Incorporating Existence, Relatedness & Growth needs in transport mode choice: A hybrid choice framework

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Abstract

Understanding the factors influencing travel mode choice is of great importance for promoting sustainable transport. This study proposes a coherent framework for representing travel mode choice that incorporates satisfaction of human needs and perceived functional and psychological barriers to use certain modes in an integrated choice and latent variable model (ICLV). Using data from a survey of commuters in the Greater Copenhagen Area the model framework is validated in a region with large shares of car users, public transport riders and bicyclists. The model results suggest that higher bicycle use is related to positive cycling self-concepts. Similarly, the choice of car is positively related to car self-concepts and negatively related to experiencing functional difficulties in car use. Finally, respondents with a strong focus on functional travel needs are most likely to commute using car and least using public transport. Future work will evaluate the impacts of a policy scenario including service improvements, and how they vary across user groups.

1 Introduction

The choice of mode is one of the most important travel decisions individuals make. Not only does this affect their mobility, it also impacts congestion levels, especially during rush hours in metropolitan areas, in which the road network capacity is typically exceeded. Many factors play a role when individuals decide on what mode to use. Being able to model mode choice decisions is important in terms of evaluating traffic policies such as road pricing, bus priority and cycling infrastructure. Hence, it is crucial to ensure that important parameters are included in the mode choice model.

The traditional literature on travel mode choice has typically investigated the influence of directly observed quantifiable parameters including service characteristics, e.g. travel time, travel costs and travellers' socio-economic characteristics. While it is uncontested that these are indeed crucial for mode choice, they do not fully consider the motivators of travel behaviour, which are suggested to be governed by a holistic experience comprising of perceptions, emotions, past experiences, attitudes and social climate (Abou-Zeid et al., 2012; Susilo and Cats, 2014). Studies have shown that travellers associate the travel choice context with both relatedness and personal growth, which are part of essential human needs (Alderfer, 1969; Maslow, 1943). Car-use is associated with gaining travel independence and self-image through status and prestige (Sigurdardottir et al., 2014). Public transport is correlated with self-esteem and respect for others through travel mode fairness (Kaplan et al., 2014), with "relational value" through "social climate appreciation"

(Salvá et al., 2015). Hence, the use of public transport is associated with both functional and psychological needs of relatedness and growth as also suggested by Perone et al. (2005). Similarly, cycling is related to individual self-esteem such as self-identity and life-values self-concepts (Spotswood et al., 2015), and improving the feelings of self-esteem, self-confidence and empowerment (van der Kloof et al., 2014). Hence, it is important to consider a wide spectrum of needs when considering the perceived travel experience and thus mode choice of travellers (Mateo-Babiano, 2016; Taniguchi et al., 2014).

Recent studies within the mode choice literature have considered such elements by incorporating latent variables related to individuals' personal attitudes. Popuri et al. (2011) found positive effects of attitudes to the importance public transport, need for reliable and stress-free commute, and negative effects of need for privacy, perceived safety and dynamic work schedule for the choice of public transport. Similarly, Paulssen et al. (2014) found that commuter mode choice is highly influenced by personal values including power and hedonism. Kamargianni et al. (2014) found strong influence of social interaction on mode choice, i.e. the influence of parents' preferences on mode choice to school hence suggesting the importance of incorporating social elements in the context of mode choice. Similar importance of social norms were confirmed in Sottile et al. (2015) as choice of using park-and-ride facilities at public transport stations were influenced by feeling obligated to do so due to the behaviour of others. Also, Kamargianni et al. (2015) found that personal beliefs related to green lifestyle and physical activity were highly significant on public transport use and bicycle use, respectively.

While these studies have managed to incorporate important aspects related to individuals' personal beliefs regarding social norms and self-perceptions into the choice context, no studies have focused on the importance of needs satisfaction using a coherent framework that considers both lower-order functional needs and higher-order personal needs associated to self-identity while considering individuals' perceived mode-specific barriers. Hence, the objective of this paper is to study the interrelationships between psychological beliefs and quantitative measures of travel characteristics in travel mode choice by proposing a coherent framework based on the ERG theory of needs (Alderfer, 1969) and the self-efficacy theory (Bandura, 1977). The ERG theory is developed from Maslow's hierarchical theory of motivation (Maslow, 1943) and is based on a three-fold conceptualisation of human needs: 1) Existence (e.g., material and physiological needs), 2) Relatedness (e.g., interpersonal relations with significant others), and 3) Growth (e.g., self-actualization, fulfillment of inner potential and life opportunities). The coherent framework allows considering preferences related to how well each mode fulfils the needs of users, which traditionally are not taken into account in mode choice models, while also taking into account explicitly perceived travel difficulties as obstacles towards the use of certain modes. The model structure is adopted from previous work on modelling and evaluating travel satisfaction and travel use frequency using structural equation models (Ingvardson et al., 2018, 2017). Empirical validation of the proposed framework is ensured by utilising data from a tailor-made survey of commuters in the highly multi-modal Greater Copenhagen area, which has large shares of car users, public transport riders and bicyclists.

