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Why is active travel more satisfying than motorized travel? Evidence from Dublin

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Some trips are better than others, and more and more studies find that active travel (walking and cycling) is more satisfying than motorized forms of travel (using the car or public transport). Why is this the case? Using data on travel satisfaction from 4134 commutes to a large University campus in Dublin, Ireland, this paper replicates the differences in travel satisfaction between active and motorized travel. We attribute these differences in large part to the duration of the trip. Subjective trip characteristics, such as safety and convenience, also play important roles. The trip duration explains rush-hour effects as well as why people starting from less affluent and more difficult-to-reach places are less satisfied with their trips. Longer-term policy options suggested by these results include infrastructure developments and spatial development strategies. A shorter-term initiative would be to delay university schedules in the morning to avoid low travel satisfaction during the slow rush-hour period and simultaneously ease pressure on the transport network at peak times.

\section*{1. Introduction}

People do not always make choices that are in their own best interests. A large and growing literature in behavioral economics has identified and explored this discrepancy between decision utility (which informs choice) and experienced utility (which is the basis for welfare) (Benjamin et al., 2012; Berridge and Aldridge, 2008; Comerford, 2011; De Vos et al., 2016; Kahneman et al., 1997; Read, 2007). For example, some people live far away from their workplaces and yet travel to work by car and public transport despite happiness research indicating that long commutes in motorized modes are one of the least satisfying daily activities (Kahneman et al., 2004; Lancée et al., 2017; Stone and Schneider, 2016). Furthermore, these low levels of travel satisfaction can spill over to low levels of life satisfaction (De Vos, 2019a; Friman et al., 2017; Olsson et al., 2013; Stutzer and Frey, 2008).\footnote{Such findings suggest that choices (e.g. about transportation modes) alone offer only a limited perspective to fully understand the welfare consequences of our behavior (Hausman, 2012; Infante et al., 2016; Sugden, 2018). Hence, policy-makers who are interested in increasing people’s welfare when traveling need additional information to better inform transport policy design.\footnote{The terms “welfare” and well-being are often used interchangeably in the literature on welfare economics.}}

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\textsuperscript{1} Of course, in many cases people are not able to decide whether to live close or far away from their workplaces as this is determined by, for example, budget constraints. Travel choices are often influenced by other, longer-term choices regarding, for example, lifestyle and residential location.

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Over the last decade, a growing group of scholars, including transportation researchers, have argued that subjective well-being can be used as a welfare measure to inform policy (Dolan and White, 2007; Friman et al., 2018; Layard, 2006). Subjective well-being is often defined as an experienced momentary feeling, and diary studies or other naturalistic monitoring tools are used to measure it (Kahneman et al., 2004; Shiffman et al., 2008). Arguably the most common finding from the literature on experienced subjective well-being in the transport context is that people who travel actively (i.e., who walk or cycle) are more satisfied with their travel than people who drive and/or use public transport (De Vos, 2018, 2019b; De Vos et al., 2013; Ettema et al., 2011; Friman et al., 2017; Lancée et al., 2017; Smith, 2017; Westman et al., 2017). However, it is not yet clear why this is the case. For example, De Vos (2019b) reviews the literature on differences in travel satisfaction across travel modes and notes that “studies on travel satisfaction barely give explanations for these differences; and when they do, these explanations are not empirically founded and therefore not entirely convincing” (p. 15).

This paper presents results and analysis from a commuting survey at University College Dublin, Ireland that asked participants to indicate how satisfied they were with their most recent trip to the campus. We initially assess whether active travel (walking and cycling) is ranked as more satisfying than motorized travel (driving and public transport) amongst the 4134 participants whose last commute was to the main campus. Thereafter we aim to explain the differences in travel satisfaction across travel modes by empirically investigating the effects of starting time of travel, duration of travel, distance of travel, subjectively assessed characteristics of the trip, social interaction during travel, and demographic variables. We also test whether living close to bus stops, using a real-time information app about bus departures, and parking difficulties on campus are associated with travel satisfaction. Finally, we test for associations between travel satisfaction and geospatial information on the location from which participants started their trip, focusing on economic deprivation and the accessibility to transport at that location.

One key finding of the paper is that differences in travel satisfaction across travel modes can be attributed in large part to the duration of the trip (e.g., trips with the bus take longer than when people walk or cycle). This suggests a need to control for trip duration when examining differences in travel satisfaction across travel modes in future studies. We also find that the duration of the trip depends on the starting time of the trip (a rush-hour effect) and use these insights to formulate an ambitious policy proposal: delaying the starting schedule of universities would deliver higher trip satisfaction ratings, whilst simultaneously easing pressure on transport infrastructure and services during the morning peak commute.

The remainder of the paper is structured as follows: Section 2 reviews the literature on the determinants of travel satisfaction; Section 3 presents the data and methodology used for the study; Section 4 presents the results; Section 5 discusses contributions to the literature, policy implications, and avenues for future research. The last section concludes.

2. Literature review

2.1. Measuring travel satisfaction

When measuring the subjective quality of travel, researchers do not elicit general travel satisfaction ratings.3 Rather, they ask study participants about feelings during specific trips. This focus on specific trips reduces biases in the response patterns and allows to correlate satisfaction ratings with situational context variables such as travel mode, time of the day, and other situational trip-specific variables (Bryson and MacKerron, 2017; Dolan et al., 2008; Friman et al., 2018).

There are a number of scales to measure the quality of specific trips (e.g., see Mokhtarian and Pendyala, 2018). The most common is the Satisfaction with Travel Scale (STS) introduced by Ettema et al. (2011).4 The STS consists of nine question items that allow answers on a scale from −3 to 3 with a higher score implying higher satisfaction (De Vos et al., 2015; Friman et al., 2013). The STS measures three sub-components of travel satisfaction with three questions each. The first two sub-components deal with affect and differentiate between valence and activation as suggested by the Swedish Core Affect Scale (SCAS) (Västfjäll et al., 2002). They measure feelings from negative activation to positive deactivation (“stressed to calm”, “worried to confident”, and “hurried to relaxed”) and from negative deactivation to positive activation (“bored to enthusiastic”, “tired to alert”, and “fed up to engaged”). The third sub-component is cognitive evaluation, which is measured by the following three items: “the trip was the worst/best I can think of”; “the trip was very low/high standard”; and “the trip did not work out/worked out well”.

