutes from surrounding cities are generally too far even for bicycling. Even so, over 200 of students, staff, and faculty not living in Davis are estimated to commute by bicycle (Thigpen, 2015).

The train offers the highest quality commute (next to biking) for those living outside of Davis: train riders disagree that their travel time is wasted time, and they like their mode. As prior research on the Capitol Corridor line shows, riders use free wi-fi service to “multitask” for work and other purposes (Berliner et al., 2015); other studies echo this result (Lyons et al., 2007). Train riders report a moderate level of stress, on average, perhaps owing to concerns over the potential for delays; although the service achieves 90% on-time performance (Amtrak, 2017), it has a reputation for occasional long delays owing to priority given to the freight trains with which it shares tracks. Train riders rate their commute as far better than bus riders do, even though bus commutes are far shorter on average (2.6 miles versus 54.5 miles). Bus riders generally feel stressed when they get to campus, they feel that travel time is wasted, and fewer of them like their mode. This difference is consistent with prior research that highlights crowding and lack of control, which are more of a problem on the bus than the train, as factors that increase stress and reduce commute satisfaction (Abou-Zeid and Ben-Akiva, 2014; Cantwell et al., 2009; Stradling et al., 2007). Note that while train riders are mostly faculty and staff, bus riders are mostly undergraduate students.

Of the undergraduates living in Davis, nearly equal shares bicycle and ride the bus to campus (40% and 44%, respectively, with driving alone accounting for 10%). Yet the quality of these commutes are vastly different, with bus riders most likely to agree that travel time is wasted and that traveling to campus is stressful. Why then, do so many undergraduates ride the bus? A dislike of bicycling may provide much of the explanation: 86% of undergraduates who bicycle agree that they like biking, whereas just 47% of those riding the bus agree and 31% disagree that they like biking. Indeed, analysis of the bicycling mode choice using UC Davis Campus Travel Survey data from a previous year showed that liking biking was one of the most significant predictors of the choice to bicycle to campus among students as well as faculty and staff living in Davis (Miller and Handy, 2012).

A closer look at the relationship between mode, mode liking, and commute stress for undergraduates adds additional nuance. Most students who bike say that they like biking, and these students are by far the least likely to report stressful commutes of all students (26%). Students who like biking but take the bus report stressful commutes at a much higher rate (39%). These students might feel less stress if they shifted to bicycling. As for why they are not bicycling, even though they like bicycling and find the bus stressful, we do not know, though anecdotally students often cite stolen or broken bicycles as a problem. Students who don’t like biking are the most stressed of all, whether they take the bus (55%) or bike (46%). This finding could reflect frustration with a transportation system within the city and on the UC Davis campus that prioritizes bicycling. It could also suggest the possibility of fundamental differences between students who like biking and those who don’t with respect to their general stress levels.

Drive alone commuting falls somewhere in the middle. Many drivers feel that the commute is stressful and their travel time is wasted time, and they are less likely to like their commute mode than bicyclists or train riders (though more likely than bus riders). Driving with others

appears to offer a somewhat higher quality commute: it is equally stressful, but travel time is less likely to be seen as wasted. The social aspects of commuting with others could explain the latter result, as well as the potential for working in the car if someone else is driving. The fact that stress is about the same for those riding with others and those driving suggests the possibility of trade-offs between sources of stress, e.g. the stress one feels when driving versus the stress one feels when someone else is driving.

Gender differences are notable. The model for commute satisfaction suggests that women are more satisfied than men, all else equal. But all else is not equal. Women report lower quality commutes on all three dimensions: more stress, more sense that travel time is wasted, less liking of their modes. We do not have a way to assess whether their commutes are objectively worse than those of men, but prior research hints at reasons why women might perceive lower quality commutes on these dimensions, including greater responsibilities for childcare and other household duties (e.g. Taylor et al., 2015; Gimenez-Nadal and Molina, 2016).

The degree to which a participant's commute mode reflects choice rather than necessity also influences satisfaction, but not in the direction we expected. Studies showing that control is positively related to satisfaction (e.g. Sposato et al., 2012) would suggest that greater flexibility leads to greater satisfaction. Our findings show the opposite: mode-constrained commuters have higher satisfaction, all else equal. Mao et al. (2016) found, however, that the relationship between mode flexibility and trip satisfaction is not linear: the commuters with the most flexibility are the most satisfied but those with the least flexibility often had high levels of satisfaction as well. The tendency for people to adjust their attitudes to match their behavior, in order to achieve cognitive consistency, could be one explanation (Gawronski, 2012; Kroesen et al., 2017). It is important to note that residential location, which dictates the available commute modes, may also be a matter of affordability rather than preference, as housing prices in Davis are high relative to surrounding communities.

