Findings

Lunke, Erik Bjørnson, and Øystein Engebretsen. 2023. "Public Transport Use on Trip Chains: Exploring Various Mode Choice Determinants." *Findings*, April. https://doi.org/10.32866/001c.74112.

TRANSPORT FINDINGS

Public Transport Use on Trip Chains: Exploring Various Mode Choice Determinants

Erik Bjørnson Lunke, Øystein Engebretsen

Keywords: Public transport, Trip chains, Accessibility, Transport mode choice, Logistic regression

https://doi.org/10.32866/001c.74112

Findings

The purpose of the study is to explore the relative influence of different measures of accessibility, public transport quality and local density on trip chain mode choice. This study uses data from the National Travel Survey in Norway and develops a logistic regression model on the choice between public transport and car on daily trip chains. Results show that the most important factors in explaining the use of public transport are 1) the travel time competitiveness of public transport versus the car, 2) parking restrictions, 3) centrality of trip chain destinations, and 4) waiting time between departures.

1. Questions

For the development of effective measures to reduce car use, it is important with detailed knowledge of which factors influence transport mode choice. While the traditional literature has focused on density (as well as diversity and design, see for example Cervero and Kockelman (1997)), Handy (2020, 2018) suggests that the research focus should be shifted to *accessibility*. Geurs and van Wee (2004) distinguish between location-, person-, infrastructure- and utility-based measures of accessibility. They argue that person-based measures are lacking in the academic literature, compared to location-based measures. Moreover, location-based measures are "less suited for understanding the complexities of and individual difference in human spatial behavior" (Geurs, De Montis, and Reggiani 2015, 83). This concern resonates with current policies to reduce car use in urban contexts where location-based accessibility measures are often favored over person-based measures. In the Oslo region, for instance, one of the strategies to reduce car use is to densify the inner city and around public transport (PT) hubs. Moreover, in the current literature, there is a lack of awareness on the time-geographic opportunities and constraints of individuals (Hägerstrand 1970; Lenntorp 1975). Existing research tends to focus on single trips, single trip purposes or vehicle kilometers travelled (Cervero and Kockelman 1997; Engebretsen, Næss, and Strand 2018; Ewing and Cervero 2010; Wolday 2018). A central feature of daily travel behavior is, however, the chaining of trips with different purposes. The motivation for trip chaining is to save time carrying out daily activities. At the same time, trip chaining is often associated with higher car use (Grue, Veisten, and Engebretsen 2020; Strathman, Dueker, and Davis 1994; Ye, Pendyala, and Gottardi 2007).

In order to get better knowledge on how to reduce car use, this study explores how various factors influence the choice between public transport (PT) and car on daily trip chains. We ask the following research question:

How are different measures of accessibility, PT quality and local density associated with the use of PT over private vehicles on trip chains in the Oslo region?

From previous research we know that factors concerning PT attractiveness, restrictions on car use and the competitiveness of PT versus car, as well as other built environment characteristics are important in explaining transport mode choice. Important PT characteristics include service quality, frequency and proximity to stops (Kwan 1998; Balcombe et al. 2004; Paulley et al. 2006; Ewing and Cervero 2010; Redman et al. 2013; Levinson and King 2020; El-Geneidy and Levinson 2021), as well as the modal travel time disparity between PT and car (Janatabadi, Maharjan, and Ermagun 2022; Kwok and Yeh 2004; Lunke, Fearnley, and Aarhaug 2021). Other important factors in explaining mode choice are parking availability, not least at the workplace location (Christiansen 2014; Christiansen et al. 2017; Willson and Shoup 1990), as well as built environment characteristics such as the concentration (density) of services and centrality (Cervero and Kockelman 1997; Ewing and Cervero 2010).

2. Methods

This study uses data from the National Travel Survey in Norway (NTS) from 2018/2019 linked with additional geographical data gathered from public registers. The unit of analysis is trip chains, defined as a series of single trips where the first trip starts, and the last trip ends at the respondent's residence (home address).[1] In the analysis we include the respondents' registered trip chains where either car or PT is the main mode of transport and where PT is available.[2] Trip chains conducted by persons under 18 years are not included.

