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Location and daily mobility

By

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Abstract

The aim of this paper is to discuss the interaction between location and daily mobility in cities. According to previous research, distance travelled daily and the amount of car use in Scandinavian cities are factors influenced by urban density and residential location. Urban sprawl was a characteristic of cities in Norway 15-20 years ago, i.e. a change towards an increasingly car dependent city. In the years since then, it has become attractive to settle in the inner city areas. This reurbanization has probably moderated the increase in car traffic. Nevertheless, car traffic is increasing, and one reason could be the re-location of workplaces and other business activities.

The paper presents the results from an analysis of travel behaviour in the cities of Oslo, Bergen, and Trondheim. The main data source has been a database containing merged data from five large travel surveys conducted in 2001. The travel surveys have included geocoding, which provides unbiased information about exactly where trips start and end, and makes it possible to emphasize the geographical context in analyses of travel behaviour, and to analyse land use and transport by using GIS.

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1. Introduction

The aim of this paper is to discuss the interaction between location and daily mobility in cities. According to previous research, distance travelled daily and the amount of car use in Scandinavian cities are factors influenced by urban density and residential location (Næss 2002). One of the findings is that low-density land use and urban sprawl result in more car use. Another is that people living close to town centres travel shorter distances and use the car less than people living elsewhere in the city.

Research in this field has traditionally been in the form of aggregated studies of urban density and energy use at city level (Næss 2003), or case studies in small areas. The present study is based on national and regional travel surveys. Since 2001, the Norwegian national travel survey has included geocoding, which makes analysis of land use and transport possible. Geocoding means that the origins and destinations of each trip, as well as the locations of people's homes and workplaces, are located to statistical wards.[1] This provides unbiased information about exactly where trips start and end, and makes it possible to emphasize the geographical context in analyses of travel behaviour. Using the geographical references, we are able to integrate other information connected with the wards (for instance data on accessibility and land use). Generally, the advantage of using geocoded travel surveys in analysing the interaction of land use and transport is the large number of interviews and the geographical coverage of all areas within the city.

This paper presents the results from an analysis of travel behaviour in three Norwegian cities: Oslo with approximately 800 000 inhabitants, Bergen with 210 000 inhabitants, and Trondheim with 145 000 inhabitants (Engebretsen 2003, Vibe et al. 2005). The main data source has been a database containing merged data from five large travel surveys conducted in 2001: The national travel survey and four local surveys covering the counties of Oslo and Akershus, the county of Vestfold, the region of Bergen, and the region of Trondheim, all of them designed approximately in the same way, including the geocoding. These five travel surveys contain information from nearly 53 000 interviews representing about 177 000 trips (approximately half of them are applied in this article). The Institute of Transport Economics (TØI) carried out the national survey, while local authorities were responsible for the local surveys. TØI merged the different databases.

The comprehensive dataset, which is a good base for analysing urban travel behaviour, includes a new analytical tool consisting of GIS-based maps showing geographical differences in travel. Use of these maps in this article is a major element in unveiling some of the challenges in land use and transport

[1] Norway is divided into approximately 14 500 statistical wards, which are the smallest areas used for presenting statistics in Norway. Essentially, a ward is a geographical area that is as homogeneous as possible with respect to population size, communication and building structure. Each ward has a separate number and name, and is well documented on maps and through coordinate referencing as well as address descriptions. The units are fairly small. For the three cities in this paper, including about 2000 wards, the smallest are approximately 1 hectare, while the average size is clearly less than 1 sq. km. Just a few wards are more than 1 sq. km because they include some forested and other un-built land on the urban fringe. The mean population of wards in the three cities is 400-600 inhabitants, the maximum is 3500 inhabitants (however, the area of this ward is less than 0.4 sq. km).

planning. In our analysis, the hypothesis has been that location of trip destination is the most important aspect of differences in travel behaviour, such that location of the workplace and other business activities are vital elements in urban planning.