2 Model framework

To study the relationships between satisfaction of travel needs, perceived travel difficulties, traditional level-of-service characteristics, and mode choice, we utilize an Integrated Choice and Latent Variable (ICLV) model to simultaneously model individual latent constructs and choice of mode. The proposed model framework is illustrated in Figure 1.

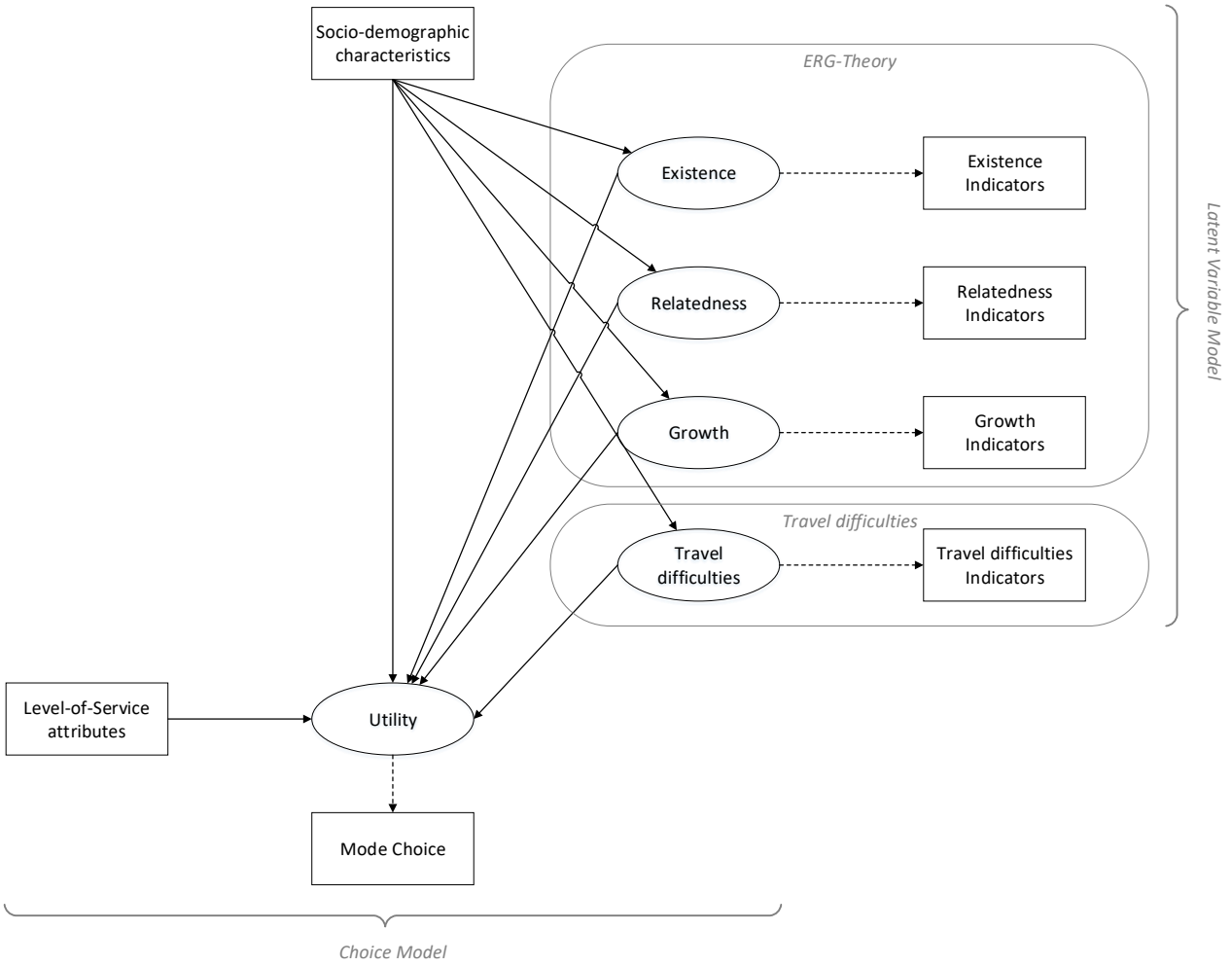

Figure 1; Model framework incorporating the ERG theory of needs satisfaction and travel difficulties into the mode choice context together with traditional level-of-service attributes and users' socio-economic characteristics.