Our study does not include all options, e.g. other choices of destinations, but rather the destinations chosen in the observed trip chains. The analysis does not constitute a complete time-geographical model, but still has a strong connection to the theory. Trip chain mode choice is seen as the result of individual needs (travel to work, shopping etc.), spatial opportunities and individual constraints in time and space. To answer the research question, we estimate a logistic regression model on the choice of PT over car as the main mode on trip chains.

The model includes seven key independent variables covering accessibility, PT quality and local density characteristics, as well as a string of control variables covering trip chain and individual characteristics.

The key independent variables are: 1) proximity to rail-based PT, 2) the modal travel time disparity between car and PT, expressed as $(P - C)/(P + C)$, 3) the total waiting time between PT departures, 4) workplace parking

1 In other words, each trip chain consists of several single trips with potentially different trip purposes.

2 Available PT means that it is possible to travel with PT on the observed trip chain.

Table 1. Descriptive statistics of variables applied in the analysis – mean and percent (for the binary variables) across trip chains (N = 17,373).

Variables in the model	Mean, percent
Dependent variable:	
Public transport as main transport mode (binary)	25.3%
Key independent variables	
Proximity to rail-based PT	43.7%
Modal travel time disparity (PT vs. car)	0.3977
Sum waiting time with public transport (minutes)	35.3439
No free parking at work (when work trip is included) (binary)	8.0%
Max parking restrictions among trip chain destinations (%)	3.8570
Density – sum of residents and jobs within 1 km from residence	13,093.7
Highest centrality among trip chain destinations (index)	955.75
Control variables:	
Weekday (binary)	79.8%
Work trip included in the trip chain (binary)	41.6%
Shopping/errand included in trip chain (binary)	33.9%
Accompaniment of children included in the trip chain (binary)	11.3%
Gender/woman (binary)	49.7%
Age (number of years)	45.40
Employed (binary)	74.5%
Income (NOK 1000 / year) (9 levels)	500-599
Car subsidies (binary)	9.5%

restrictions, 5) general parking restrictions (the highest registered restrictions across trip chain destinations), 6) population- and employment density at the residential location, and 7) the highest centrality level among the trip chain destinations, based on Statistics Norway's centrality index. Description of all variables is included in the Supplementary Information. Descriptive statistics are shown in Table 1.

The study area consists of Oslo municipality (the capital city) and the surrounding Viken regional municipality. The total population in the study area is 2,000,000 (in 2022), representing roughly 36 percent of Norway's population.

3. Findings

In order to evaluate the relative impact of each independent variable, we follow the suggestions of Meyers, Gamst, and Guarino (2016) and concentrate on four outputs of scale-neutral coefficients: standardized coefficients (Beta and Exp(Beta)),[3] Wald coefficients, and the log likelihood test of change in -2LL if the variable was to be removed from the model. Table 2 shows the results of the logistic regression model with unstandardized coefficients, significance levels

3 Coefficients based on a regression model with standardized independent variables

and the scale-neutral coefficients. All covariates appear with clearly significant results. The model gives a relatively high R^2 (0.465), meets the Hosmer-Lemeshow test with a clear margin and shows no indications of collinearity or multicollinearity.[4] The model predicts transport mode with 87.4 percent accuracy.

Among the individual characteristics, being a man and being employed, higher age and income, as well as receiving car subsidies are all related to a reduced probability of using PT on the trip chain. Car subsidies and age show the strongest effect, according to the scale-neutral coefficients. However, all these covariates may be considered as various indicators of income, indicating a strong (negative) relationship between income and PT use.

Mode choice also varies by travel purpose. If the trip chain includes a trip to or from work, the probability of choosing PT increases. On the other hand, trip chains including shopping, errands or accompanying children are associated with lower PT shares. This indicates that the PT service is more attractive, and competitive to private car use, on work related trips than on other trip purposes. Moreover, the impact of shopping/errand and accompaniment of children in the trip chain also suggests that higher trip chain complexity encourages car use.