Most studies differentiate between all three sub-components of the STS (e.g., De Vos, 2018; Ettema et al., 2012; Ettema et al., 2011; et al., 2017). However, De Vos et al. (2015) suggest using a two-factor interpretation and differentiate only between affective feelings and cognitive evaluation (De Vos, 2019a; De Vos et al., 2019). Friman et al. (2013) show that the three dimensions of the STS can also be used as a global measure of travel satisfaction as they form an overall construct and this approach is adopted by several studies (Friman et al., 2017; Taniguchi et al. 2014; Ye and Titheridge, 2017).

2.2. Determinants of travel satisfaction

The literature on the determinants of travel satisfaction is growing rapidly. Detailed reviews of this literature are provided elsewhere (De Vos, 2019b; De Vos and Witlox, 2017; Friman et al., 2018; Gao et al., 2018), and we review only selected findings of

3 Exceptions are studies that ask survey respondents to indicate how satisfied they are with their commutes in general, i.e. not specific to one particular commute (e.g., Abou Zeid, 2009; Abou-Zeid and Ben-Akiva, 2011; Bergstad et al., 2011).

4 Other studies rely on single-item measures of travel satisfaction (e.g., Gao et al., 2017, 2018).
relevance to the present study. We differentiate between trip-specific and individual-specific determinants of travel satisfaction.

In terms of trip-specific determinants of travel-satisfaction, several studies find that people who travel actively (i.e., who walk or cycle) are more satisfied with their travel than people who drive and use public transport (De Vos et al., 2013; Ettema et al., 2011; Friman et al., 2017; Lancée et al., 2017; Singleton, 2019; Smith, 2017; St-Louis et al., 2014; Westman et al., 2017; Ye and Titheridge, 2017; Zhu and Fan, 2018). It is not entirely clear what explains these mode-effects. Highlighting this knowledge gap, De Vos (2019b) argues that the effect of travel mode on travel satisfaction is in part explained by whether travelers have positive or negative attitudes towards their chosen travel mode.

Amongst other determinants of travel satisfaction, trip duration and trip distance are often negatively related to travel satisfaction (De Vos et al., 2016; Handy and Thigpen, 2019; Higgins et al., 2018; Higgins et al., 2018; Morris and Guerra, 2015; St-Louis et al., 2014; Stone and Schneider, 2016; Westman et al., 2017; Zhang et al., 2016). When trips are unusual, longer trips may also represent an escape from the daily routine (Mokhtarian et al., 2015) and thus influence travel satisfaction positively. However, in these cases people may confound their liking for the uncommon activity that starts after the trip with the liking for the trip itself (De Vos et al., 2016).

Subjective evaluations of trip attributes that are correlated with travel satisfaction include reliability (Mahmoud and Hine, 2016), punctuality, speed, and service frequency (Mouwen, 2015; de Oña et al., 2016), flexibility (Mao et al., 2016), comfort (Mahmoud and Hine, 2016; Susilo and Cats, 2014), convenience (Mahmoud and Hine, 2016; de Oña et al., 2016), congestion levels and overcrowding (Higgins et al., 2018; Morris and Hirsch, 2016; Smith, 2017), as well as cleanliness and safety (Susilo and Cats, 2014). Travelling alone (in contrast to travelling in company) has a negative effect on travel satisfaction in some studies (De Vos et al., 2016; Lancée et al., 2017; Mokhtarian et al., 2015; Zhu and Fan, 2018).

There is limited research on the associations between geospatial determinants and travel satisfaction. First findings suggest that suburban respondents report higher levels of travel satisfaction than urban respondents, a relationship strongest for car and public transport users (De Vos et al., 2016). Mokhtarian et al. (2015) find that urban residents consider trips less tiring, but also less pleasant compared to non-urban residents. Other studies do not find direct associations between the residential location and travel satisfaction (Mokhtarian and Pendyala, 2018; Ye and Titheridge, 2017). In a sample of walkers, Manaugh and El-Geneidy (2013) do not find associations between travel satisfaction, distance, and elevation change. However, they do find effects in sub-group analyses dividing walkers by their motivations to walk.

Research has also shown that people living in lower-income areas tend to have relatively fewer travel options, are more likely to experience transport poverty which can impact on their ability to undertake activities and consequently their well-being, and face more dangerous and unhealthy travel conditions (Currie et al., 2009; Lucas et al., 2016). More generally, there is considerable research on the connections between transport and social disadvantage (Lucas, 2012; Lucas et al., 2018; Schwanen et al., 2015). However, there are no studies examining the links between the affluence of the area from where the trips start, social disadvantage, and travel satisfaction.

In terms of individual-specific factors, several studies show that older people report higher travel satisfaction (Cao and Ettema, 2014; De Vos et al., 2016; Ettema et al., 2013; Friman et al., 2017; St-Louis et al., 2014; Susilo and Cats, 2014; Ye and Titheridge, 2017). Some studies find that males are more satisfied than females (Handy and Thigpen, 2019; Higgins et al., 2018), and in some studies this effect is present only for specific modes of transport (mainly public transport) (St-Louis et al., 2014). There are also studies that do not find significant associations between gender and travel satisfaction (Carrel et al., 2016). A number of studies show that positive attitudes towards travelling predict higher satisfaction with travel, especially when the attitudes are mode-specific (Cao and Ettema, 2014; De Vos, 2018; Ye and Titheridge, 2017). Also moods such as feeling happy, relaxed and angry predict travel satisfaction (Gao et al., 2017). Some studies find that people with pro-environmental attitudes are more satisfied with active modes of travel (Manaugh and El-Geneidy, 2013) and that personality traits, such as being critical and being easy-going, predict travel satisfaction (Gao et al., 2017).

The literature reviewed above shows that there are various potential pathways that may explain differences in travel satisfaction across travel modes. Hence, the results of one study might not be replicable in other contexts. It is also clear that the empirical strategy, and in particular the choice of control variables, matters when analyzing and quantifying the differences of travel satisfaction across travel modes and different studies and contexts. Finally, the literature suggests that the role of geospatial determinants on travel satisfaction is somewhat under-researched thus far.