2. Variations in travel behaviour - differences between cities

More than 60 percent of travel is by car in Oslo, Bergen and Trondheim; 25 percent is by walking or cycling (from start to end) and only 15 percent by public transport (17 percent in Oslo). Even on weekdays more than half the volume of travel in these cities is by car – day and night. Figure 1 shows trip distribution over 24 hours on weekdays in Oslo (the number of car trips is estimated accurate to ±6 percent in the daytime).

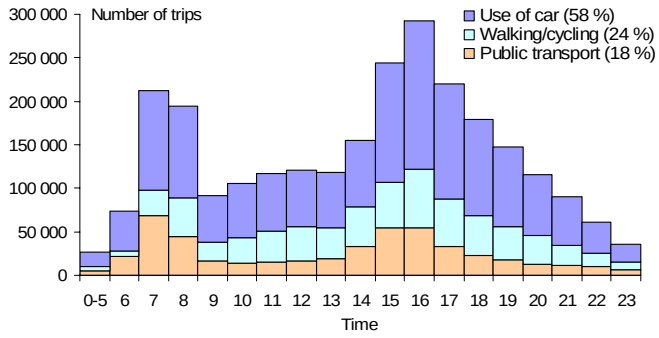


Figure 1: Trip distribution during workdays in Oslo.

Travel behaviour varies from town to town. Public transport features predominantly in the biggest towns, the middle-sized towns relatively more by car traffic. One reason for the differences may be the density in land-use patterns. A high level of urban density on average means shorter travel distances for everyday affairs and therefore less need for motorised transport -- in addition, a better market for public transport.

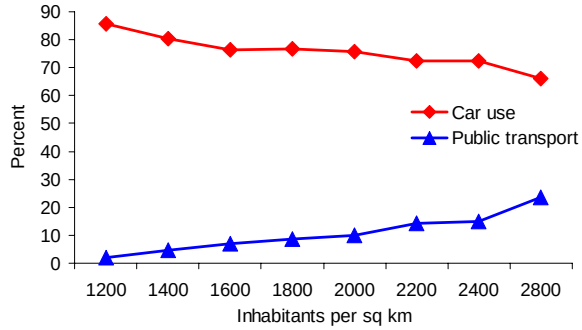


Figure 2: Percentage distribution of daily travel distance (passenger km) by urban density in Norwegian cities with more than 20 000 inhabitants (trips with origin and destination in the same city).

Figure 2 confirms how the share of total travel distance (passenger km) by car decreases with increasing urban density, while the reverse is the case for

public transport, i.e. the share increasing with increasing urban density. The diagram includes all towns with at least 20 000 inhabitants and is based on the national travel survey and urban land-use statistics (Central Bureau of Statistics). The results correspond with those from previous studies showing decreasing fuel consumption with increasing urban density (Næss 1993).

3. Variations within cities – differences between residential locations

Travel behaviour varies more within cities than between cities. This can be seen in maps (figures 3-5) showing the percentage of people travelling by car on trips starting at home in Oslo, Bergen and Trondheim, respectively (Monday-Friday).[2]

The map of Oslo (figure 3) shows clearly that car use increases from the centre of the city towards the urban fringe. People living in the central areas of the city use the car on fewer than half their trips from home. The share is less than one-third close to the town centre. Outside the central area, i.e. more than 5 km from the midpoint of the city, and especially in the suburbs, car use is substantially higher. In some areas, car use is more than 75 percent, but in residential areas along some of the metro lines, car use is lower.