6. Implications

UC Davis has established the well-being of its students and employees as an important goal, and commute quality is clearly important for well-being. If UC Davis wants to increase commute quality so as to increase well-being, what should it do? Given the strong connection between mode and commute quality, two paths are possible: improve each mode so as to reduce stress and increase enjoyment, or get commuters to switch to higher quality modes. Transportation planning efforts in the region have long aimed toward the former, and our results suggest the need for improvements to bus service. But the fact that the modes yielding the highest quality commutes are also more environmentally sustainable than the driving-alone alternative gives the university further motivation to pursue the second aim, a mode shift. Indeed, UC Davis is now developing a comprehensive transportation demand management plan with the goal of reducing its drive-alone mode share.

Our results suggest that getting more Davis residents bicycling to campus and getting more of those who live outside of Davis commuting by train would lead to higher overall satisfaction. The university already offers incentives to use these modes through its Go Club, which provides discounted train tickets among other incentives. Of course, it is important to consider mode self-selection: commuters generally use the modes they do for good reasons, including the satisfaction that they derive from that mode. Forcing commuters into other modes might not increase their satisfaction: undergraduates now taking the bus might find bicycling far more stressful and less enjoyable; employees driving alone might have the same reaction to taking the train. The association we and others have found between mode and satisfaction does not necessarily imply causality, or at least not uni-directional causality.

Given the likelihood of at least some degree of mode self-selection, employers like UC Davis might do well to focus on two types of strategies. First, they might identify "mis-matched" employees – employees who are not using the mode that would yield the highest commute satisfaction. Using the readiness for change model widely employed in the public health field, we previously identified a segment of UC Davis commuters who would like to bicycle but don't (Thigpen et al., 2015). These commuters may need just a small nudge or a bit of assistance to switch modes. Second, the university might target underlying mode perceptions and preferences through social marketing techniques. In other words, they could help their employees to see how other modes can be less stressful and more enjoyable.

The question of who lives in Davis and who lives outside of Davis is important to this discussion. Many staff members choose to live outside of Davis owing to the high cost of housing in Davis, and they often live in areas not linked to Davis by the train, thereby being dependent on lower quality modes. Thus, another strategy for increasing commute quality is to increase the feasibility of living in Davis. The university already has plans for price-controlled housing for staff and faculty to be built on university-owned land; the city also has policies that encourage more affordable housing. For those who choose to live in Davis, the possibility of a high-quality commute by bicycle or at least a shorter and thus higher quality commute by car may help to compensate for higher housing costs or even be a primary motivation for this choice. Land use policies are thus an essential complement to – and indeed an essential component of – strategies that aim to improve the quality of modes and encourage commuters to shift to higher quality modes.

Cross-sectional studies like this one provide a basis for the design of experimental or quasi-experimental studies that can more directly test the effectiveness of mode shifts in increasing commute satisfaction. A handful of such studies so far suggest that mode switching can increase satisfaction (Ettema et al., 2016). In future work, we will be assessing the effectiveness of the university's TDM programs in bringing about a shift in modes and the degree to which this shift reduces commute stress, increases enjoyment, and raises overall levels of satisfaction.

7. Conclusions

This paper adds to the nascent literature on commute satisfaction. It replicates a commute satisfaction measure used in European studies, provides new evidence on the contribution of commute stress and enjoyment to satisfaction, and echoes prior studies in finding a strong connection between mode and perceived commute quality. These studies together point to a variety of strategies for improving well-being, life satisfaction, and happiness through improvements to commute quality.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.tbs.2018.03.001.

References

Abou-Zeid, M., Ben-Akiva, M., 2011. The effect of social comparisons on commute well-being. Transp. Res. Part A: Policy Pract. 45 (4), 345–361.

Abou-Zeid, M., Ben-Akiva, M., 2014. Satisfaction and Travel Choices. In: Handbook of Sustainable Travel. Springer Netherlands, pp. 53–65.

Amtrak, 2017. Capitol Corridor On-Time Performance. Available: https://www.amtrak.com/capitol-corridor-train&mode=perf&overrideDefaultTemplate=OTPPageVerticalRouteOverview (accessed 6.07.17).

Berliner, R. M., Malokin, A., Circella, G., Mokhtarian, P. L. 2015. Travel-based multitasking: modeling the propensity to conduct activities while commuting. In: Transportation Research Board 94th Annual Meeting (No. 15-5018).