3. Data and methodology

3.1. Setting

The data used in this research is taken from a large-scale travel behavior survey carried out at University College Dublin (UCD) in Ireland by the University’s Estates Service Team who have run a Commuting Survey annually since 2011. The main aim of these commuter surveys is to inform campus development by identifying commuting requirements. The 2018 survey was the first to include questions on travel satisfaction and other factors of the most recent commute to campus.

The university has several campuses in Dublin but over 90% of staff members and students work or study at the largest campus Belfield (according to the 2018 UCD commuting survey). Accordingly, this paper focuses on commutes to this campus. Belfield is

5 University College Dublin (www.ucd.ie) is Ireland’s largest university with a staff and student population in excess of 30,000.
located approximately 4 km south of the city center in one of the city’s more affluent areas. It is a stand-alone campus with 11
entrances. Permit parking spaces can be used (if available) for an annual fee and hourly parking spaces are available as well. Public
transport is available for students at a discount. The campus is serviced by a number of bus routes but does not have a high-capacity
rail transport link nor dedicated train or tram stops. The closest tram and train stations are roughly a 30-minute walk from the
campus.

UCD staff members and students often need to commute long distances. Reasons for this include a limited supply of living space
near the campus, high rents in surrounding areas and the city center, and a propensity for lower density development in the past in
Dublin. Commuters who use the car tend to arrive early on campus in order to find a free parking spot. Moreover, levels of congestion
in the city are high, and a report suggests that only in Bogota and Rome do commuters lose more time in congestion. Commuting to
the campus by bike is sometimes perceived as unsafe and inconvenient because bike lanes are shared with buses for long stretches of
road or end somewhat abruptly. Commuting to the campus on foot is possible for those living close to the campus as footpaths are
provided in all built-up areas. In terms of public transport, the bus network is described as discontinuous and the attractiveness of bus
journeys is reduced by delays caused by a small number of choke points across the road network (NTA, 2016).

3.2. Sample

On November 5th and November 14th, 2018, the University’s Estates Service distributed an invitation to participate in the Annual
Commuting Survey via email to all students, university staff members, and faculty. As an incentive, participants were offered the
opportunity to enter a lottery for a €200 voucher. During the time that the survey was live, 6253 responses were recorded (4608
students and 1645 staff members).

For this study, we focus only on those participants who worked or studied in the biggest campus (Belfield), who were aged 18 or
older, for whom we have full information on travel mode, travel duration, companion, subjective experience, and satisfaction of the
most recent commute to campus as well as key demographics (student/staff status, age, gender, the number of days the participant
usually commutes to the campus). We retained only participants who made their most recent commute by bus, train, car, bicycle or
on foot (thus dropping 189 observations of passengers in the car and 72 observations who indicate having used “Other” travel
modes). This left us with a final sample size of 4134. Table 1 presents the details of this sample.

3.3. Descriptive statistics

We focus on the survey questions that dealt with the participants’ most recent commute to the campus. The survey measured their
travel satisfaction using the Satisfaction with Travel Scale as described in Section 2.1 and presented in full in the Supplementary
Information. The Satisfaction with Travel Scale was included in the survey as it is the most elaborated measure for travel satisfaction
and has become the standard domain-specific measure in the domain of travel (De Vos, 2019b). For this paper’s analyses, we use the
global outcome measure for travel satisfaction in order to keep the already detailed analyses as straightforward as possible. Using the
two or three sub-components of the Satisfaction with Travel Scale would render the presentation of our findings very complicated. In
our data, travel satisfaction has a mean of 0.165 (SD = 1.284; Skewness = −0.078; Min = −3; Max = 3; alpha = 0.9017).

The survey asked participants to indicate the type of travel mode they used for their trip. The primary travel mode was the bus in
38.83% of the trips, followed by the car (24.43%), the bicycle (18.36%), walking (12.58%), and the train (6.10%). Fig. 1, Panel A
shows a density plot of the distributions of travel satisfaction for all modes combined as well as separated by travel mode. Already this
figure indicates that people are more satisfied when they walk or cycle than when they take the car, and in particular, than when they
use public transport.

Participants indicated the time of the day when they started their most recent commute to the campus. Most trips started between
7 am and 9 am. Fig. 1, Panel B presents density plots based on the start of the commute in 15-minute intervals by travel mode. It
shows that active commutes began later than motorized commutes. In terms of the duration of the trip, 662 (16.01%) trips took less
than 15 min, 945 (22.86%) took between 15 min and 30 min, 692 (16.74%) took between 30 min and 45 min, 634 (15.34%) took
between 45 min and an hour, and the remaining 1201 (29.05%) trips took more than an hour. Trip duration is measured from door to
door, i.e. it includes, for example, the ca. 30-min walk when people take the train. The duration of the trip differed by travel mode as
illustrated in Fig. 2, which shows, for example, that active trips were shorter than other trips. Trips for which participants used the
train as the primary mode took the longest time.

Participants were also asked to describe their commute on a scale from “0 (Not at all)” over 1–5 to “6 (Very much)” for the
following five attributes - “Safe”, “Clean”, “Congested/Overcrowded”, “Strenuous”, and “Convenient”. Table 3 presents the mean values
of these attributes for all trips and also separated by travel mode. It shows, for example, that biking was perceived as the least safe and
most convenient travel mode.

In terms of the company during the trip, 2222 (53.75%) of the trips were alone, on 1476 (35.70%) trips strangers were present,
6 For example, only about 24% of our sample indicate having a typical commute of less than 4 km and more than 18% have a typical commute of
over 25 km.
7 This is based on an Inrix Report (2018) that compares congestion in over 200 cities across the world. The same report also shows that Dublin has
the slowest downtown peak speed across the 200 cities analyzed with drivers travelling at an average of less than 10 km/ph at peak times in the city
center.
and on 436 (10.55%) trips people known to the participant were around. Almost half (48.69%) of the participants indicated that they regularly use a mobile phone app that provides real-time information about bus departures, and 41.94% of the participants indicated that they lived less than 500 m away from a bus stop. Of the 1381 participants who indicated that they drove regularly to the campus,

Table 1

| Variables       | Observations (percent) |
|-----------------|------------------------|
| Gender          |                        |
| Male            | 1619 (39.16%)          |
| Female          | 2515 (60.84%)          |
| Age categories  |                        |
| 18–24           | 2400 (58.06%)          |
| 25–34           | 683 (16.52%)           |
| 35–44           | 490 (11.85%)           |
| 45–54           | 359 (8.68%)            |
| Over 55         | 186 (4.5%)             |
| Rather not to say | 16 (0.39%)         |
| Status          |                        |
| Student         | 3046 (73.68%)          |
| Staff           | 1088 (26.32%)          |

Fig. 1. Panel A: Distribution of travel satisfaction based on the average of all nine items by travel mode. Panel B: Start of commute in 15 min-intervals by travel mode.