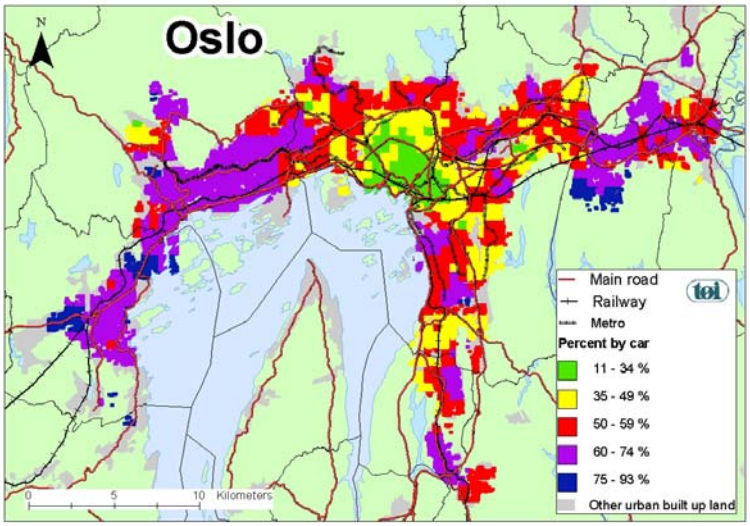


Figure 3: Percent travelling by car on trips starting at home. Monday-Friday. Oslo.

Car use in Bergen (64 percent) (figure 4) and in Trondheim (67 percent) (figure 5) is generally higher than in Oslo (58 percent), although the geographical patterns are more or less identical in the three cities, with low car use in central areas and high car use at the urban fringe.

[2] The percentages represent the average for the statistical wards within overlapping 1×1 or 2×2 km cells (with a minimum of interviews). The coloured areas on the map (showing percent by car) consist of pixels representing the houses in the middle of each cell.

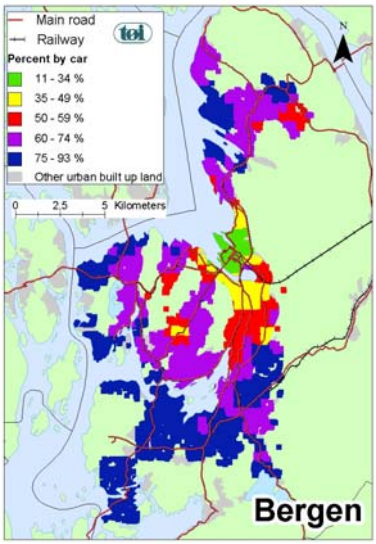


Figure 4: Percent travelling by car on trips starting at home. Monday-Friday. Bergen.

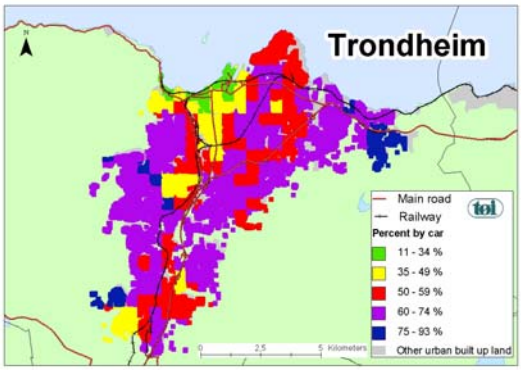


Figure 5: Percent travelling by car on trips starting at home. Monday-Friday. Trondheim.

The deviations in percentage points between neighbouring cells in the maps are not statistically significant everywhere. However, on aggregating the results to zones (as in figure 6), significant difference in car use can be proved with increasing distance to town centres. We therefore conclude with confidence that people living in central areas use their cars substantially less often than people living in other parts of the city.

In addition (as we also can see from figure 6), people living in central areas travel on average shorter distances during the day than others living further away from the town centre. The average distance estimates include trips shorter than 100 km (all travel modes) made by people starting from their home in the morning and returning at the end of the day.