Among the key independent variables, the four scale-neutral coefficients[5] suggest that the modal travel time disparity, parking restrictions, centrality and waiting time has the largest influence on the use of PT over car (Table 2). Density at the residential location also has a substantial impact. Less important are the variables concerning proximity to rail-based PT stations and workplace parking availability. However, the variable measuring workplace parking was not measured for the whole sample because of insufficient data (see Supplemental Information). We can therefore assume that this coefficient is somewhat underrated.[6]

These findings suggest that, in order to reduce car-use, policies could benefit from a focus on measures to increase the competitiveness of the PT service (in terms of travel times) in combination with parking restrictions. Compared to measures that increase density and proximity to services, these enhancements of PT quality and competitiveness are easier and less time-consuming to implement.

---

4 We observe no VIF values above 10, and no tolerance values below 0.1, as are the recommended thresholds (Hair et al. 2009; Tabachnick, Fidell, and Ullman 2001).

5 Standardized coefficients (Beta and Exp(Beta)), Wald coefficients and change in -2LL

6 A test confirms this hypothesis. We reran the model only for the individuals with valid information on this variable. The results showed that the B coefficient for “No free parking at work” increased to 1.165 (the Beta coefficient increased to 0.391).

Table 2. Logistic regression. Dependent variable: Choice of public transport as main mode of transport on motorized trip chains in the Oslo/Viken region for persons 18 years or older. N=17,373.

					Scale-neutral coefficients			
Covariates	B	S.E.	Exp(B)	Sig.	Beta	Exp(Beta)	Wald	Change in -2LL*
Key independent variables								
Proximity to rail-based PT	0.338	0.063	1.403	0.000	0.168	1.183	28.984	28.940
Modal travel time disparity (PT vs. car)	-4.161	0.210	0.016	0.000	-0.607	0.545	392.376	414.639
Ln sum waiting time with public transport	-0.634	0.046	0.530	0.000	-0.548	0.578	190.745	196.798
No free parking at work (when work trip is included)	0.702	0.084	2.017	0.000	0.190	1.209	69.645	70.191
Max parking restrictions among trip chain destinations (%)	0.091	0.005	1.095	0.000	0.556	1.743	351.486	373.635
Sqrt density (1000) within 1 km from residence	0.206	0.015	1.229	0.000	0.429	1.535	180.936	188.386
Highest centrality among trip chain destinations	0.011	0.001	1.011	0.000	0.806	2.239	271.151	304.503
Control variables								
Work trip included in the trip chain	0.863	0.065	2.370	0.000	0.425	1.530	176.007	180.698
Shopping/errand included in trip chain	-0.484	0.059	0.616	0.000	-0.229	0.795	67.022	68.108
Accompaniment of children included in the trip chain	-0.772	0.096	0.462	0.000	-0.245	0.783	64.676	69.445
Weekday	0.332	0.071	1.394	0.000	0.133	1.143	22.162	22.544
Gender/woman	0.289	0.052	1.335	0.000	0.144	1.155	31.173	31.306
Age	-0.019	0.002	0.981	0.000	-0.303	0.739	115.607	117.885
Employed	-0.721	0.077	0.486	0.000	-0.314	0.730	87.459	88.153
Income (9 levels)	-0.113	0.015	0.893	0.000	-0.239	0.787	57.932	58.420
Car subsidies	-1.585	0.119	0.205	0.000	-0.466	0.628	177.582	219.828
Constant	-8.222	0.700	0.000	0.000	-2.034	0.131	137.812	

McFadden rho square: 0.465.

Hosmer-Lemeshow test: Chi-square = 10.4 (sig. 0.238)

*If term removed (a higher value indicates a higher influence on the overall model fit).

An important limitation of this study is the lack of causal inference and control for self-selection in the relationship between spatial context and travel behavior (Cao, Mokhtarian, and Handy 2009). Future research could use qualitative or longitudinal data to investigate these topics further.

