

Residential location influences travel - but how and why?

Paper for the Traffic days at Aalborg University, August 26-27, 2002.

Petter Næss, Aalborg University, Fibigerstræde 11, DK-9220 Aalborg Ø, Denmark.

E-mail petter@i4.auc.dk

Background, theory and methods

Investigations in a number of cities and metropolitan areas have shown that those living in the outer, low-density parts travel considerably longer by motorized means of transportation, compared to the residents of inner and central parts of the town. The same main pattern has been found in cities as different as Paris (Mogridge, 1985; Fouchier 1998), London (Mogridge, *ibid.*), New York and Melbourne (Newman and Kenworthy, 1989), San Fransisco (Schipper *et al.*, 1994), Greater Oslo (Næss, Røe and Larsen, 1995; Røe 1999), Bergen (Duun, 1994), and Trondheim (Synnes, 1990). However, many of the early empirical studies demonstrating correlations between urban structure and travel behavior have been criticized for not taking into consideration socioeconomic factors and/or disregarding the influence of the travelers' attitudes and lifestyles. Because, among other things, the income levels, household structures, age and leisure interests of the inhabitants often vary between inner and outer parts of the city, there is a risk that differences in the transportation pattern actually caused by such factors are being explained with differences in the location. In some studies, attempts have been made to meet these points of criticism by including socioeconomic variables in the analyses (e.g. Næss, Røe and Larsen, *ibid.*), and in a few studies also indicators of the travelers' attitudes and lifestyles (e.g. Røe, *ibid.*). Still, some critics call attention to the fact that statistical correlations, even with multivariate control, can never establish whether a *causal* relationship exists between urban structure and travel behavior.

In order to meet the above criticisms, a comprehensive study of urban structure and transport has recently been conducted in the Copenhagen area, aiming to identify the overall relationships as well as the more detailed mechanisms through which the location of residences within the metropolitan area influences travel behavior. In the remaining part of this paper, the theoretical basis, research questions and methods the Copenhagen area study will first be discussed. A number of mechanisms through which residential location affects travel behavior will then be identified, drawing mainly on qualitative interviews. Thereupon, the question of which mechanisms and influences are the dominating ones will be addressed, based on statistical analyses of data from two comprehensive travel surveys.

Theoretical point of departure

According to theories of transport geography and transport economy, the travel between different destinations is assumed to be influenced on the one hand by the reasons people may have for going to a place, and on the other hand by the discomfort involved when traveling to this location (Jones, 1978; Beimborn, 1979). Or, in other words, by the attractiveness of the locations and the friction of distance. By creating proximity as well as distance between activities, and by facilitating various modes of traveling, the urban structure makes up a set of incentives facilitating some kinds of travel behavior and discouraging other types of travel behavior. The causes of travel behavior of course also include personal characteristics of the travelers, such as age, sex, income, professional status, as well as their values, norms, lifestyles and acquaintances. Also symbolic and cultural features attributed to an area may affect the number of visitors attracted. The choices of destinations, modes of traveling and trip routes are influenced by structural constraints and incentives (among which the material urban structure is only one category), as well as the resources, preferences and aspirations of individuals. The emerging transportation pattern is a result of people's resources, needs and wishes, as modified by the constraints and opportunities given by the structural conditions of society

Traditionally, many European cities have had a concentration of workplaces and service functions in the downtown area. In particular, this applies to public offices, cultural facilities, restaurants, entertainment and specialized stores. In many cities, a wide range of facilities covering the city as a

whole or the city region are located in this area. The historical urban core is often the geographical center of gravity of the housing stock, and also the main node of the public transport system. (Christaller, 1933/1966). For the same reason, public authorities and agencies are often located in the city center. In many cities, the downtown area also has an attractive "atmosphere".

The closer to downtown the residences of such cities are located, the more workplaces and service facilities are likely to be available in the proximity of the dwelling. Therefore, inner-city residents could be expected to make shorter daily trips than their outer-area counterparts, and a high proportion of destinations might as well be easily reached by foot.

The location of a residence within an urban area also affects the likelihood of being surrounded by either a high-density or low-density local community. Usually, there is neither tradition nor demand for the same densities in peripheral parts of a city as in the inner and central areas (Mogridge, 1985:482-484; Holsen, 1995). With a higher density of residences and/or workplaces in the local area, the population base for various types of local service facilities will also increase (Christaller, 1933/1966:45, 53). Hence, the average distance from residences to local service will also be shorter, possibly encouraging some of the residents to make their trips to these facilities by non-motorized modes.

Admittedly, in many cities the historical urban core has lost some of its dominant position during the recent 20 or 30 years, both as a result of urban planning strategies aiming to reduce the pressure against the historical cores by establishing extra-urban relief centers and tendencies in the property market. Yet, most European cities still have a higher concentration of workplaces, retail, public agencies, cultural events and leisure facilities in the central inner districts than in the outer areas (cf., among others, Newman and Kenworthy, 1999:94-95). This also applies to the case of this study, the Copenhagen metropolitan area.