Mode choice is hypothesized to be influenced by each of the three types of needs, namely existence needs, relatedness needs and growth needs. However, another important aspect of mode choice is related to perceived mode-specific barriers, which can be considered a measure of perceived behavioural control or self-efficacy expectations (Bandura, 1977). Hence, such specific travel difficulties complement the ERG theory by adding functional and psychological barriers. Level-of-service characteristics includes travel time and travel costs associated with public transport and car, and solely travel time for bicycle. Lastly, respondents' socio-demographic information is considered explicitly in the mode choice and in influencing the latent variables related to the ERG and travel difficulties constructs.

3 Case study

The data used for this study was based on a tailor-made online survey designed to analyse the relationships between the ERG dimensions and mode choice. The survey consisted of four parts: i) general travel habits and commute characteristics; ii) the ERG dimensions, iii) mode-specific difficulty statements, and iv) individual socio-economic characteristics. The survey was based on commuting trips within the Greater Copenhagen Area, thus the statements were tailored to the commute mode choice context. The survey is briefly described in the following whereas a full description of the survey design and data collection can be found in Ingvardson et al. (2018).

Respondents were asked about their travel trends, including the frequency of using each travel mode (i.e. car, bicycle, public transport, public transport with bicycle) measured on a Likert scale ranging from rarely to daily, with 2–3 times monthly, once weekly, and 2–3 times weekly as intermediate points. For the mode choice model in this study it was required that respondents used the same mode every day and had reported their origin and destination in the survey. Due to these restrictions the number of observations for this part was reduced from the total number of 1,481 to 1,109. As the 372 observations which did not meet these restrictions, still had complete information regarding the latent constructs (as well as socio-demographic characteristics) these observations were retained for estimating the latent variables model. Hence, the choice model is estimated on a (large) subset of full sample.

The respondents were also asked about their usual travel time using their preferred mode. However, since we are using RP-data for estimation and due to this being reported only as a total travel time, we decided to estimate individual parameters for the different time components for public transport, i.e. access/egress time, waiting time, in-vehicle time, and transfer time. However, as it was not possible to estimate these empirically, it was decided to estimate a single parameter for the (generalized) total travel time (TTT) for public transport. The generalized TTT includes access/egress time, waiting time, in-vehicle time, and the number of transfers, and is based on the Danish National Transport Model. As transfers are perceived by passengers to be more onerous than actual travel time, i.e. equalling 5-20 minutes of in-vehicle travel time (Anderson et al., 2014), this was taken explicitly into account by assuming a general transfer penalty of 10 minutes in-vehicle travel time when calculating the generalised TTT.

The statements measuring the human needs (ERG dimensions) were defined based on a thorough literature review, cf. Ingvardson et al. (2018). They were phrased to measure the ability to satisfy individual needs when travelling, e.g. positive attitudes towards a mode or general travel preferences which are not mode-specific. For existence needs they covered functional needs when travelling, e.g. time and monetary savings. Relatedness needs were related to interpersonal relationships, e.g. travelling with friends, colleagues or family members. Growth needs covered higher-order personal needs including developing self-concepts, self-identity or self-esteem, e.g. self-efficacy, social status, or prestige. Finally, statements related to travel difficulties were formulated for each mode with 4-5 statements per mode, e.g. perceived accessibility of transit, bicycling being to difficult due to weather or hilliness, or travelling by car being to congested. The 46 statements including summary statistics are reported in Table 1. Note that this is based on the full sample of 1,481 observations, which is used for the estimation of the latent variables in the ICLV model. Further statistical analyses of the survey data can be found in Ingvardson et al. (2018).