Fig. 2. Distribution of trip duration for each transport mode.

Table 2

| Total | Bus | Car | Bike | Feet | Train |
|-------|-----|-----|------|------|-------|
| Travel Satisfaction | 0.16 | −0.28 | 0.11 | 0.83 | 0.83 | −0.19 |
| Safe | 4.25 | 4.48 | 4.34 | 3.21 | 4.87 | 4.33 |
| Clean | 3.93 | 3.68 | 4.33 | 3.66 | 4.57 | 3.41 |
| Congested | 3.29 | 3.82 | 3.22 | 2.69 | 2.21 | 4.26 |
| Strenuous | 2.66 | 2.82 | 2.42 | 2.79 | 2.15 | 3.31 |
| Convenient | 3.70 | 3.14 | 3.89 | 4.53 | 4.33 | 2.68 |
| N | 4134 | 1593 | 1010 | 759 | 520 | 252 |
27.15% indicated rarely or never having problems finding a parking place, 30.70% answered with 1–2 times per week, 19.12% with 3–4 times per week, and 23.03% with 5 or more times per week.

Participants also indicated the origin point of their trip using a list of regions that could be accessed from a drop-down menu. Respondents started their trips from 259 different regions with 221 (5.35%) starting from the Campus itself. We mapped all of these regions to the nearest Local Election Area (LEA) in order to produce Fig. 3. The numbers in each LEA in this figure indicate the number of participants who started their trip from the respective area along with the travel mode share in percent for public transport, car use, and active transport. The figure shows, for example, that active commutes are much more prevalent from LEAs

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**Fig. 3.** Travel Satisfaction by Local Election Areas. The numbers indicate the number of respondents who start their trip in the respective area along with the travel mode share in percent for (Public Transport, Car, Active Transport).

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Each county and city in Ireland are divided into Local Electoral Areas (LEAs) for the purposes of local elections. In 2019 there were 166 LEAs in Ireland.
close to the campus than from LEAs far away from the campus. The color-coding in the figure indicates the average travel satisfaction rating for each LEA, using a 5-point color-coded classification from red, indicating lower levels of travel satisfaction, to green, indicating higher levels of travel satisfaction. The map suggests that the distance to UCD is an important geographical determinant of travel satisfaction. However, it is possible that distance only predicts lower travel satisfaction because distance and duration are positively correlated. Moreover, there seems to be a North/South divide with commutes that start in LEAs north of the river Liffey being less satisfying than commutes from south of the river.

There are recognized differences in affluence between the south and the north of the city (e.g., Doherty et al., 2015) and prior research has investigated the link between economic deprivation and travel satisfaction (e.g., Currie et al., 2009). The accessibility to public transport may be an important reason for this link between economic deprivation and travel satisfaction. In order to investigate the impact of deprivation and accessibility on travel satisfaction in Dublin, we referred to two complementary geospatial datasets: (i) the 2016 Haase-Pratschke (HP) Index of Relative Deprivation described in Haase et al. (2012) and available online, and (ii) the 2008 Accessibility Index (Gamma and Haase, 2008). The former measures the relative deprivation of Ireland’s regions based on economic, demographic, and social Census-based indicators and the latter focuses purely on transport-based accessibility indicators. Both datasets are available at Electoral Division Level, which is more detailed than the level of LEAs. Hence, we linked the survey participants’ points of journey origin also to the Electoral Division Level.

Finally, using the information on the Electoral Divisions, we created a measure for the distance of each journey. We used the network analyst extension of ArcGIS and the Open Street Map road network to generate an Origin-Destination matrix with the origin of each trip defined as the centroid of each Electoral Division and the destination point defined as the UCD Belfield Campus. This provided us with a distance measure in kilometers indicating the shortest distance that people would need to travel on the existing road network between the trip origin and the campus. This procedure allowed us to calculate the distance for 3970 trips. The mean distance of these trips is 13.5 km (SD: 19.03 km; Min: 0.15 km; Max: 130.44 km). There are substantial differences in distance across the main travel mode people used. The averages for the respective travel modes are as follows: Walking: 2.21 km; Cycling: 6.19 km; Bus: 16.11 km; Car: 19.06 km; Train: 26.72 km.

3.4. Analysis strategy

In order to analyze the differences in travel satisfaction across travel modes, we run a number of linear regressions with the global Satisfaction with Travel Scale (STS,) for individual i as the dependent variable. The full regression model of the main analysis is specified as

\[ STS_i = \beta_0 + \beta_1 \text{Mode}_i + \beta_2 \text{Dur}_i + \beta_3 \text{Char}_i + \beta_4 \text{ToD}_i + \beta_5 \text{Comp}_i + X_i + \varepsilon, \]

where Mode indicates a categorical variable for the primary travel mode, Dur is the duration of the commute, Char is a vector indicating five subjective trip characteristics (safe, clean, congested/overcrowded, strenuous, and convenient) interpreted as continuous variables, ToD is a continuous variable indicating the time of the day when the commute started, Comp is a dummy variable indicating whether there was a company or not, X is a vector indicating the individual-specific control variables (age, gender, role at university, and days per week on the campus), and \( \varepsilon \) is the robust error term. In the main analysis, we first quantify the effect of the travel mode on travel satisfaction controlling for the time of the day, company, and the variables described in X. We then add further variables to the mode. We are particularly interested in the effect of travel mode on travel satisfaction and hence observe how the travel mode coefficients change when adding further variables (travel duration and subjective trip characteristics). This stepwise addition of variables helps us to explain differences in travel satisfaction across travel modes as identified in the previous literature and also helps us to control for sample heterogeneity (e.g., travel duration differs systematically across travel modes).