Of course, the choices made by human beings tend to be a bit more complex and less predictable than indicated by the above influences. For example, high accessibility might create increased demands. A high accessibility might be utilized by opting between a wider range of jobs, shops and leisure activities, rather than reducing the amount of transport. Furthermore, trip destinations and choices of mode of transport are considerably influenced by factors like income level, household composition, and lifestyle. Thus, the relationship between land use and transport is embedded in contexts where causes are multiple and where it is necessary to take into account a broad range of possible factors of influence in order to disentangle the specific effects of residential location on travel behavior.

It is also important to be aware that the importance to the amount of travel of living close to or far away from facilities may differ, depending of the facility type. For some functions, we almost always choose the closest facility, because the various facilities are more or less equal. But for other facilities, quality differences within each category may make people travel beyond the closest facility to a more attractive one. For example, having a cinema in the local neighborhood doesn't help much if you are interested in Lars von Trier films and the local movie theater has only spaghetti westerns on the repertoire. For cinemas and a number of other recreational facilities, many types of shops, and not the least workplaces, a number of other features than proximity are also important when choosing among facilities. Therefore, the amount of transport will depend more on the location of residences in relation to *concentrations* of such facilities, rather than the distances from residences to the *closest single facility*.

In addition to this distinction between types of functions, travel for some purposes may be characterized as *bounded* trips, e. g. journeys to work or school. Other trips are much less bounded, for example recreational trips in holidays or weekends (Vilhelmson, 1990). The urban structure might be expected to exert a stronger and more direct influence on the amount of travel for bounded trips than for non-bounded trips, since the latter may simply be cancelled or substituted if the destination in question is too far away.

Methods of the Copenhagen area study

The Copenhagen area study included a large travel survey among inhabitants of 29 residential areas, a more detailed travel diary investigation among some of the participants of the first survey, and qualitative interviews with 17 households. In addition to recording socioeconomic background variables and travel distances by different modes on each day during a week, the first survey included questions about frequency of participation in activities, attitudes to transport and environmental issues, perception of car dependency, changes in the amount of transport among respondents who had moved recently, annual driving distance of the households' cars, and holiday trips. In the travel diary investigation, a more detailed picture was given, including location of destinations for the various trips, trip length and travel mode by travel purposes, changes in activities and car ownership due to moving, and flights and other trips outside the domestic region. The qualitative interviews were semi-structured, focusing on the interviewees' reasons for choosing activities and their locations, travel modes and routes, as well as the meaning attached to living in or visiting various parts of the city.

Mechanisms through which residential location affects travel behavior

The qualitative interviews show examples of many of the mechanisms postulated in the theoretical part. Below, we shall concentrate on 9 of the 17 interviews, where four interviewee households living in a remote residential area are contrasted with five interviewee households in the inner area of Copenhagen.

How important is proximity to the choice of facilities?

While it may be true that most modern people are less tied to local places than previous generations (although this varies considerably among population groups), and hence engage in activities and utilize facilities more or less independently of what is available in the neighborhood of the residence, this does not mean that the location of urban functions has lost its importance to the amount of transport carried out in order to reach these destinations. On the contrary, the less people limit their choices of destinations (e.g. workplaces, schools, shops and leisure facilities) to what is available locally, the more will the amount of transport carried out be influenced by the location of the residence in relation to the city-level pattern of such facilities.

Among the interviewee households, the *workplace* (or in the cases of students: place of education) is the daily-life destination where the longest distance from the dwelling is accepted. The journey to work (or school/university) is also the most "bounded" among the trip purposes. Among workforce participants, students and pupils, getting to the workplace or place of education is usually the basic trip purpose on weekdays, to which other trip purposes (e.g. shopping) may be linked.

Obviously, there is some threshold beyond which job opportunities are considered irrelevant unless the household is willing or able to move to another residence. This threshold varies a lot among individuals, depending on, among others, their degree of professional specialization, mobility resources (driver's license, car ownership, time budget etc.), willingness to mobility (could be influenced e.g. by an environmentally motivated wish to reduce travel), and responsibility for bringing children to and from kindergartens or schools. Our interviews also show an example where a workplace originally chosen close to the dwelling, later came to require long daily commutes as the household moved to another residence.

Minimizing traveling distances is more common when choosing among stores for *daily-life shopping*, which often takes place in shops on the way home from work two or three times a week. In such cases, the additional transport is often very modest, compared to traveling directly home. By combining the trip home from work and the trip to the store, a larger choice can be obtained than what is available in the proximity of the dwelling. Shopping in connection with the trip home from work is more common among those interviewees who live in the periphery. In this way, the longer distances to shops, typical for residences in the outskirts of the city, can to some extent be compensated. When living in the periphery, the local grocer is often only used for "emergency purchases", e.g. when there is no coffee left in the house in the late afternoon. Among those living in the central parts of Copenhagen, local shops are used to a higher extent for ordinary shopping. Along with shopping on everyday late

afternoons, it is common among our interviewees to make a main shopping trip once a week (usually on Saturdays). Sometimes, Saturday grocery shopping is combined with buying clothes or other more specialized goods, which may lead to a preference for downtown rather than a district center. The Saturday shopping trips are exceptions from the above-mentioned tendency to distance minimizing, as they originate from the dwelling and usually end in the locations where the choice is largest, regardless of the existence of any less assorted shops in-between. The length of these trips therefore tends to vary with the distance from the dwelling to downtown Copenhagen and to the local sub-centers with the strongest retail concentration.

