



Environmental correlates of cycling: Evaluating urban form and location effects based on Danish micro-data



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ABSTRACT

The paper analyses the environmental correlates of cycling based on Danish transportation and urban form micro-data. The results show that established walkability factors such as density, connectivity and diversity are related to cycling, but access to retail concentrations/centres, public transportation level-of-service, as well as competition between walking and cycling depending on environmental features can be added. Attractive conditions for using public transportation or walking are related to less cycling. The findings quantify the effects of urban form on the probability of cycling and the distance cycled. A high probability of cycling generally implies short cycling distances leading to non-uniform, non-monotonous relationship between environmental indicators such as walkability and cycling.

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1. Introduction

Cycling is being promoted as a potential means to increase the sustainability of transportation and improve public health. There is, however, still limited research on the interaction between land use, destinations, infrastructure and the willingness to cycle. Cycling as a travel mode or activity may be conceived as something in between 'street life', which is highly sensitive to environmental qualities, and a more utility-oriented mode of travel which involves the movement between origin and destination. Following Forsyth and Krizek (2011), there is a distinctive 'view from the bicycle' that is different to that experienced when walking. Walking and cycling are often classified and analysed together, and this is likely to miss important nuances, warranting further research into the factors, which predetermine cycling.

This paper analyses the urban form and location factor correlates of cycling in a Danish context. This includes urban form elements at various scales, traffic environments, and indicators of level-of-service to determine how the competition between cycling and other transport modes is affected by urban form. It focuses on the effects of urban form at a micro level based on the Danish National Travel survey. The main methodological reference is economic behavioural theory as well as the large number of quantitative studies on urban form and transportation and the associated concepts of urban form and location.

2. Methodology

The source of data for cycling is the Danish National Travel survey and a representative sample of 10–85 years old citizens who are interviewed every year regarding their travel activities on the previous day (Jensen, 2009). The survey provides a

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detailed account of one day's travel activities including trip stages, trips, journeys and the travel purposes that they link. We consider two years 2009/2010 and 2010/2011 over which 39,222 individuals were surveyed with 9128 of them cyclists on the day covered by the survey, averaging 7.7 kms. Cycling includes cycling as the main mode of transportation as well as cycling as a stage mode, e.g. connecting to public transport. An improved survey methodology was applied in these two years, employing a prompting of access mode registration based on automated GIS analysis of origin and reported public transport stops/access points that improved the account of cycling.

Cycling was predominantly 'utility' cycling connecting to work and leisure destinations. Recreational (non-utilitarian) cycling, understood as roundtrips without a destination, was only reported by 610 survey participants but accounted for 11% of cycling distance. As the survey was not devised to fully include leisure cycling, some cycling at 'destinations' such as on trails in forests or recreational areas is likely to be undercounted, but not to the extent that it could challenge the dominance of utility cycling. The dependent variable analysed in the paper is the distance cycled per individual per day. The Danish National Travel survey also collects data at the level of the household as well as the individual participant. This includes information regarding household cars, household composition, age, gender, education, employment, occupation, type of residence, homeownership, driver's license, and bicycle access (Christiansen and Haunstrup, 2011). These variables are treated as possible explanations for the variation in cycling and are included in the statistical analysis as control variables. Urban form and location factors are measured based on geographically detailed national data sets and are assigned to the participants in the Danish national travel survey based on the home address of the respondents.

The 'Six Ds' (density, diversity, design, destination accessibility, distance to transit, and demand management) developed by Ewing and Cervero (2010) provide the frame for measuring environmental attributes. First, the density around respondent home addresses is measured regarding population, jobs and retail jobs. The diversity is measured based on the use of land for urban areas; forest and nature areas; land use variation based on 44 land use classes, as well as the blend of population, jobs and retail. Measures of urban design are based on the number and density of three-way intersections; the composition of the road network (traffic roads, distributor roads, and local roads); and the proportion of buildings in the area that were built before 1950 is used as an indicator of pre-motorisation urban design. Destination accessibility is defined as access to key services such as the nearest primary school and grocery shops, as well as access to job and retail concentrations of sizes and scales. Distance to transit was based on a national database of public transportation stops and train and bus departures by stop. Finally, the demand management aspect is defined as on-site land use intensity (floor-area-ratio within 150 m) as a proxy for parking difficulties, as well as distance to a motorway ramp or large road as a proxy for level-of-service for car travel.¹

Destination accessibility, distance to transit and demand management were implemented as either distance measures or service measures based on the number of transit departures within 500 m, or the floor space to land ratio as a proxy for parking. The density, diversity and design measures are constructed as neighbourhood measures, but for an individualised neighbourhood based on each survey participant's home address, and for two neighbourhood sizes: 500 m and 1500 m airline distances. The two neighbourhood sizes reflect how the degrees of convenience or proximity may influence cycling, and facilitate the testing of the significance of spatial scale. The scales also represent a convenient walking range and a convenient cycling range that correspond to the maximum cycling range from home for the youngest respondents, and 8–10 min of cycling for the average Danish cyclist. The environmental attributes derived from the Six Ds. are supplemented by measures of topography in the form of the maximum and minimum elevation also within 500 m and 1500 m of the home.

The available data does not allow the representation of cycling networks in the analysis. Instead, cycling provisions and policies are represented by place-based dummy variables based on municipalities. The Danish municipalities are responsible for cycling infrastructure and local cycling policies.

In addition to urban form and location variables, an area measure of mean property values was constructed based on the registration of sales in the property register between 2008 and 2010. A trade-off between transportation and housing expenditures exists in models of urban economics, such as Alonso's (1964) monocentric model, which predicts a bid-rent for land based on the costs of transportation to a central job-concentration, but this has never really been taken into account in analyses of urban form-transport relationships. The inclusion of this variable facilitates the testing of its significance and, indirectly, of the robustness of the urban environment-cycling correlation.

According to transport-economic theory, cycling speed is an important cost variable that is expected to affect the daily cycling distance. Cycling speed is included in the analysis to represent the main effects that may affect the relationship between urban form and cycling. As in Boarnet and Crane (2001), the speed is measured as the median cycling speed based on the individual respondent's cycling trip stages.

The individual attributes, the urban environment, topography, and area-based property values are brought together in an analysis of correlates of daily cycling distance. Indexing and data reduction were not employed and the aim was to identify the set of individual and environmental variables that provide a sound explanation of the variations in cycling distances in the Danish sample.

In order to deal with the strong spatial correlation between urban form factors and the associated risk of random results, it was decided to only rely on population density as a measure of net density. Jobs and retail jobs are then measured in

¹ The data for measuring urban form and location factors are from the Danish building register (Daugbjerg and Hansen, 2000); the register of companies and workplaces (Erhvervsstyrelsen, 2012); population in the 1 ha cells of the Danish datagrid (Statistics Denmark, 2012); Navteq road network; digital elevation model (National Survey and Cadastre, 2012); and finally Corine land cover datasets (European Environment Agency, 1999) to determine land use.

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