In additional regression analyses, we omit the travel mode variable and run separate regressions for each travel mode with the remaining variables. This provides mode-specific associations between the independent variables and travel satisfaction. We also make use of some additional questions asked in the travel survey and test whether living close to bus stops, using a real-time information app, and parking difficulties are associated with travel satisfaction for certain modes. Finally, we test for associations between travel satisfaction and external information on the location from which participants started their trip, focusing on distance, economic deprivation, and the accessibility to transport.

4. Regression results

Table 3 presents the study’s main results on the determinants of travel satisfaction. Models (1)–(3) present the results using the full sample adding variables gradually. Specifically, model (2) adds the trip duration and model (3) the subjective trip characteristics to the regression. Models (4)–(8) repeat model (3) but for each of the travel modes separately in order to identify mode-specific determinants of travel satisfaction.

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9 The 2016 Pobal HP Deprivation Index for Small Areas (SA) is available from http://trutzhaase.eu/deprivation-index/the-2016-pobal-hp-deprivation-index-for-small-areas/ (retrieved on June, 04, 2019).
10 Electoral Divisions (EDs) are the smallest legally defined administrative areas in Ireland. Generally, LEAs are created by the aggregation of EDs. In 2019 Ireland was divided into 3440 EDs.
11 While we interpret the global travel satisfaction variable as continuous and run OLS regressions in the main analyses, we present the results of an ordered logit model in the Supplementary Information. The results are qualitatively unchanged.
4.1. Travel mode effects

Model (1) shows that active modes of transport (walking and biking) are associated with higher travel satisfaction compared to non-active modes. Calculating the predicted travel satisfaction ratings for each travel mode holding all other variables constant at their mean shows that walking and biking obtain predicted travel satisfaction ratings of 0.894 (95% Confidence Intervals: 0.795, 0.994) and 0.810 (95% CIs: 0.739, 0.882), respectively. Car trips obtain predicted travel satisfaction ratings of −0.021 (95% CIs: -0.102, 0.060).

Table 3

Results of linear regression models predicting global travel satisfaction.

| VARIABLES                        | All          | All          | All          | Bus          | Car          | Bike         | Feet         | Train        |
|----------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Travel mode. Base = Bus          |              |              |              |              |              |              |              |              |
| Car                              | 0.166***     | −0.0874      | −0.154***    | (0.0607)     | (0.0598)     | (0.0531)     |              |              |
| Bike                             | 0.984***     | 0.386***     | 0.597***     | (0.0530)     | (0.0626)     | (0.0593)     |              |              |
| Walking                          | 1.067***     | 0.522***     | 0.414***     | (0.0606)     | (0.0682)     | (0.0608)     |              |              |
| Train                            | 0.0349       | 0.305***     | 0.379***     | (0.0773)     | (0.0753)     | (0.0631)     |              |              |
| Length of the trip. Base = Less than 15 min |              |              |              |              |              |              |              |              |
| 15–30 min                        | −0.175***    | −0.00501     | −0.202*      | (0.0562)     | (0.0506)     | (0.176)      | (0.121)      | 0.0777       |
| 30–45 min                        | −0.347***    | 0.00978      | −0.247       | (0.0658)     | (0.0595)     | (0.172)      | (0.131)      | 0.125        |
| 45–60 min                        | −0.671***    | −0.155**     | −0.370**     | (0.0726)     | (0.0665)     | (0.173)      | (0.139)      | 0.212        |
| 60+ min                          | −1.202***    | −0.517***    | −0.711***    | (0.0728)     | (0.0681)     | (0.169)      | (0.146)      | 0.317        |
| Safe                             | 0.185***     | 0.106***     | 0.292***     | (0.0211)     | (0.0325)     | (0.0505)     | (0.0413)     | 0.0411       |
| Clean                            | 0.0846***    | 0.147***     | −0.0158      | (0.0196)     | (0.0305)     | (0.0427)     | (0.0411)     | 0.0602       |
| Congested                        | −0.0674***   | −0.0975***   | −0.0989**    | (0.0194)     | (0.0326)     | (0.0403)     | (0.0409)     | 0.0403       |
| Strenuous                        | −0.157***    | −0.192***    | −0.105**     | (0.0202)     | (0.0321)     | (0.0440)     | (0.0408)     | 0.0583       |
| Convenient                       | 0.376***     | 0.412***     | 0.284***     | (0.0197)     | (0.0301)     | (0.0431)     | (0.0483)     | 0.0623       |
| Time of day                      | 0.0226***    | 0.00554      | 0.00332      | (0.00411)    | (0.00405)    | (0.00341)    | (0.00492)    | 0.00372      |
| Company. Base = Strangers were around |              |              |              |              |              |              |              |              |
| I was alone                      | 0.0304       | 0.0317       | 0.0539       | (0.0472)     | (0.0458)     | (0.0396)     | (0.0567)     | 0.130        |
| People I knew                    | 0.134**      | 0.138**      | 0.108**      | (0.0670)     | (0.0637)     | (0.0545)     | (0.0801)     | 0.150        |
| Female                           | −0.135***    | −0.139***    | −0.109***    | (0.0374)     | (0.0357)     | (0.0312)     | (0.0486)     | 0.0182       |
| Age Category. Base = 18–24       |              |              |              |              |              |              |              |              |
| 25–34                            | 0.0827       | 0.106*       | 0.129***     | (0.0597)     | (0.0565)     | (0.0806)     | (0.119)      | 0.101        |
| 35–44                            | 0.297***     | 0.379***     | 0.328***     | (0.0839)     | (0.0796)     | (0.0690)     | (0.120)      | 0.134        |
| 45–54                            | 0.659***     | 0.697***     | 0.396***     | (0.0923)     | (0.0881)     | (0.0769)     | (0.156)      | 0.146        |
| 55+                              | 0.770***     | 0.719***     | 0.564***     | (0.124)      | (0.115)      | (0.100)      | (0.195)      | 0.165        |
| Rather not say                   | 0.381        | 0.271        | 0.361        | (0.316)      | (0.269)      | (0.251)      | (0.326)      | 0.327        |
| Staff (vs Student)               | 0.0914       | 0.0347       | 0.00111      | (0.0696)     | (0.0652)     | (0.0565)     | (0.0990)     | 0.112        |
| Days in per week                 | 0.0271       | −0.0211      | −0.0247      | (0.0204)     | (0.0197)     | (0.0171)     | (0.0259)     | 0.0381       |
| Constant                         | −0.854***    | 0.461***     | 0.129        | (0.136)      | (0.157)      | (0.136)      | (0.241)      | 0.481        |
| Observations                     | 4134         | 4134         | 4134         | 1593         | 1010         | 759          | 520          |              |

Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, * p < 0.1.
do not hallucinate.
also Table SI 5). As such, the association between leaving time and travel satisfaction is fully explained by the time it takes to reach the campus.