Statement	Factor loading	Mean	St. Dev.	Skewness
Positive cycling self-concepts (0.916)				
I feel on top and with good energy when I cycle	0.89	3.65	1.09	-0.64
I feel mentally strengthened when I cycle	0.88	3.63	1.08	-0.62
I feel good about myself when I cycle	0.85	3.86	1.01	-0.95
I enjoy challenging myself physically when I cycle	0.74	3.25	1.11	-0.15
I feel good about contributing to the environment when I cycle	0.66	3.66	1.07	-0.63
It is important for me to get exercise	0.53	3.51	1.25	-0.51
It is important for me to get fresh air	0.51	3.48	1.22	-0.48
Travel togetherness (0.890)				
It is important for me to talk about a shared hobby related to travel mode	0.86	2.10	1.02	0.59
It is important for me to exercise by bicycle with friends	0.85	2.06	0.99	0.60
It is important for me to travel with my colleagues	0.78	2.07	1.00	0.56
It is important for me to be part of a bicycle culture	0.77	1.95	0.93	0.57
It is important for me to spend quality time together with others on the way	0.75	2.05	1.01	0.71
It is important for me to participate in Bike-to-Work campaigns	0.69	2.28	1.12	0.44
It is important for me to bring/collect others on the way	0.48	2.42	1.25	0.48
Car use functional difficulties (0.758)				
Driving a car is too stressful for me	0.76	2.76	1.30	0.20
Driving a car is too unreliable (congestion) for me	0.65	2.80	1.15	0.04
Searching for parking takes too long for me	0.64	2.81	1.35	0.21
Driving a car is too dangerous for me	0.60	2.14	1.00	0.65
Driving a car is too expensive for me	0.52	3.19	1.16	-0.09
It is important for me to avoid worrying about parking	0.51	3.49	1.27	-0.47
It is important for me to avoid driving stress	0.47	2.86	1.37	0.07
It is important for me to avoid road congestion	0.46	3.52	1.13	-0.48
It is important for me to save money	0.40	3.28	1.13	-0.23
I believe it is important not to contribute to congestion	0.37	3.23	1.03	-0.26
Transit is inaccessible to me	0.24	2.44	1.24	0.56
Positive car self-concepts (0.905)				
Driving a car makes me feel optimistic and high-on-life	0.88	2.30	1.09	0.44
Driving a car is a cool way to travel	0.83	2.33	1.11	0.46
Driving a car makes me feel that I get the most out of every situation	0.76	2.54	1.21	0.28
I live life to the fullest when I drive my car (e.g. by listening to music)	0.67	2.93	1.21	-0.05
I feel more independent when I drive a car	0.61	3.16	1.31	-0.33
Satisfying functional needs (0.750)				
It is important for me to arrive on time	0.58	4.43	0.77	-1.65
It is important for me to carry my things	0.57	3.94	0.96	-0.83
It is important for me to avoid having to change transport mode/line	0.56	3.91	1.10	-0.93
It is important for me to arrive safely	0.54	3.94	0.97	-0.90
It is important for me to avoid congestion in transit	0.50	3.57	1.11	-0.45
It is important for me to save time	0.50	4.28	0.90	-1.24
It is important for me to go wherever and whenever I want	0.48	4.10	1.02	-1.08
It is important for me to have privacy during my transport	0.30	2.76	1.22	0.13
Cycling self-efficacy (0.755)				
Biking is difficult for me because of the distance	0.69	2.14	1.04	0.71
Biking is difficult for me because of the terrain	0.66	3.03	1.59	-0.01
Biking is difficult for me because of the weather	0.55	2.53	1.11	0.32
Biking is dangerous for me due to other traffic	0.47	2.48	1.13	0.40
Functional difficulties in transit (0.823)				
Transit is too crowded for me	0.74	3.65	0.99	-0.34
Transit is unreliable for me	0.66	3.53	1.07	-0.24
Transit is too expensive for me	0.57	3.87	1.03	-0.86
Transit is too slow for me	0.56	3.61	1.19	-0.57

Table 1; Basic descriptive statistics. All items measured on the 5-point Likert scale. N = 1481, Cronbach's alpha in parenthesis.

4 Results

The latent variable and choice models are estimated jointly in order to obtain consistent and more robust parameter estimates. The choice model is estimated on 1,109 observations whereas the latent variables are estimated on the full sample using all 1,481 observations. The travel time parameters are incorporated into the utility function separately for motorised and non-motorised modes as these modes are substantially different, i.e. one parameter for bicycle and one combined for public transport and car. As travel costs for non-motorised modes are negligible, only a single combined cost coefficient is estimated for public transport and car jointly. The main results of the choice model is shown in Table 2, whereas Table 3 reports the influence of socio-economic characteristics on the latent variables as well as latent variable mediator effects.