If you live centrally, it will only take a little extra transport to choose the most well-assorted stores instead of the closest ones. If you live in the periphery, opting for a large assortment will require more transport.

Distinct from the "bounded" and "semi-bounded" activities mentioned above, *leisure activities* are "non-bounded". Among our interviewees, such activities are to a considerable extent adapted to what is locally available. (Of course, the causality might be the opposite: that the choice of residence is adapted to the leisure facilities available in the different parts of the Copenhagen area. Probably, both directions of influence exist.) In particular, visits to cafés, restaurants, movie theaters, gymnastics clubs, concerts and other cultural events are often dropped or carried out less frequently if there are no local opportunities. "Local" here refers not only to the immediate surroundings of the dwelling, but the opportunities within a somewhat wider radius, e.g. a 20 minutes walk.

Visits can generally be expected to occur less frequently the further away the destination is. "Distance decay" will primarily occur for "non-bounded" trips, and to a much lesser extent for "bounded" trips. For example, the workplace must usually be visited each day, regardless of whether the commuting distance is short or long. IT-based work at home might be an exception, but neither among our interviewees nor among the survey respondents such work substitutes daily commutes to any extent worth mentioning. However, as mentioned above, the frequency of participation in a number of leisure activities tends to be reduced if there is a long distance to the places where these activities are carried out.

Also get-together events with friends are more common among the interviewees living in the central than in the peripheral part of the Copenhagen area. In the central city, friends most often meet at a cafe or go to a movie theater together. This comes in addition to visits at home. When living in the outer areas, contacts with friends typically occur in the form of pre-invited visits in each other's homes. Such visits are still not more common than among our survey respondents living in the inner city. Among the interviewees living on the periphery, it is quite common to have none, or at most a small part, of one's acquaintances in the local area or its immediate surroundings. When living in a central and densely populated area, having a large proportion of one's acquaintances within a few kilometers distance from the dwelling is much more common. Possible causes of this include:

- There is a larger number of potential friends to choose within a given radius, and a higher chance that someone you work together with lives in the same local area or district of the city as you do yourself. It is also easier to maintain frequent contacts with people who do not live too far away.
- There is a more frequent use of public space (cafés etc.), providing opportunities to meet other local area residents.

Our interviews show an example of a group of friends who had decided when they were students to go to live close to each other in the inner city of Copenhagen after graduation. It is difficult to imagine that a remote area on the urban fringe would have been chosen as these women's common neighborhood.

Trip lengths of different travel purposes among central city dwellers and residents on the periphery

Both in the periphery and in the central areas of Copenhagen, our interviewees travel out of their local areas in order to reach their workplace or place of education. With a peripheral residential location, these most important "bounded" trip destinations are typically situated at a long, or at best medium, distance from the dwelling. Among our employed interviewees living in the peripheral area, the

distances from the dwelling to the workplace vary from 14 to 42 km. Among those living in the inner city, the workplace is often only a kilometer or two outside the local neighborhood. Long commutes to work occur also among these residents, but this will be much less typical.

The probability of finding a vacant job matching one's own qualifications within a short distance from the dwelling is considerably lower when living on the periphery than if the residence is close to downtown. This follows both from the generally more centralized locations of workplaces than dwellings, and from the fact that the distance to a randomly chosen address in the Copenhagen area will be longer from a peripheral than from a centrally located residence. For specialized jobs, the catchment area from which employees are recruited will be large and typically include large parts of or the entire Copenhagen metropolitan area. For non-specialized jobs, commuting distances are not to the same extent influenced by the location of the residence relative to the center of Copenhagen. Jobs as e.g. cashiers have largely the same job content and wages, independent of the workplace's specific location within the metropolitan area, and the employees within this job segment therefore have a higher possibility of finding a suitable job close to the dwelling than persons with more specialized qualifications. The job markets for non-specialized jobs are therefore likely to be more locally delimited. Differences in the mobility resources of specialized and non-specialized workforce participants may add to the differences in the size of job catchment areas. For example, women working in low-income and non-specialized occupations tend to have a car at their disposal for the commute to a lesser degree than persons with a high income and a long and specialized education.

The children's schools and kindergartens are located relatively close to the residence, both among inhabitants of the inner city and those living on the urban fringe. Bringing and picking up children is typically carried out in connection with the journey to the workplace or place of education. Often, this requires little additional transport, but the daycare or school may also be situated in a different direction from home than the workplace. Thus, two of the peripheral interview households had to drive a bit further away from the workplace in order to bring their children before they could start the journey towards the job site.