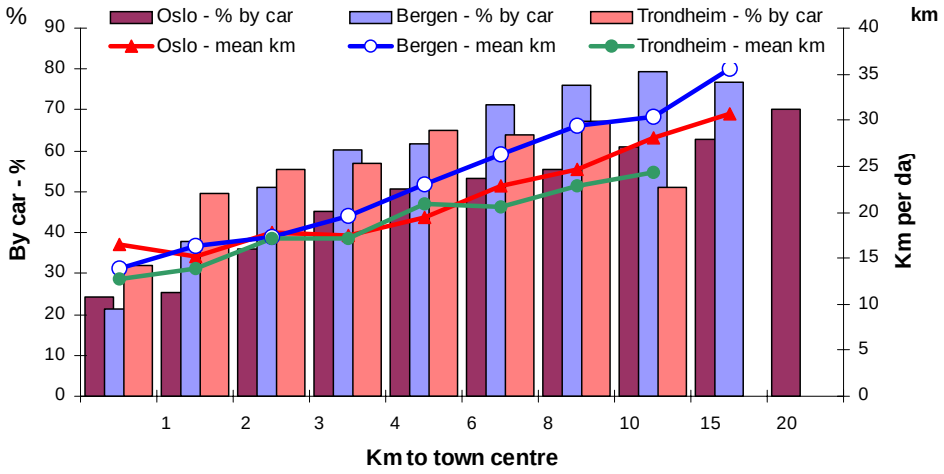


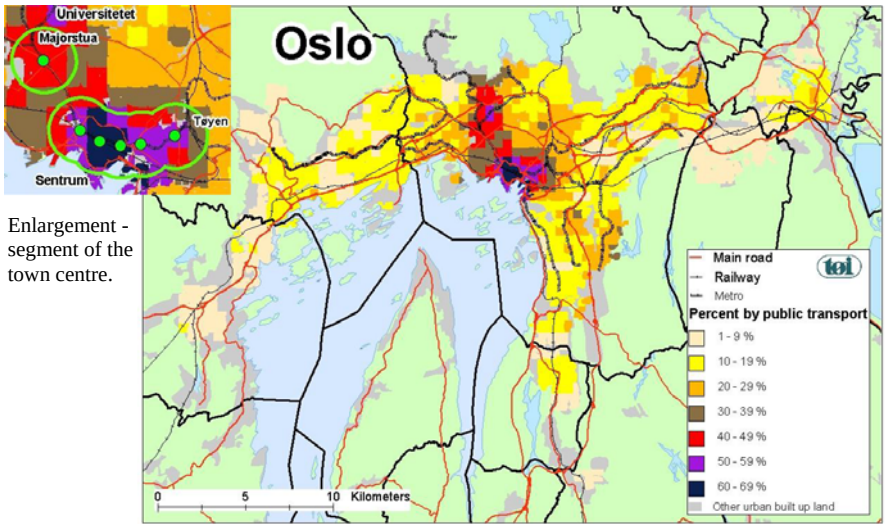
Figure 6: Percent travelling by car on trips starting at home, and average travel distance per day, by distance from home to town centre (as the crow flies). Monday – Friday.

Why are inner city residents so different? Some of the explanation has to do with prosperity. While the percentage holding a driving licence is almost the same in the inner city as in the rest of the city, car ownership is much lower. Only about half the respondents in the inner city live in households with access to a car as opposed to 80-90 percent in the rest of the city. The low car ownership could be due to a predominance of the age group 20-34 years. Necessarily low car ownership must be a limiting factor for car use.

Still, the most important explanation for less car use is that inner city residents have most of their activities in the town centre, thus a preponderance of walking and cycling as a consequence of short distances (the need to own a car is therefore probably also lower). An important observation, however, is that when the residents in these areas travel to destinations in the outer areas of the city, their car use is almost at the average level for the city as a whole. Location of trip destination is therefore an important factor in the choice of mode of transport.