Acknowledgements

The work was funded by the Research Council of Norway (grant number 249733), the Regional Research Fund Viken (grant number 313313) and Viken county municipality. The authors would like to thank Guro Berge (Viken county municipality) for the cooperation and excellent input to this study.

Submitted: February 15, 2023 AEST, Accepted: April 01, 2023 AEST

REFERENCES

Balcombe, R., R. Mackett, N. Paulley, J. Preston, J. Shires, H. Titheridge, M. Wardman, and P. White. 2004. "The Demand for Public Transport: A Practical Guide." No. TRL593. London, UK: Transportation Research Laboratory.

Cao, Xinyu (Jason), Patricia L. Mokhtarian, and Susan L. Handy. 2009. "Examining the Impacts of Residential Self-Selection on Travel Behaviour: A Focus on Empirical Findings." *Transport Reviews* 29 (3): 359–95. https://doi.org/10.1080/01441640802539195.

Cervero, Robert, and Kara Kockelman. 1997. "Travel Demand and the 3Ds: Density, Diversity, and Design." *Transportation Research Part D: Transport and Environment* 2 (3): 199–219. https://doi.org/10.1016/s1361-9209(97)00009-6.

Christiansen, Petter. 2014. "A Case Study of Parking Charges at Work Places – Effects on Travel Behaviour and Acceptance." *Selected Proceedings from the Annual Transport Conference at Aalborg University* 9. https://doi.org/10.5278/UTD.V9I1.3812.

Christiansen, Petter, Øystein Engebretsen, Nils Fearnley, and Jan Usterud Hanssen. 2017. "Parking Facilities and the Built Environment: Impacts on Travel Behaviour." *Transportation Research Part A: Policy and Practice* 95: 198–206. https://doi.org/10.1016/j.tra.2016.10.025.

El-Geneidy, Ahmed, and David Levinson. 2021. "Making Accessibility Work in Practice." *Transport Reviews* 42 (2): 129–33. https://doi.org/10.1080/01441647.2021.1975954.

Engebretsen, Øystein, Petter Næss, and Arvid Strand. 2018. "Residential Location, Workplace Location and Car Driving in Four Norwegian Cities." *European Planning Studies* 26 (10): 2036–57. https://doi.org/10.1080/09654313.2018.1505830.

Ewing, Reid, and Robert Cervero. 2010. "Travel and the Built Environment." *Journal of the American Planning Association* 76 (3): 265–94. https://doi.org/10.1080/01944361003766766.

Geurs, Karst T., Andrea De Montis, and Aura Reggiani. 2015. "Recent Advances and Applications in Accessibility Modelling." *Computers, Environment and Urban Systems* 49: 82–85. https://doi.org/10.1016/j.compenvurbsys.2014.09.003.

Geurs, Karst T., and Bert van Wee. 2004. "Accessibility Evaluation of Land-Use and Transport Strategies: Review and Research Directions." *Journal of Transport Geography* 12 (2): 127–40. https://doi.org/10.1016/j.jtrangeo.2003.10.005.

Grue, Berit, Knut Veisten, and Øystein Engebretsen. 2020. "Exploring the Relationship between the Built Environment, Trip Chain Complexity, and Auto Mode Choice, Applying a Large National Data Set." *Transportation Research Interdisciplinary Perspectives* 5: 100134. https://doi.org/10.1016/j.trip.2020.100134.

Hägerstrand, Torsten. 1970. "What about People in Regional Science?" *Papers of the Regional Science Association* 24 (1): 6–21. https://doi.org/10.1007/bf01936872.

Hair, J.F., W.C. Black, B.J. Babin, and R.E. Anderson. 2009. *Multivariate Data Analysis: A Global Perspective*. 7th ed. Upper Saddle River. Prentice Hall.

Handy, Susan. 2018. "Enough with the 'D's' Already — Let's Get Back to 'A.'" *Transfers*.