Among our interviews living in the central part of Copenhagen, almost all daily-life shopping is carried out in the local area. Also a majority of "non-bounded" activities, such as visits to cafés, restaurants and movie theaters, visiting friends and aerobics/gymnastics exercising take place in the immediate surroundings of the dwelling. Among those interviewees living on the periphery, the children's stay at school or kindergarten, and occasional "emergency shopping" at the local grocer, are the only daily-life activities taking place at a short distance from the residence, except for running/jogging. The latter trips usually start from the dwelling or a place close by, both among those living in the inner city and on the periphery.

As can be seen from the above, trip lengths for most traveling purposes, in particular journeys to work, are longer among those interviewees living on the urban fringe. When living in the central part of the metropolitan area, all "bounded" trip destinations are often located within a short or medium distance from the dwelling. These interviewees tend to participate in a larger number of "non-bounded" activities outside the dwelling, and hence have a larger number of this category of trips. However, because each of these trips is usually short, the higher trip frequency for "non-bounded" trips has very little impact on the total traveling distance for daily-life purposes, which is considerably longer among the interviewees living on the periphery.

Modes of transportation, car dependency and car ownership

Among our interviewees, the bike is often used on short distances, also among those interviewees living in the outskirts of the Copenhagen area. However, most of the destinations of the peripheral residents are located beyond what the interviewees consider to be acceptable biking distance. Car is then usually chosen, mainly because it is perceived to be the fastest and most convenient mode. If a peripheral household has only one car (e.g. for economic reasons), it sometimes occurs that the husband and wife drive together to and from the job. This will sometimes require one of them to combine the car trip with another means of transport (public transport or bike) on the last part of the

journey to work. In situations with two workforce participants living in the periphery and only one car in the household, the most common practice is still that one of the two drives to work while the other person goes by public transit.

When the residence is located in the inner city, bike is preferred to public transport on short distances. *How* short distances this applies to vary from person to person, but inner-city interviewees typically accept longer biking distances than those living on the periphery. Among our interviewees living in central Copenhagen, a preference for the bike on distances up to about 8 kilometers is quite common, and one interviewee has a daily commuting distance by bike of 17 kilometers in each direction. Among the interviewees of the peripheral area, the car is used more frequently also for quite short trips. In the periphery, the deterrents of congestion and parking problems are present to a much lesser extent than in the central city, where our interviewees find local trips by car to be slow and stressful. In addition, the peripheral local communities appear to a higher extent to be characterized by a "car culture", where driving is seen as the "normal" way of moving around. The prevalence of such an attitude may of course itself be - at least partly - a result of the poor conditions for walking, biking and public transport when living at the urban fringe.

All four interviewees in the peripheral area have at least one car in the household, and two of them have two cars. Among the inner-city interviewees, three households have never had a car. In each of the two remaining central-city households there is one car. Our interviewees include examples of car purchases when moving to a peripheral residence. In one case, a household leading a car-less life in the more central parts of Copenhagen metropolitan area bought its first car when moving to the periphery. In another case, car number two was bought immediately before the outward move. According to this interviewee, the additional car was necessary in order to reach daily activities in a situation where the distances to relevant destinations would be radically longer and public transport would be very time-consuming due to poor services in the local area. In a third case, purchase of car number two would be triggered if the interviewee was elected as a member of the municipal council after the impending election. The location of the residence would here be a contributory cause of the purchase, as it would not have been necessary to drive to and from the meetings of the municipal council if the interviewee had lived in the municipal center. In the remote village where he lived, buses go to and from the municipal center only once an hour, and not at all after 10 p.m.

Two of the four interviewee households on the urban periphery consider that they would have to reduce their weekly working hours if they were to manage without a car. They would also have to cut back on their "non-bounded" trips (leisure activities, visits to friends etc.). The latter also applies to the "non-bounded" trips of a third peripheral household. In this household, the woman was on birth leave, so for the time being they would not need to make additional reductions of their weekly working hours. Yet, it would be difficult for both members of this couple to work full time without at least one car at their disposal. Probably, also a reduction from two cars to one would make it difficult to reach daily activities.

The mechanisms above imply that residents on the urban periphery are quite *car dependent* in their daily life. This applies to their "bounded" as well as to their "non-bounded" trips. Distinct from that, the residents of the inner city are often *independent* of cars, in particular for "bounded" trips, but also to a considerable extent for "non-bounded" activities. Also in those (relatively few) cases where an inner-city resident has a long distance to go between home and a peripheral workplace, it is often considered unnecessary to have a car, because so many of the other trip destinations are located close to the dwelling. This of course requires that the accessibility by public transport to the workplace is not too inconvenient.

Which are the dominating influences and mechanisms?