4. Variation within cities – differences between destinations

A wider analysis confirms that travel mode varies with location of destination. Figures 7-9 display the market share for public transport on motorized trips to different destinations in the cities (not including destinations in the traveller's own home). Most trips by public transport terminate in the central business district (CBD) or surrounding areas, so it is primarily to this part of the city that public transport has any substantial market share. For motorized trips to the central areas surrounding the CBD (within 2-4 km of the centre), public transport has a market share of at least 20 percent on workdays. For trips to the CBD itself, the share is 60-70 percent in Oslo and 40-50 percent in Bergen and Trondheim. To the outskirts of the town the market share is close to zero.



Enlargement - segment of the town centre.

Figure 7: Percent travelling by public transport by destinations of motorised trips (not counting trips that end in the traveller's own home). Monday-Friday. Oslo.

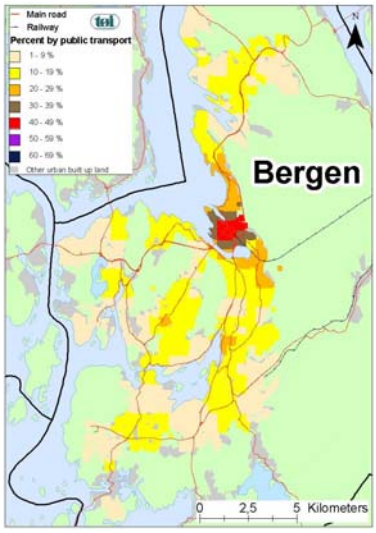


Figure 8: Percent travelling by public transport by destinations of motorised trips (not counting trips that end in the traveller's own home). Monday-Friday. Bergen.

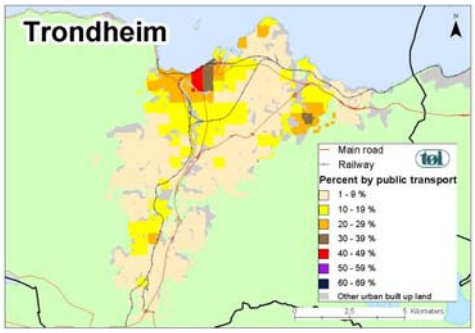


Figure 9: Percent travelling by public transport by destinations of motorised trips (not counting trips that end in the traveller's own home). Monday- Friday. Trondheim.

A big market share for public transport is achieved where the system offers good accessibility from all places throughout the city. This is shown in the detail of the town centre of Oslo in figure 7, where the green points show the location of the metro stops and the green circles the market area within walking distance (i.e. radius 800 metres). This is the most accessible area by public transport in Norway (by railway, metro, tram, bus and local ferries). The map is not meant for analysing geographical details, but it shows very clearly the correlation between good accessibility and a large market share for public transport.

The most important message from the three maps (figures 7-9) is that public transport plays only a limited role in most areas in the city. Although accessibility by the bus and rail network is fairly good in some areas outside the town centres, car traffic predominates. Good accessibility by public transport is therefore not a sufficient condition for reducing car use. In addition, it must to some extent be exasperating to use the car. However, the high standard (high capacity, effective tunnels beneath the town centres, etc.) of the road system in Norwegian cities means almost no delays - even during rush hours. The only factors that can hinder car use today are lack of parking space and car parking costs.

The effect of accessibility by public transport and access to parking is given in figure 10 in an analysis of travel to work (analysis based on logistic regression). Access to parking is defined as free parking at the workplace. Accessibility by public transport is measured as the relative travelling time defined as the total travelling time by public transport (from door to door - including walking to the bus stop, waiting time, etc.) in proportion to travelling time by car in the morning traffic.

As already mentioned, high quality public transport is not the only reason for travel by public transport. As can be seen from the figure, access to parking is

equally important. In Norwegian cities, most employers provide free parking in the vicinity; the exceptions are primarily found in the town centres.