———. 2020. "Is Accessibility an Idea Whose Time Has Finally Come?" *Transportation Research Part D: Transport and Environment* 83: 102319. https://doi.org/10.1016/j.trd.2020.102319.

Janatabadi, Fatemeh, Sanju Maharjan, and Alireza Ermagun. 2022. "A Spatiotemporal Disparity of Transit and Automobile Access Gap and Its Impact on Transit Use." *Environment and Planning B: Urban Analytics and City Science* 23998083221147530. https://doi.org/10.1177/23998083221147527.

Kwan, Mei-Po. 1998. "Space-Time and Integral Measures of Individual Accessibility: A Comparative Analysis Using a Point-Based Framework." *Geographical Analysis* 30 (3): 191–216. https://doi.org/10.1111/j.1538-4632.1998.tb00396.x.

Kwok, Rebecca C.W., and Anthony G.O. Yeh. 2004. "The Use of Modal Accessibility Gap as an Indicator for Sustainable Transport Development." *Environment and Planning A: Economy and Space* 36 (5): 921–36. https://doi.org/10.1068/a3673.

Lenntorp, B. 1975. "En tidsgeografisk studie av kollektivresenärens förflyttningsmöjligheter." No. SOU 1975:48. Stockholm: Kommunikasjonsdepartementet.

Levinson, D., and D. King. 2020. *Transport Access Manual: A Guide for Measuring Connection between People and Places*. Committee of the Transport Access Manual, University of Sydney.

Lunke, Erik B., N. Fearnley, and J. Aarhaug. 2021. "Public Transport Competitiveness vs. the Car: Impact of Relative Journey Time and Service Attributes." *Research in Transportation Economics* 90: 101098. https://doi.org/10.1016/j.retrec.2021.101098.

Meyers, L.S., G. Gamst, and A.J. Guarino. 2016. *Applied Multivariate Research: Design and Interpretation*. Sage publications.

Paulley, Neil, Richard Balcombe, Roger Mackett, Helena Titheridge, John Preston, Mark Wardman, Jeremy Shires, and Peter White. 2006. "The Demand for Public Transport: The Effects of Fares, Quality of Service, Income and Car Ownership." *Transport Policy, Innovation and Integration in Urban Transport Policy* 13 (4): 295–306. https://doi.org/10.1016/j.tranpol.2005.12.004.

Redman, Lauren, Margareta Friman, Tommy Gärling, and Terry Hartig. 2013. "Quality Attributes of Public Transport That Attract Car Users: A Research Review." *Transport Policy* 25: 119–27. https://doi.org/10.1016/j.tranpol.2012.11.005.

Strathman, James G., Kenneth J. Dueker, and Judy S. Davis. 1994. "Effects of Household Structure and Selected Travel Characteristics on Trip Chaining." *Transportation* 21 (1): 23–45. https://doi.org/10.1007/bf01119633.

Tabachnick, B.G., L.S. Fidell, and J.B. Ullman. 2001. *Using Multivariate Statistics*. 5th ed. New York: Harper and Row.

Willson, Richard W., and Donald C. Shoup. 1990. "Parking Subsidies and Travel Choices: Assessing the Evidence." *Transportation* 17 (2): 141–57. https://doi.org/10.1007/bf02125333.

Wolday, Fitwi. 2018. "Built Environment and Car Driving Distance in a Small City Context." *Journal of Transport and Land Use* 11 (1). https://doi.org/10.5198/jtlu.2018.1176.

Ye, Xin, Ram M. Pendyala, and Giovanni Gottardi. 2007. "An Exploration of the Relationship between Mode Choice and Complexity of Trip Chaining Patterns." *Transportation Research Part B: Methodological* 41 (1): 96–113. https://doi.org/10.1016/j.trb.2006.03.004.

SUPPLEMENTARY MATERIALS

SI

Download: https://findingspress.org/article/74112-public-transport-use-on-trip-chains-exploring-various-mode-choice-determinants/attachment/155426.pdf