Thus far, we have focused on some of the qualitative mechanisms by which a central and a peripheral residential location may influence travel behavior. But it is also important to get knowledge about the form of combination and proportions of the various mechanisms leading to a certain travel behavior. Which types of residential location would be favorable in order to reduce the overall amount of car

travel in the Copenhagen? Such knowledge is, of course, of a high policy relevance to policy-making and planning.

As mentioned above, our quantitative material consists of two parts. In the main questionnaire survey a total of 5800 questionnaires were distributed by mail to the residents of the selected residential areas, of which 1932 returned completed questionnaires. Given the quite large sample, requiring respondents to register their daily transport over a whole week, the response rate of 33% must be considered normal and acceptable. (For comparison, in an American survey including questions about travel behavior over a 3-day period (Kitamura et al., 1997), a response rate of only 11% was achieved.) Our travel diary investigation included trip purposes, trip lengths and travel times of all trips during a four-day period (from Saturday morning to Tuesday evening). Here, 273 persons responded out of a gross sample of 775, i.e. a response rate of 35%.

Sample characteristics of our two surveys were compared with census data for the Copenhagen metropolitan area as a whole as well as for our demarcated residential areas. The biases found were largely the same in both surveys. Persons who were neither workforce participants nor students are clearly underrepresented among our respondents. The same applies to persons without a car in the household. In order to investigate what these distortions might imply, separate analyses have been carried out among each of the mentioned subgroups of the respondents.

Activity frequencies, trip distances and travel time

In line with the tendencies and mechanisms found in the qualitative interviews, our statistical analyses show influences on the respondents' patterns of activities from urban structural conditions. Controlling for socioeconomic, attitudinal and other investigated variables, respondents living close to downtown Copenhagen do shopping (in particular groceries) more frequently and go to a larger number of cultural events and activities (notably movies) than those living in the peripheral parts of the metropolitan area. Living in a dense local area also contributes to more frequent shopping, more visits to cafés and restaurants, and less time spent on maintaining car, house and garden. On the other hand, except for walks in the local neighborhood, there is a tendency to a lower frequency of outdoor sports and recreation activities among respondents living in a dense area, in particular visits by foot or bike in natural areas. The above-mentioned differences between residents of central and peripheral areas are evident both in our cross-sectional data and from special analyses of respondents who have moved from one residence to another within the metropolitan area.

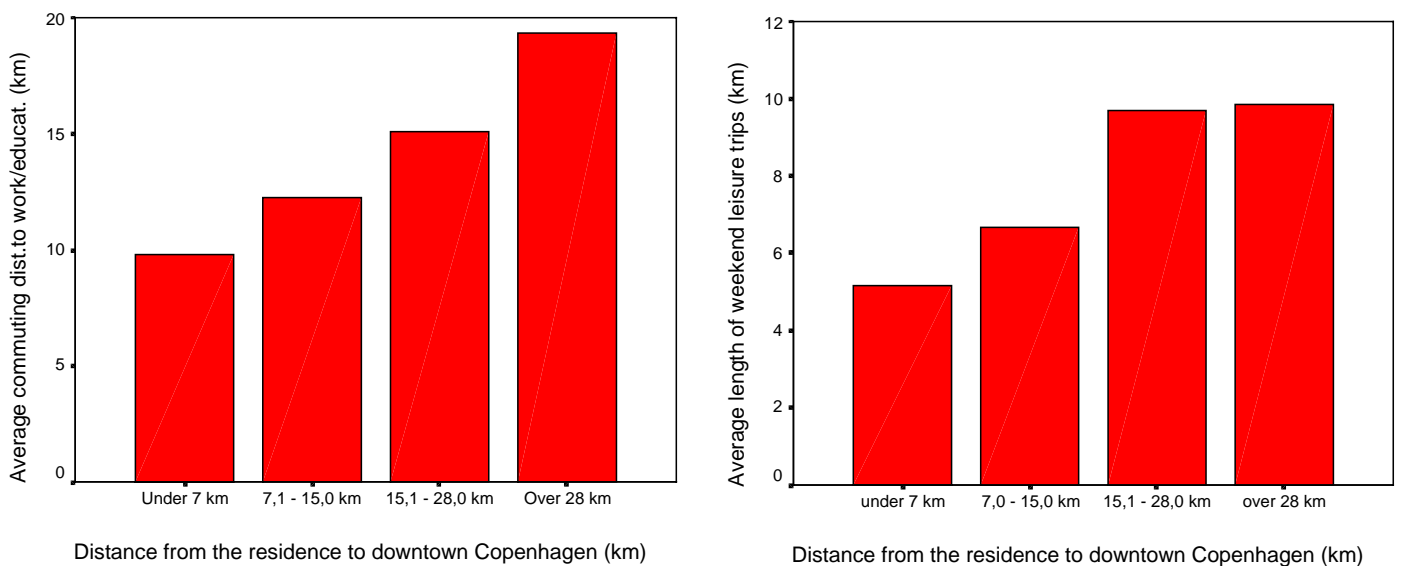


Figure 4. Average trip lengths for journeys to work or education (left) and leisure trips in the weekend (right) among respondents living within different distance intervals from downtown Copenhagen. N = 273.