	Bicycle		Public transport		Car	
Variable	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Travel characteristics / LoS						
Travel time	-0.0779*	-2.08	-0.0311**	-2.58	-0.0311**	-2.58
Travel costs	-	-	-0.0166**	-5.39	-0.0166**	-5.39
Latent (needs) factors						
Bicycle self-concepts (F1)	1.64**	9.02	-	-	-	-
Car use functional difficulties (F3)	-	-	-	-	-4.72**	-7.42
Car self-concepts (F4)	-	-	-	-	0.457**	2.58
Functional needs (F5)	-1.49**	-3.35	-2.39**	-4.70	-	-
Socio-economic characteristics						
Workplace location, city centre	2.07**	7.10	2.00**	6.47	-	-
Education, vocational	-	-	0.528	1.93	-	-
Education, long	-	-	-	-	-0.783**	-2.84
Income, low	-	-	0.945**	3.33	-	-
Couple with children	0.639**	2.82	-	-	-	-
Alternative-specific constants	-14.6**	-5.99	-6.69**	-2.62	-	-

Table 2; Results of the DCM. * p<0.05, ** p<0.01.

Dependent (mediator) variables	Explanatory variable	Coefficient	t-value
Bicycle self-concepts (F1)	Bicycle self-efficacy (F6)	1.000	4.63
	Travel togetherness (F2)	0.254	6.59
Travel togetherness (F2)	Education, long	-0.110	-1.81
Car use functional difficulties (F3)	Male	-0.0712	-2.71
	Home location, city	0.124	4.04
	Work location, city	0.258	7.81
	Car availability	-0.235	-6.54
Car self-concepts (F4)	Single	0.167	1.05
	Car availability	0.348	4.50
	Home location, city	-0.282	-3.61
Functional needs (F5)	Car availability	0.148	3.97
	Couple with children	-0.0755	-2.00
Bicycle self-efficacy (F6)	Male	0.0737	2.94
	Home location, city	0.422	7.00
	Home location, suburb	0.295	6.70
	Work location, city	0.0747	2.56
	Car availability	-0.0739	-2.61

Table 3; The influence of socio-demographic characteristics on the latent variables.

As the results show, we found numerous constructs of the ERG theory to be significant in explaining the commute mode choice, either directly or indirectly through other constructs that act as mediators. More

specifically we found that the choice of bicycle as commuting mode is positively related to bicycle self-concepts, which suggests that respondents' are more likely to choose bicycle if they feel it contributes to their personal beliefs of having an active lifestyle, contributing to a better environment, etc. It can also be observed that bicycle self-efficacy is a significant positive mediator for improved self-concepts, i.e. exerting strong bicycle competences is positively related to developing positive bicycle self-concepts and by that contributing to a higher likelihood of choosing bicycle as commuting mode. Similar results are observed for travel togetherness, which indirectly affects mode choice, possibly due to bicycling creating a strong relationship with peers, e.g. through bike-to-work campaigns. On the other hand, respondents' emphasising a short commute time are less likely to choose bicycle.

Not surprisingly, respondents' with a strong emphasis on satisfying lower-level functional needs are more likely to choose car. Also, users who perceive driving a car as onerous, e.g. due to congestion or difficulties finding parking are less inclined to use car. This suggests the importance of considering perceived personal travel difficulties. Lastly, as for bicyclists, car users also have higher utility of choosing car if they feel that the car satisfies higher-order needs related to self-identity and personal image. This suggests that the choice of car not only is due to its advantages in terms of satisfying functional needs, but also confirms previous findings stating that car use is highly motivated by personal motives related to self-identity, as also highlighted by Steg (2005).

The choice of public transport is negatively related to satisfaction of functional needs at a larger magnitude of that of bicycle. This suggests that respondents with a strong focus on travel time and comfort prefer car to bicycle and bicycle to public transport.

Finally, we tested various socio-demographics both as explanatory variables directly in the choice and the latent variables. We found only a few socio-demographics to have a direct impact on the choice, while a rich set of socio-demographics explains the latent constructs, and in turn, thereby indirectly impacts the choice through the ERG latent constructs.

5 Future work

The model results suggest significant influence of the latent variables related to fulfilment of needs and perceived travel difficulties that combined affects travel mode choice. Next steps will be to evaluate a policy scenario using the ICLV model as well as a simple conventional choice model without latent variables. This will be used to analyse how various user groups might react differently to improved network conditions, e.g. improved bicycle infrastructure or improved public transport services. By comparing the simpler model with the ICLV model taking into account needs satisfaction and perceived travel difficulties it will be possible to estimate user changes in a more detailed manner than using conventional mode choice models.

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