Buehler, T., Handy, S., 2008. Fifty years of bicycle policy in Davis, California. Transp. Res. Rec. J. Transp. Res. Board 2074, 52–57.

Cantwell, M., Caulfield, B., O'Mahony, M., 2009. Examining the factors that impact public transport commuting satisfaction. J. Public Transp. 12 (2), 1.

Chng, S., White, M., Abraham, C., Skippon, S., 2016. Commuting and wellbeing in London: the roles of commute mode and local public transport connectivity. Preventive Med. 88, 182–188.

De Vos, J., Witlox, F., 2017. Travel satisfaction revisited. On the pivotal role of travel satisfaction in conceptualising a travel behaviour process. Transp. Res. Part A 106, 364–373.

Eriksson, L., Friman, M., Gärling, T., 2013. Perceived attributes of bus and car mediating satisfaction with the work commute. Transp. Res. Part A: Policy Pract. 47, 87–96.

Ettema, D., Friman, M., Gärling, T., Olsson, L.E., 2016. Travel Mode Use, Travel Mode Shift and Subjective Well-Being: Overview of Theories, Empirical Findings and Policy Implications. In: Mobility, Sociability and Well-being of Urban Living. Springer Berlin Heidelberg, pp. 129-–150.

Ettema, D., Gärling, T., Olsson, L.E., Friman, M., 2010. Out-of-home activities, daily travel, and subjective well-being. Transp. Res. Part A: Policy Pract. 44 (9), 723–732.

Ettema, D., Gärling, T., Olsson, L.E., Friman, M., Moerdijk, S., 2013. The road to happiness: measuring Dutch car drivers' satisfaction with travel. Transp. Policy 27, 171–178.

Evans, G.W., Wener, R.E., Phillips, D., 2002. The morning rush hour: predictability and commuter stress. Environ. Behavior 34 (4), 521–530.

Friman, M., Fujii, S., Ettema, D., Gärling, T., Olsson, L.E., 2013. Psychometric analysis of the satisfaction with travel scale. Transp. Res. Part A: Policy Pract. 48, 132–145.

Gatersleben, B., Uzzell, D., 2007. Affective appraisals of the daily commute: comparing perceptions of drivers, cyclists, walkers, and users of public transport. Environ. Behav. 39 (3), 416–431.

Gawronski, B., 2012. Back to the future of dissonance theory: cognitive consistency as a core motive. Social Cognition 30 (6), 652–668.

Gimenez-Nadal, J.I., Molina, J.A., 2016. Commuting time and household responsibilities: evidence using propensity score matching. J. Reg. Sci. 56 (2), 332–359.

Kroesen, M., Handy, S., Chorus, C., 2017. Do attitudes cause behavior or vice versa? An alternative conceptualization of the attitude-behavior relationship in travel behavior modeling. Transp. Res. Part A: Policy Pract. 101, 190–202.

LaJeunesse, S., Rodríguez, D.A., 2012. Mindfulness, time affluence, and journey-based affect: exploring relationships. Transp. Res. Part F: Traffic Psychol. Behav. 15 (2), 196–205.

Lucas, J.L., Heady, R.B., 2002. Flextime commuters and their driver stress, feelings of time urgency, and commute satisfaction. J. Bus. Psychol. 16 (4), 565–571.

Lyons, G., Chatterjee, K., 2008. A human perspective on the daily commute: costs, benefits and trade-offs. Transp. Rev. 28 (2), 181–198.

Lyons, G., Jain, J., Holley, D., 2007. The use of travel time by rail passengers in Great Britain. Transp. Res. Part A 41, 107–120.

Mao, Z., Ettema, D., Dijst, M., 2016. Commuting trip satisfaction in Beijing: exploring the influence of multimodal behavior and modal flexibility. Transp. Res. Part A: Policy Pract. 94, 592–603.

McElreath, R., 2015. Statistical Rethinking: A Bayesian Course with Examples in R and Stan. CRC Press, Boca Raton, FL.

Miller, J., Handy, S., 2012. Factors that influence university employees to commute by bicycle. Transp. Res. Rec. J. Transp. Res. Board 2314, 112–119.

Mokhtarian, P.L., Papon, F., Goulard, M., Diana, M., 2015. What makes travel pleasant and/or tiring? An investigation based on the French National Travel Survey. Transportation 42 (6), 1103–1128.