Except for a drop in the lengths of some categories of trips in the very outskirts of the metropolitan area, trips tend to become longer for all investigated travel purposes when the distance between the residence and downtown Copenhagen increases. This relationship is in particular strong for journeys to work or education, but it is also evident for leisure trips (especially in the weekends), official trips, errand and shopping trips on weekdays, and for trips with the purpose of bringing or picking up children. There is also a tendency among respondents living in the outer areas to longer trips when visiting friends and relatives on weekdays. Figure 4 shows average trip lengths for journeys to work or education and leisure trips in the weekend among respondents living within different distance intervals from downtown Copenhagen, based on the travel diary investigation. The influence of residential location on the distance between home and work is also demonstrated in the larger survey. Controlling for other socioeconomic and attitudinal variables, commuting distances increase the further away from downtown Copenhagen the residence is located, the lower the local area density is, and the further away the residence is located from the closest urban rail station (the latter probably because such stations often are situated in local centers with some employment opportunities).

The impacts of urban structural conditions on travel distances also have their imprints on travel times, but the differences between central and peripheral areas are much more modest than what is the case for travel distances. The small difference in travel times can only to a little extent be explained by the higher trip frequencies among those living close to downtown Copenhagen (see below). Instead, the relatively even travel times in spite of travel distance differences is mainly a result of the lower travel speeds among those living in the central areas, due to more congestion in the inner city as well as a higher share of trips by bike or on foot.

Traveling distances and modes on weekdays and in the weekend

The differences in trip lengths between respondents living in central and peripheral parts of the metropolitan area are much larger than the corresponding differences in activity frequencies. Therefore, the tendency to a larger number of trips among inner-city residents cannot at all outweigh the longer distances traveled by the outer-area respondents in order to reach their destinations. The *location of the residence relative to downtown Copenhagen* stands out as a key urban structural factor exerting a strong impact on the residents' patterns of traveling. The further away from the center of Copenhagen the residence is located, the longer is the average total travel distance among the residents, as well as the distance traveled by car. This also holds true when controlling for the above-mentioned socioeconomic, attitudinal and other control variables. At the same time, living close to downtown Copenhagen contributes to more travel by foot or bicycle, both on weekdays and in the weekends. The share of transport traveled by car tends to be increased, the further away from the center of Copenhagen the residence is located, whereas the opposite applies to the share of walking/biking. On the weekend, a tendency can also be seen of reduced shares of public transport when the residence is located in the peripheral part of the metropolitan area.

Compared to weekend and holiday travel, trips on weekdays are to a much higher extent a result of routine tasks and obligations like going to the workplace or school, bringing children to daycare, etc. In other words, the proportion of "bounded trips" is higher on weekdays.

Controlling for socioeconomic and attitudinal variables, the average weekly traveling distance (including weekend transport) is 115 km longer among residents of a low-density area 43 km from downtown Copenhagen and with no local urban rail stop, than among residents of the high-density areas closest to downtown.

The relationships found between the transportation variables and the distance from the residence to the center of Copenhagen are not linear. Based on theoretical considerations and several iterations, a transformation of the measured distance along the road network by means of a non-linear function (a hyperbolic tangential function combined with a quadratic function) was found to provide the best fit (see Figure 5).

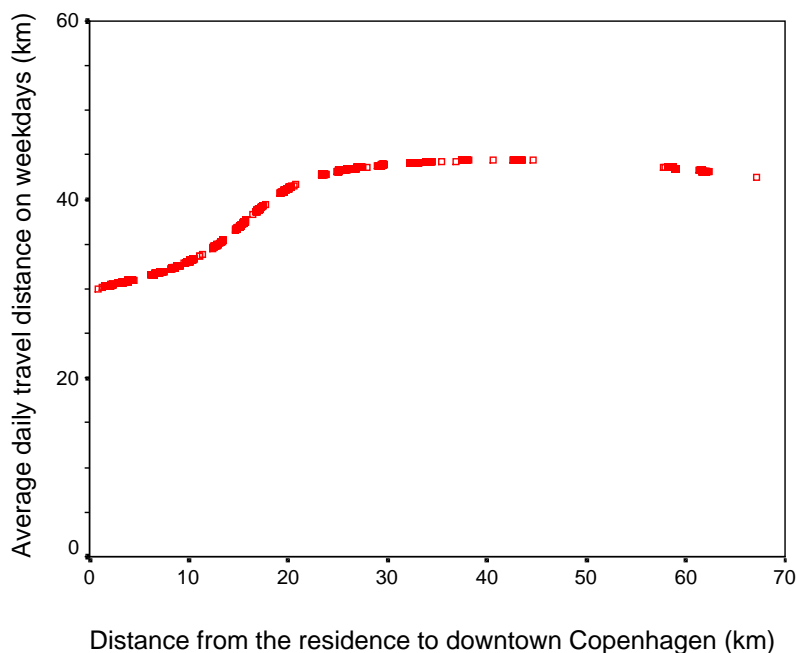


Figure 5 Average daily traveling distances over weekdays (Monday - Friday) among respondents living at different distances from the center of Copenhagen, controlled for a number of socioeconomic, attitudinal, urban structural and other control variables. N = 1498. Sig. = 0,000