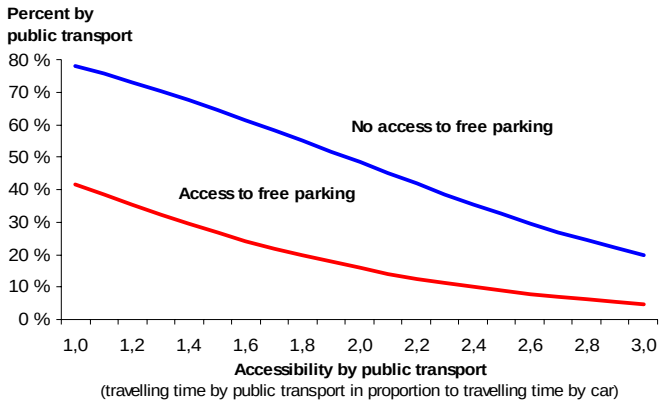


Figure 10: Percent commuting by public transport in Oslo by accessibility by public transport and by access to free parking. Accessibility by public transport is measured as the relative travelling time defined as the total travelling time by public transport (including walking to the bus stop, waiting time, etc.) in proportion to travelling time by car in the morning traffic. Monday-Friday.

As can be seen from the curves in the figure, there is little likelihood that commuters will choose public transport if they have access to free parking at work, unless travelling time by public transport is about the same as by car (door to door). On the other hand, people with no free parking choose public transport even if the standard of the system is low. Public transport is much preferred to destinations where the supply of free parking is limited and accessibility good by this means, which is mainly the situation in town centres.

About half of all travel on workdays is commuting, so reducing car dependency among commuters should be an important measure in any sustainable urban transport policy. To do this, it will be necessary to increase the standard of the public transport system, possibly supplemented by a strict parking policy, but developing sufficient accessibility by public transport is not feasible everywhere. In practice, efforts have to be concentrated in certain intersections in the public transport network. The challenge is therefore to develop a localization policy for concentrating business activities, with many employees and/or many visitors around these nodes.

Any strategy designed to reduce dependency on the car in urban traffic should take into consideration at least three elements: increased accessibility by public transport (in given areas), a more restrictive car parking policy (in given areas), and a policy for locating business activities with many employees and/or visitors to areas with high accessibility by public transport. This is in fact the same strategy as in the Dutch planning guidelines entitled “The Right Business at the Right Place” or the ABC policy that was implemented 15 years ago (Ministry of Housing, Physical Planning and Environment 1991).

The ABC policy was also introduced in Norway (Engebretsen and Hanssen 1994) and rapidly became a model for integrated land use and transportation planning in the country. Despite this, the effects of the planning philosophy have been poor -- just as in The Netherlands (Le Clercq and Bertolini

2003). So far, it has been difficult to change the localization policy for business activities and, of course, most land-use remains unchanged.

Increasing the use of public transport in Norwegian cities is difficult. Almost everywhere the car is the fastest mode of transport. Public transport can compete with the car only in town centres. The challenge is that 70-80 percent of the destinations for car trips are in other parts of the city (not counting trips that end in the traveller's own home). In addition, with destinations dispersed as they are (see figure 11), it is difficult to develop an urban transport system that would compete with the flexibility afforded by the car.