4.4. Influence of subjective trip characteristics

Model (3) in Table 3 adds the subjective trip-characteristics to the regression. The main effects of these subjective trip-characteristics on travel satisfaction are summarized in Panel A of Fig. 6. This figure shows that trips that are experienced as safe, clean, and convenient are associated with higher travel satisfaction and trips that are experienced as congested/overcrowded and strenuous are associated with lower travel satisfaction. Convenience is the most important characteristic. A one-standard-deviation increase of convenience is associated with an increase of 0.376 (p < 0.001) in travel satisfaction, controlling for all other subjective characteristics. Congestion is the least important trip characteristic (b = −0.067; p = 0.001).

Adding the subjective trip characteristics to the regression in model (3) also changes the effects of travel mode on travel satisfaction. In particular, and as illustrated in Fig. 3, the predicted travel satisfaction for biking increases, which is an effect in the opposite direction of the effect that adding duration in model (2) has. Moreover, once we control for the trip characteristics, the effect of duration on travel satisfaction is attenuated. For example, in model (3) trips that last for less than 15 min are not significantly different in terms of their travel satisfaction compared to trips that last 30–45 min.

4.5. Effects of demographics

In terms of demographics, females are less satisfied with their trip than males (b = −0.135, p < 0.001; based on model 1) and this effect attenuates only slightly when controlling for more variables in models (2) and (3). Age is positively associated with trip satisfaction. For example, based on model (1), travelers aged 18–24 have a mean travel satisfaction score of 0.022 (95% CIs: −0.038, 0.082) and travelers aged over 55 have a mean travel satisfaction score of 0.793 (95% CIs: 0.571, 1.014). There are no differences in travel satisfaction between students and staff members and it does not matter for travel satisfaction how often participants commute to the campus per week on average.

![Fig. 5](image_url). Travel satisfaction by time the trip started with and without controlling for the length of the trip. The shaded areas indicate 95% Confidence Intervals.

![Fig. 6](image_url). Effects of the five subjective trip-characteristics on travel satisfaction for all modes combined (Panel A) and separated by mode (Panel B).
4.6. Travel mode-specific effects

Models (4)–(8) repeat the analysis from model (3) for each of the five travel modes separately. This analysis reveals that trip duration matters more for bus and car-trips than when people bike, walk, or take the train. The effects of trip duration on travel satisfaction in each of the travel modes is attenuated, however, by the inclusion of the five trip characteristics. In (not reported) regressions that do not control for subjective trip characteristics, trip duration is a significant and negative predictor for all travel modes. Models (4)–(8) also show that females are less satisfied with their travel than males only during bus trips. There are no gender differences in other modes. Fig. 6, Panel B shows the associations between the subjective trip-characteristics and travel satisfaction separated by travel mode, suggesting that, for example, cleanliness matters for bike and bus trips, but not when walking, for train trips, or car trips.

4.7. Distance from a bus stop, use of the real-time app, and parking difficulties

The survey contained a number of additional variables and we tested for the associations between these and travel satisfaction. We found that travel satisfaction is higher when people live less than 500 m away from the nearest bus stop \( (b = 0.146, p < 0.001) \), and that this effect is driven by bus users, walkers, and train users. We also found that bus travelers were not more or less satisfied with their trip depending on whether they used a real-time information app (an app that gives real-time information about when the next bus arrives) \( (b = -0.087, p = 0.137) \). Parking difficulties, which were assessed only for participants who indicated that they drive to the campus regularly, had a strong effect on travel satisfaction for those whose last commute was by car. In a model similar to model (2) from Table 3, the predicted travel satisfaction ratings for commuters who have parking difficulties 5 or more times a week is \(-0.236\) (95% CIs: \(-0.390, -0.082\)). The predicted travel satisfaction for those who have parking difficulties 3 or 4 times a week is \(-0.134\) (95% CIs: \(0.257, -0.010\)), for those who have parking difficulties 1–2 times per week it is 0.252 (95% CIs: 0.146, 0.359), and for those who rarely or never have parking difficulties it is 0.547 (95% CIs: 0.420, 0.675).

4.8. Deprivation and accessibility effects

Finally, we tested for associations between travel satisfaction and the geospatial variables economic deprivation and accessibility at the location where the trip started. As illustrated in Fig. 7, Panel A when only controlling for demographics the economic deprivation index is positively associated with travel satisfaction \( (b = 0.0241, p < 0.001) \). People are more satisfied with their trips when they come from a more affluent area. This association is in the expected direction as the campus is in an affluent area of the city and people are more satisfied with shorter trips. When additionally controlling for the travel mode, the effect is attenuated \( (b = 0.0104, p < 0.001) \), indicating that travelers in affluent areas close to the campus more frequently use active travel modes. Finally, when also controlling for the duration of the trip (and some other variables as in model 3), the association between the deprivation index and travel satisfaction becomes negative and significant \( (b = -0.0144, p < 0.001) \). This suggests that if the trip lasted for the same amount of time, travelers would be more satisfied with the trip when starting from a deprived area rather than a less deprived area. However, the data show that deprivation alone is not a reason for lower levels of travel satisfaction. We repeat the same analysis with the accessibility index and the results are shown in Fig. 7, Panel B. Again, better accessibility to public transport is positively associated with travel satisfaction. This effect is entirely explained by other control variables and in particular by travel mode and the duration of the trip.