This curve implies that the amount of travel first increases at a moderate pace as the distance between the dwelling and the city center increases, then at a faster rate until it starts leveling off (with a maximum at some 40 - 45 kilometers from downtown). Beyond that distance from the city center, traveling distances begin to fall slightly again, reflecting the lower attraction of downtown Copenhagen as the friction of distance increases. For the distances between the residence and the closest second-order urban center and the closest urban rail station, respectively, logarithmic transformations were found to fit the data best. These transformations reflect situations where one kilometer's increased distance from the dwelling to the facility exerts a stronger influence on travel if the distance is short at the outset than if it is already long.

A separate analysis of factors influencing the annual driving distance of the cars belonging to the respondents shows a similar influence from the location of the dwelling relative to downtown Copenhagen. Moreover, an examination of those respondents who had moved from one residence within the Copenhagen area to another during the latest five years (411 respondents) brings additional support to the above results. Moving away from downtown increases the likelihood that the respondents have increased their amount of transport due to move, whereas moving closer to downtown increases the likelihood that the respondent have experienced a reduced transport due to the move.

As mentioned above, it is difficult to disentangle the influences of more detail-level urban structural conditions from the impacts of the four main urban structural variables. If these four variables are omitted from the analyses, the accessibility to shopping facilities is the remaining urban structural factor most strongly correlated with traveling distances. Variations in the distances to schools, kindergartens and post offices appear to cause less variation in the amount of travel - possibly because these service categories are more evenly distributed over the Copenhagen area than many other types of service. There is a slight, but somewhat uncertain tendency that living close to a green recreational area contributes to shorter weekend trips.

Residential location influences car ownership

Controlling for socioeconomic, attitudinal and other control variables, the number of cars per adult household member is higher in areas located far away from downtown Copenhagen, far away from the closest second-order center, and with a low local density. It might be objected that these differences reflect a preference (for other reasons than those represented by the control variables) among car owners for suburban locations, e.g. because a high car ownership enables households to widen their locational choices. However, also in the latter case, residential location would influence the need for car travel - if not, people would choose places of residence independently of their present (or expected future) access to cars. Moreover, our quantitative data also show a tendency to increased car ownership due to (according to the respondents' own judgment) moving further away from downtown Copenhagen.

Differences between subgroups of the population

Analyses where the respondents have been divided into subgroups according to socioeconomic characteristics or their attitudes to transport and environmental issues show that urban structure influences travel within all these groups. There is, however, a good deal of variation between the groups, both in the relative importance of different urban structural factors and in the aspects of transport influenced. The location of the residence relative to downtown Copenhagen influences traveling distances in particular among men, workforce participants, persons with a high income and persons with a long education. Among women, low-income groups and groups with a short education, the amount of transportation is mainly influenced by more local urban structural conditions (the distances from the residence to the closest second-order urban center and the closest urban rail station, and the local area density). Among non-participants of the workforce, among which "bounded" trips account for a lower share of the amount of transportation, traveling distances are less influenced by urban structural conditions than among the respondents in general. The same applies to single people without children in household, males as well as females. This is probably due to the fact that single people have a higher possibility for a mutual adaptation of the locations of their residences and workplaces, and hence a better opportunity to obtain modest commuting distances even if they live in the outer part of the metropolitan area. If there are two workforce participants in the household, it is more difficult to obtain proximity between home and workplace for both, in particular when living in a peripheral part of the urban area.

Concluding remarks

The Copenhagen area study shows that residential location affects travel behavior, also when taking into consideration socioeconomic and attitudinal differences among the inhabitants. On average for all our respondents, living in a dense area close to downtown Copenhagen contributes to less travel, a lower share of car driving and more trips by bike or on foot. In particular, the length and travel mode of journeys to work is affected by the location of the dwelling relative to the city center of Copenhagen. But also for a number of "non-bounded" trip purposes a centrally located residence facilitates less travel and a higher share of non-motorized transport.

For most travel purposes, our respondents and interviewees emphasize choice rather than proximity. This means that the amount of travel is influenced to a higher extent by the location of the residence in relation to concentrations of facilities, rather than the distance to the closest single facility within a category. In particular, this is the case for workplaces and places of higher education, but also for cultural and entertainment facilities, specialized stores and, to some extent, also grocery stores. As a result, among most population groups the amount of travel is influenced first and foremost by the location of the residence in relation to the main center of the metropolitan area (downtown Copenhagen), and to a lesser extent by the distance to lower-order centers. Among persons less tied to the concentration of facilities found in the central city, notably non-participants of the workforce, the location of the residence relative to local centers may still be more important.