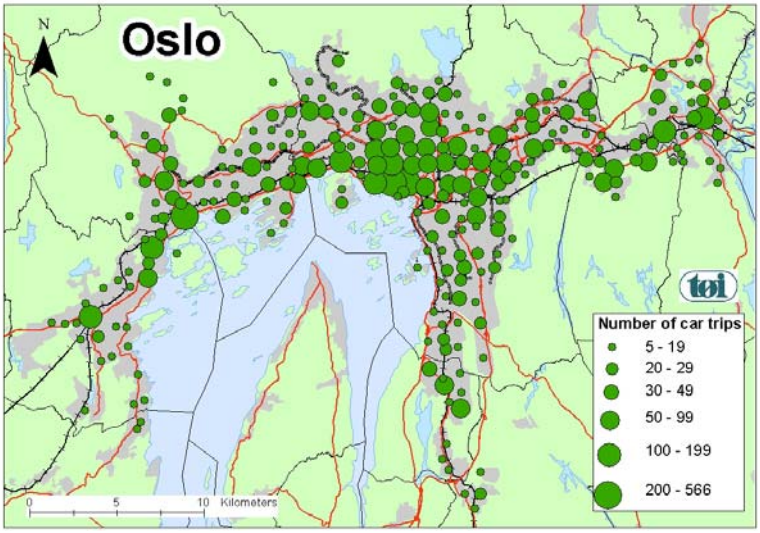


Figure 11: Main destinations for car trips in Oslo made by a sample of travellers (not counting trips that end in the traveller's own home). Monday-Friday.

5. Consequences of urban expansion

The increase in urban populations and car ownership is one important driving force behind the growth in car traffic in cities. Urban development with changed location patterns is another force with an effect on traffic. Based on the above findings, it is obvious that if the volume of traffic in general is to be reduced, especially car traffic, a settlement pattern concentrated around town centres would be favourable. Urban sprawl was a characteristic of cities in Norway 15-20 years ago, with a reduction of the population in inner city areas and growth in outermost areas, i.e. a change towards an increasingly car dependent city. In the years since then, it has become attractive to settle in the inner city areas in Norwegian cities. This reurbanization has gradually resulted in a stabilization of the urban density, a better balance between different parts of the city, and thus has probably moderated the increase in car traffic.

Nevertheless, car traffic is increasing, and one reason could be the re-location of businesses and other significant destinations. In particular, the location of workplaces is a central component. To go deeper into these questions, we can use the Oslo region as an example; 20 years ago about half the workplaces in the city of Oslo were located within 3 km of the town centre. In the years since then, there has been a trend of businesses moving from the central areas to the urban

fringes. Most businesses have increased floor space outside the central area of the city, i.e. often in areas with limited accessibility by public transport. This is illustrated in figure 12 showing new enterprises with at least 500 square metres of floor space.

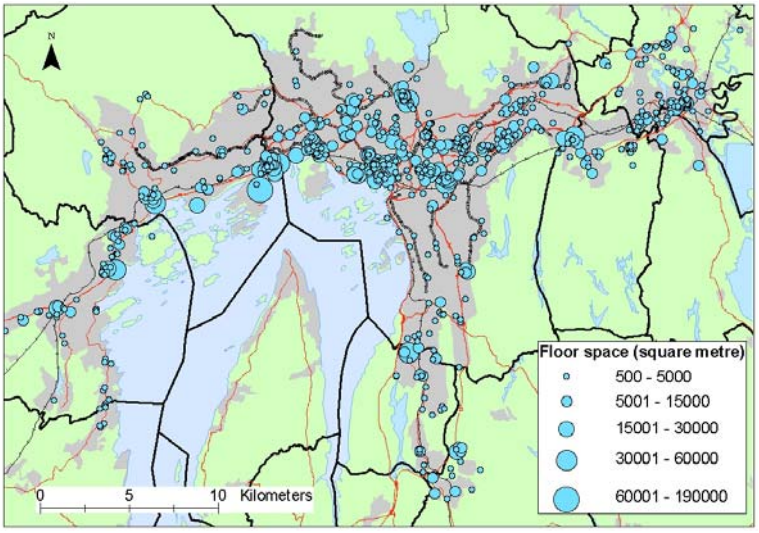


Figure 12: New business buildings with at least 500 square metres of floor space built beetween January 1985 and autumn 2004. Square metres floor space. Oslo. Data source: GAB[3].