5. Discussion

5.1. Contributions to the literature

The paper contributes to the literature on travel satisfaction in a range of ways. First, it replicates several associations with travel satisfaction in a different travel environment with a comparatively large sample of over 4000 participants in a city with a less...
developed transport infrastructure. In our data, travel satisfaction has a mean of 0.165 (on the Satisfaction with Travel Scale that ranges from −3 to +3), which is comparatively low compared to other studies using the same scale in different geographical areas (e.g., compared to De Vos et al., 2015; Friman et al., 2013, 2017). 14

The study replicates recent findings indicating that travel satisfaction is highest for active transport modes (e.g., De Vos, 2018, 2019b; De Vos et al., 2013; Ettema et al., 2011; Friman et al., 2017; Lancée et al., 2017; Smith, 2017; Ye and Titheridge, 2017; Zhu and Fan, 2018). Going beyond showing these associations, our study empirically investigates why travel satisfaction differs across travel modes. As highlighted by De Vos (2019b), “no study up till now has been able to indicate why travel satisfaction levels differ according to the chosen travel mode” (p. 15). He argues that the strong effects of travel mode on travel satisfaction typically found in the literature are likely to be overestimated. We show, for example, that the duration of the trip explains why people prefer car trips over public transport trips: If both trip types had the same duration, people would prefer using public transport in our sample. Our findings thus suggest that it is essential for future studies to control for trip duration when examining differences in travel satisfaction across travel modes. While De Vos (2019b) suggests that attitudes towards travel modes mediate the mode effect on travel satisfaction, we show empirically that trip duration is also an important mediator. However, travel mode remains a significant predictor of travel satisfaction in our data even after controlling for many variables (such as the duration of the trip). But if we had also controlled for (unavailable) data on people’s attitudes towards travel modes, the travel mode effects on travel satisfaction might be even more attenuated.

The study also contributes to the literature on the links between subjective trip attributes and travel satisfaction (Higgins et al., 2018; Mahmoud and Hine, 2016; Mao et al., 2016; Morris and Hirsch, 2016; Mouwen, 2015; de Oña et al., 2016; Smith, 2017; Susilo and Cats, 2014). We test the correlations of 5 subjective trip characteristics (safe, clean, congested/overcrowded, strenuous, and convenient) with travel satisfaction and find that, for example, safety and in particular convenience predict travel satisfaction positively. It is noteworthy that in the current study, biking is perceived as more satisfying than the non-active travel modes although people perceive it to be relatively dangerous to bike in Dublin (the average safety rating for all modes on a scale from 0 to 6 in our data is 4.25; the average safety rating for biking is only 3.21).

We also advance the nascent literature on geospatial determinants of travel satisfaction. For example, some studies find that suburban respondents report higher levels of travel satisfaction than urban respondents (e.g., de Vos et al., 2016) and other studies do not find direct associations between the residential location and travel satisfaction (e.g., Ye and Titheridge, 2017). As can be seen in Fig. 3, in our data commutes from suburban areas are less satisfying than commutes from urban areas. However, once we controlled for various variables, including duration of the commute, this effect reversed. This suggests that the inclusion of duration-related variables in the regression models might explain the differences found across studies in the previous literature. We also incorporate more specific geospatial determinants of the commute – specifically the economic deprivation and accessibility of the location where the trip started and present some associations of these variables with travel satisfaction. Hence, we contribute to the literature on the links between transportation and social disadvantage (e.g., Lucas, 2012) by directly investigating the relationship between the spatial distribution of deprivation and travel satisfaction.

The paper also provides new evidence on the link between trip duration, distance, and travel satisfaction. In line with a number of studies (De Vos et al., 2016; Handy and Thigpen, 2019; Higgins et al., 2018, 2018; Morris and Guerra, 2015; St-Louis et al., 2014; Stone and Schneider, 2016; Westman et al., 2017; Zhang et al., 2016), we find that longer trips are less satisfying. Other research finds that longer trips can be positively correlated with travel satisfaction (De Vos et al., 2016; Mokhtarian et al., 2015), but this is typically the case for unusual trips and not for commutes and routine trips as we analyze in this paper.

5.2. Implications for transport policy-making

The findings presented in this paper offer insights that can inform the design of interventions aimed at encouraging shifts to non-motorized or mass transit modes. Furthermore, the evidence leads us to consider an ambitious policy proposal that could encourage modal shifts, whilst also substantially easing transport infrastructure pressures at peak travel times.

First, we find that active travel commutes are the most satisfying form of travel. This suggests that investments in infrastructure (e.g., safe and well-lit cycling and walking paths) on the extended approach routes to the campus can help to sustain and encourage active travel. Moreover, active travel could boost the travel satisfaction of those commuting to the campus. However, to validate that this association is causal, future research should implement causal designs to test whether it is active travel that causally increases travel satisfaction.

Second, the duration of the trip is a strong predictor of travel satisfaction. Thus, we surmise that interventions that reduce commute time can increase travel satisfaction. An important characteristic of most active commutes is their short duration, which is often linked to the proximity between the origin and the destination. Whilst long-term strategies can seek to reduce commute distances through higher density planning and so forth, 15 in the short to medium term, this is not an option. However, reducing

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14 For example, using the same scale Friman et al. (2013) report a mean travel satisfaction rating of 0.75 in a sample from Stockholm, Goteborg, and Malmö. De Vos et al. (2015) report mean travel satisfaction ratings in Ghent by travel mode that can be averaged to a travel satisfaction rating of 1.23, and Friman et al. (2017) report the three sub-components of the satisfaction with travel scale that average to 0.87 in a sample in Stockholm, Goteborg, and Karlstad. However, our sample contains more bus users than most of the other studies which reduces the average trip satisfaction. An optimal study design would compare the travel satisfaction to very similar destinations (e.g., in terms of location) across different cities.

15 See for example the compact development concept in the National Planning Framework, as well as details of linked national infrastructure.
distance is not the only way to reduce trip durations. For example, the National Transport Authority of Ireland is proposing to redesign the Dublin bus network over the coming years to make bus journeys faster, more predictable, and more reliable.\(^\text{16}\) Where these investments and actions can shorten trip durations, there should be a further stimulus for modal shift to active and mass transit modes. However, the findings of this paper also suggest that it may be useful to establish a general ambition for the reduction of trip journey times within a reasonable radius to less than 45 min, on the basis of this representing a clear threshold point for trip satisfaction ratings.\(^\text{17}\)

Third, the analysis indicates convenience as a key characteristic of travel satisfaction, suggesting that transport policies should aim to increase convenience for travelers. This can include efforts to reduce waiting times for mass transit modes, facilitating easier and more direct access to the campus via walking and cycling routes and so forth.