The results of our study are highly consistent with the results of another recent, but less thorough study of residential location and transport in the Copenhagen area (Hartoft-Nielsen, 2001). They are also in line with the conclusions from in-depth studies of residential location and transport in Aalborg

(Nielsen, forthcoming) and Frederikshavn (Næss, 2001). In both these urban areas, with populations of 160 000 and 35 000, respectively, a methodology similar to the present study was used, including travel surveys as well as qualitative interviews. The same applies to Røe's (1999) study in Oslo (metropolitan population: 800 000). Thus, there appears to be a high degree of generality about our results, indicating that the dominating mechanisms through which residential location influences urban travel behavior are likely to be found across city sizes in a broad context of Scandinavian and European cities.

References

- Beinborn, E. (1979): "Transportation and Public Facilities Planning." In Catanese, A. J. & Snyder, J. S. (eds.): *Introduction to Urban Planning*, pp. 259 - 279. New York: McGraw Hill.
- Christaller, W. (1933/1966): *Central Places in Southern Germany*. Englewood Cliffs, NJ: Prentice-Hall, 1966. (Translation of "Die Zentralen Orte in Süddeutschland", published in 1933.)
- Dasgupta, M. (1994): *Urban travel demand and policy impacts*. Paper presented at the course "The urban environment and transport policy" at the Norwegian Institute of Technology, Trondheim, 10 - 12 January 1994
- Duun, H. P. (1994): *Byutviklingens transportvirkninger. En studie av transporteffekter, energibruk and utslipp til luft ved alternative byutviklingsstrategier i Bergen*. (The transportation effects of urban development. A study of transportation effects, energy use and emission to the air from different urban development strategies in Bergen) Bergen: West Norwegian Planning Group
- Fouchier, V. (1998): *Urban density and mobility in Ile-de France Region*. Paper presented at The UN-ECE 8th conference on Urban and Regional Research, Madrid, 8-11 June 1998.
- Hartoft-Nielsen, P. (2001): *Boliglokalisering and transportadfærd*. (Residential location and travel behavior.) Hørsholm: Danish Forest and Landscape Research Institute.
- Holsen, T. (1995): "Det tveeggede sverd. Teoretisk perespektiv på eiendomsutvikling and arealplanlegging i urbane områder." (The double-edged sword. A theoretical perspective on property development and land use planning in urban areas.) *Plan*, no. 1/95, pp. 17-23.
- Jones, P. (1978): "Destination choice and travel attributes." In Hensher, D. and Dalvi, Q. (eds.): *Determinants of travel choice*, pp. 266 - 311. England: Saxon house.
- Kitamura, R.; Mokhtarian, P. L. and Laidet, L. (1997): "A micro-analysis of land use and travel in five neighborhoods in the San Fransisco Bay area." *Transportation*, Vol. 24, pp. 125-158.
- Mogridge, M. H. J. (1985): "Transport, Land Use and Energy Interaction." *Urban Studies*, Vol. 22, s. 481-492.
- Newman, P. W. G. and Kenworthy, J. R. (1989): *Cities and Automobile Dependence*. Aldershot: Gower Publications.
- Newman, P. W. G. and Kenworthy, J. R. (1999): *Sustainability and Cities. Overcoming Automobile Dependence*. Washington DC/Covelo, California: Island Press.
- Nielsen, T. A. S. (forthcoming): Ph.D. thesis based on a study of land use and transport in Aalborg, Denmark. Aalborg: Aalborg University.
- Næss, P. (2001): "Residential Location and Transport in a Small Danish Town." In Nielsen, L. D. and Oldrup, H. H. (eds.): *Mobility and Transport - An Anthology*, pp. 43-61. Copenhagen: Danish Transport Council.
- Næss, P.; Røe, P. G. and Larsen, S. L. (1995): "Travelling Distances, Modal Split and Transportation Energy in Thirty Residential Areas in Oslo." *Journal of Environmental Planning and Management*, Vol. 38, no. 3, pp. 349-370.
- Røe, P. G. (1999): *Romlig-strukturelle forholds betydning for intraurbane hverdagsreiser*. (The influence of spatial-structural conditions on intra-urban everyday trips.) Paper presented at the Housing and Urban Research Seminar, Institute of Housing Research, Gävle, April 14 - 16, 1999.
- Schipper, L.; Deakin, E. and Spearling, D. (1994): *Sustainable Transportation. The Future of the Automobile in an Environmentally Constrained World*. Paper presented at a seminar organized by the Board of Communications Research, Stockholm, September 23, 1994.
- Synnes, H. (1990): *Reisevaner i Trondheim 1990*. (Travel habits in Trondheim 1990) M. Sc. dissertation at the Norwegian Institute of Technology, Trondheim.
- Vilhelmson, B. (1990): *Vår dagliga rörlighet. Om resandets utveckling, fördelning och gränser*. (Our daily mobility. On the development, distribution and limits of traveling) TFB report 1990:16. Stockholm: The Swedish Transportation Research Board.