Mokhtarian, P.L., Salomon, I., Redmond, L.S., 2001. Understanding the demand for travel: it's not purely 'derived'. Innovation 14, 355–380.

Novaco, R.W., Gonzalez, O.I., 2009. Commuting and well-being. Technol. Well-Being 3, 174–184.

Novaco, R.W., Stokols, D., Milanesi, L., 1990. Objective and subjective dimensions of travel impedance as determinants of commuting stress. Am. J. Community Psychol. 18 (2), 231–257.

Novaco, R.W., Stokols, D., Campbell, J., Stokols, J., 1979. Transportation, stress, and community psychology. Am. J. Community Psychol. 7 (4), 361–380.

Olsson, L.E., Gärling, T., Ettema, D., Friman, M., Fujii, S., 2013. Happiness and satisfaction with work commute. Social Indic. Res. 111 (1), 255–263.

Ory, D.T., Mokhtarian, P.L., 2005. When is getting there half the fun? Modeling the liking for travel. Transp. Res. Part A: Policy Pract. 39 (2), 97–123.

Ory, D.T., Mokhtarian, P.L., Redmond, L.S., Salomon, I., Collantes, G.O., Choo, S., 2004. When is commuting desirable to the individual? Growth Change 35 (3), 334–359.

Páez, A., Whalen, K., 2010. Enjoyment of commute: a comparison of different transportation modes. Transp. Res. Part A: Policy Pract. 44 (7), 537–549.

Core Team, R., 2017. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

Redmond, L.S., Mokhtarian, P.L., 2001. The positive utility of the commute: modeling ideal commute time and relative desired commute amount. Transportation 28 (2), 179–205.

Rissel, C., Crane, M., Wen, L.M., Greaves, S., Standen, C., 2016. Satisfaction with transport and enjoyment of the commute by commuting mode in inner Sydney. Health Promotion J. Aust. 27 (1), 80–83.

Schaeffer, M.H., Street, S.W., Singer, J.E., Baum, A., 1988. Effects of control on the stress reactions of commuters. J. Appl. Soc. Psychol. 18 (11), 944–957.

Smith, O., 2016. Commute well-being differences by mode: Evidence from Portland, Oregon, USA. J. Transp. Health.

Sprumont, F., Astegiano, P., Viti, F., 2017. On the consistency between commuting satisfaction and traveling utility: the case of the University of Luxembourg. Eur. J. Transp. Infrastruc. Res. 17 (2), 248–262.

Sposato, R.G., Röderer, K., Cervinka, R., 2012. The influence of control and related variables on commuting stress. Transp. Res. Part F: Traffic Psychol. Behav. 15 (5), 581–587.

St-Louis, E., Manaugh, K., van Lierop, D., El-Geneidy, A., 2014. The happy commuter: a comparison of commuter satisfaction across modes. Transp. Res. Part F: Traffic Psychol. Behav. 26, 160–170.

Stan Development Team, 2016. RStan: the R interface to Stan. R package version 2.14.1. http://mc-stan.org/.

Stradling, S.G., Anable, J., Carreno, M., 2007. Performance, importance and user disgruntlement: a six-step method for measuring satisfaction with travel modes. Transp. Res. Part A 41, 98–106.

Stutzer, A., Frey, B.S., 2008. Stress that doesn't pay: the commuting paradox. Scand. J. Econ. 110 (2), 339–366.

Taylor, B.D., Ralph, K., Smart, M., 2015. What explains the gender gap in schlepping? Testing various explanations for gender differences in household-serving travel. Social Sci. Q. 96 (5), 1493–1510.

Thigpen, C., 2015. Results of the 2014-15 Campus Travel Survey. Institute of Transportation Studies, University of California, Davis Research Report UCD-ITS-RR-15-15.

Thigpen, C.G., Driller, B.K., Handy, S.L., 2015. Using a stages of change approach to explore opportunities for increasing bicycle commuting. Transp. Res. Part D: Transp. Environ. 39, 44–55.

Wener, R.E., Evans, G.W., 2011. Comparing stress of car and train commuters. Transp. Res. Part F: Traffic Psychol. Behav. 14 (2), 111–116.

Wener, R., Evans, G., Boately, P., 2005. Commuting stress: psychophysiological effects of a trip and spillover into the workplace. Transp. Res. Rec. J. Transp. Res. Board 1924, 112–117.

Ye, R., Titheridge, H., 2017. Satisfaction with the commute: the role of travel mode choice, built environment and attitudes. Transp. Res. Part D: Transp. Environ. 52, 535–547.