Fourth, the data show that difficulties with finding a parking space on campus have a very strong negative effect on the travel satisfaction of drivers. This reinforces the importance of parking policy and strategy with regard to encouraging modal shift and influencing private car journeys to campus. Whilst the immediate response may be to consider the provision of additional parking spaces, the lower relative travel satisfaction of car journeys where parking is either scarce or strategically priced also represents an opportunity to stimulate additional transfers to non-motorized or mass transit modes of travel to campus.

Finally, we find that travelling at rush-hour, which impacts negatively on travel satisfaction, is explained by the longer time it takes to get to the campus during these peak travel times. This insight and the overall findings in this paper lead us to consider an ambitious short-term initiative that could reduce journey times for commuters to the campus, ease pressure on the morning peak transport and travel infrastructure, and potentially encourage more non-motorized and mass transit mode choices. Specifically, we would recommend that the universities consider the introduction of a newly regulated schedule that ensures classes, coursework, and most meetings do not commence before 10 am. The anticipated impact of shifting more than 30,000 staff and students to a deferred starting hour would be to reduce associated commutes during the peak travel times. Related initiatives, compatible with the systems and skillsets developed during the COVID-19 pandemic, could also see increased options into the future for remote participation in meetings and classes. These measures could contribute to reduced road congestion and potentially increased safety for cyclists and pedestrians. The reduced commuting on public transport in the busiest period of the morning, would ease pressure on public transport service capacity and open up opportunities for other commuters (e.g. 9–5 city center workers) to consider a shift to public transport. There are of course recognizable challenges that range from motorists continuing to travel early to secure parking spaces, to challenges for the campus population relating to their own personal scheduling of commitments and activities such as picking up children, doing groceries, going to leisure activities, etc. However, an initial response may suggest complementary parking strategies, and a recognition that young university students are likely amongst the most flexible of all morning commuters. Furthermore, the COVID-19 pandemic has accelerated a global understanding of what is possible in regard to remote working and learning. While a more detailed analysis of these policy proposals would need to be conducted, our results provide an important contribution to such analyses.

5.3. Further research

Our study suggests several avenues for future research. We use cross-sectional data in this study and therefore cannot interpret the associations we find in a causal way. For example, the finding that people are more satisfied with active than passive travel could reflect that people who are generally more satisfied with things are particularly likely to use active travel modes. Moreover, other, unobserved variables could explain both travel mode choice and travel satisfaction. Further research is needed in order to identify the direction of causality by either including travel satisfaction questionnaires in experimental designs, evaluating natural experiments, or making use of econometric techniques to allow us to infer causality from observational data. As a first step, it would be helpful to have the same study respondent rate a higher number of trips made with different travel modes in order to control for individual-specific fixed effects. Such studies are more burdensome for participants to complete, and as a result, they will likely have smaller sample sizes. Nonetheless, we believe that it is an important step for research in this area that could also identify further associations with travel satisfaction, such as weather and the time of the year.

An alternative avenue for future research is to identify more variables that could explain differences in travel satisfaction across travel modes. For example, active travel has health and well-being benefits (Humphreys et al., 2013; Martin et al., 2014) and active commutes might lead to happier individuals over time. To get first insights into this link, future research could test for differences in travel satisfaction between active commuters who just started commuting actively and those who already commute actively for an extended period of time. More psychological variables, such as (perceived) lack of control, might also explain differences on travel satisfaction across travel modes where active travelers perceive a higher sense of control (Beirão and Sarsfield Cabral, 2007). Finally, variables related to the environment (such as air quality, noise, and green spaces) might explain differences in travel satisfaction across travel modes.

Another avenue for further research concerns the items used in this study. For example, it would be important to test whether

(footnote continued)

\(^{\text{16}}\) https://busconnects.ie/media/1184/bus-connects-cbc-route-maps-web_14.pdf.

\(^{\text{17}}\) We acknowledge that future work can set more refined travel time bands to gain additional insight on associated travel satisfaction threshold points.
subjective trip characteristics, such as “safe” and “congested” are interpreted differently by travelers using different modes. Experiencing a busy pathway on the bike might be a different experience compared to commuting on a congested bus. Hence, comparing subjective attribute measures across modes might be an invalid comparison and further research should identify subjective attributes that are interpreted similarly across modes to allow for valid comparisons. A related avenue for future research is to investigate whether the associations we find when using the general Satisfaction with Travel Scale are also present when we investigate the sub-components of the scale.

The University campus provides us with an excellent case of substantial scale. However, the methodology could be applied more broadly, with a view to the development of a city-wide travel satisfaction index. Many national authorities run travel surveys as part of their national census and adding a question on travel satisfaction for each trip would provide valuable information that could be used to develop a dynamic index that could monitor travel satisfaction and thereby inform policy-makers of the relative strengths and weaknesses of the travel infrastructure in their city.

Finally, we have proposed an ambitious policy intervention about a delayed starting schedule and/or increased remote learning for the University campus. National ambitions relating to reduced GHG emissions, improved ambient air quality, and better citizen health and well-being could benefit from these policies. There are surmountable complexities relating to the design of such schemes, as well as a number of interactions and outcomes that would influence the degree to which the initiative may reduce emissions. Nonetheless, the primary motivation for the measure would be to reduce travel time, ease pressure on peak transport services, and enhance travel satisfaction for all. In order to advance this proposal, we would recommend further research on the policy design, with a potential ex-ante ex-post case study utilizing selected University units as a precursor to the possibility of a campus-wide measure.

CRediT authorship contribution statement

Leonhard K. Lades: Conceptualization, Methodology, Software, Formal analysis, Data curation, Writing - original draft, Writing - review & editing, Visualization. Andrew Kelly: Conceptualization, Writing - review & editing. Luke Kelleher: Conceptualization, Software, Data curation, Writing - review & editing, Visualization.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tra.2020.04.007.

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