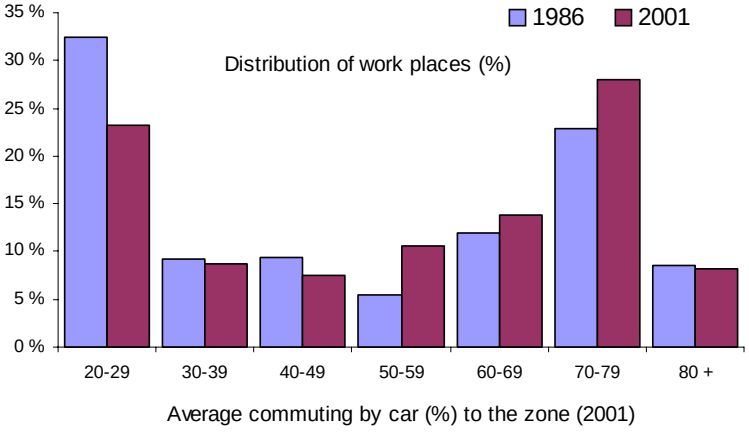


Figure 13: Distribution of work places by 1986 and 2001 by zone. Zones defined by average commuting by car by 2001. Oslo. Percent.

The outcome of this development is an increasing share of workplaces in car-based areas causing a growing auto dependency among commuters. The distribution of workplaces by traffic zones in 1986 and 2001 is shown in figure 13. The traffic zones are defined by the amount of commuting by car to the different areas according to the travel survey.

By assuming fixed shares of car use per zone, it is estimated that changes in localization pattern in the city of Oslo may have increased the number of car trips to work by 0.5 percent per year over the past 15-20 years. In the same period, population growth has been about 1.0 percent per year. The combined

[3] GAB system - public register of **G**round Properties, **A**ddresses, and **B**uildings.

effect of these two components would be an expected growth in commuting by car of approximately 1.7 percent each year. This corresponds with the increase since 1990 in the number of private cars in the region of about 1.7 percent (Central Bureau of Statistics) and the growth in car traffic of 1.9 percent (Lian 2005).

6. Conclusions and challenges

In this article, geocoded travel surveys and GIS were used to confirm the relationship between travel behaviour and urban density, residential location and location of destinations. The focus has been the integrated effect of accessibility by public transport, access to car parking, and the location of destinations.

The results confirm previous findings that travel behaviour is influenced by residential location. An equally important factor, however, is the location of workplaces and other business activities. The results indicate that businesses moving from the central areas to the urban fringes may have been one of the driving forces behind the growth in car traffic in cities the last 20 years.

Based on the results, some conclusions can be drawn associated with possible political measures. The strategies are associated with a division of the cities into two main zones – “the inner city” and “the outer city” -- the inner city encompassing the most densely built-up area, i.e. within a distance 4.5-5 km from the centre of Oslo, 2.5 km from the centre of Bergen and 2 km from the centre of Trondheim, the outer city the built-up urban land outside the inner city, mostly suburban, residential areas and some industrial zones.

The inner city is characterized by the relatively low car use of local residents and the high public transport use of daily visitors. Except for residents’ trips to the inner city, the outer city is characterized by much car use and the scattered trip destinations of both residents and daily visitors. This means that it is difficult to establish a competitive public transport network, especially for trips across arterial routes towards the centre. Most trip destinations are outside the inner city, which means that the public transport system only serves smaller parts of travel demand in the outer city.

If the measure is to reduce the total volume of car traffic (e.g. in order to reduce total carbon dioxide emissions), the results indicate that the focus should be car trips to destinations in the outer city. These represent 40 percent of all trips (all modes) in each of the three cities. Because it is difficult to operate a public transport network that can compete with the flexibility of the car for trips to the existing dispersed destinations, the challenge is working out a land-use policy stipulating the requirement for concentration of business activities and other activities in the outer city to a limited number of nodes that can be more effectively connected by an upgraded public transport system.

If the measure is aimed at reducing local environmental and traffic problems, the focus should be on car trips to the inner city. Even though public transport has a high market share of travel to this area, most of the traffic is still by car. Twenty percent of total passenger kilometres in each of the cities is the result of car trips to the inner city. Many measures are possible to influence car traffic to the central areas, ranging from improved public transport to restrictions on car use (e.g. road pricing and car parking restrictions).

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