

Urban Structure Matters

Residential location, car dependence
and travel behaviour

Petter Næss

URBAN STRUCTURE MATTERS

Previous work in this area has often been criticized for not being able to establish whether a causal relationship exists between urban structure and travel behaviour. In this book, Petter Næss uses new research from Denmark on residential location and travel to show how and why urban spatial structures affect people's travel behaviour.

A comprehensive study of the Copenhagen Metropolitan Area is used as the main case study. In important ways this study goes beyond the scope of previous investigations into the relationships between urban land use and travel. The traditional quantitative travel survey approach has been combined with qualitative interviews in order to identify the more detailed mechanisms through which urban structure affects travel behaviour. Rationales for location of activities and modal choice make up important links in these mechanisms. The statistical analyses probably include a broader range of urban structural, socio-economic and attitudinal variables than in any previous study. Differences between population groups in the way urban structure affects travel behaviour have also been investigated, as well as changes after moving from one residence to another.

The author compares the findings of the Copenhagen area study to other studies carried out in the Nordic countries, and looks at them in the light of relevant theories and the general literature on the topic. Næss also discusses principles for a less auto-oriented and transport-demanding urban development against a broader range of criteria for sustainable development.

Petter Næss is Professor of Urban Planning, at Aalborg University in the Department of Development and Planning.

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URBAN STRUCTURE MATTERS

RESIDENTIAL LOCATION, CAR
DEPENDENCE AND TRAVEL
BEHAVIOUR

PETTER NÆSS

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PREFACE

This book presents new research significantly improving the status of knowledge about the influence of urban structure on travel behaviour. A comprehensive research study in Copenhagen Metropolitan Area has been used as the book's main case. In important ways this study goes beyond the scope of previous investigations into the relationships between urban land use and travel. The traditional quantitative travel survey approach has been combined with qualitative interviews in order to identify the more detailed mechanisms through which urban structure affects travel behaviour. Rationales for location of activities and modal choice make up important links in these mechanisms. The statistical analyses probably include a broader range of urban structural, socio-economic and attitudinal variables than in any previous study. Differences between population groups in the way urban structure affects travel behaviour have also been investigated, as well as changes after moving from one residence to another.

The findings of the Copenhagen area study are interpreted in the light of other theoretical and empirical work on the topic and discussed against a broader range of criteria for sustainable development.

The author is Professor of urban planning at Aalborg University, Denmark and Senior Researcher at Norwegian Institute for Urban and Regional Research. He has for a long time been conducting research into sustainable urban development, with a particular focus on the relationship between urban land use and transport. The book is aimed at researchers, teachers, practitioners and students of urban planning.

The Copenhagen area study was financed by The Danish Transportation Council and Aalborg University and was carried out by the author with important contributions from Professor Ole B. Jensen at Aalborg University. The time necessary for writing this book was made available through internal funding from the author's two employers, namely Norwegian Institute for Urban and Regional Research and Aalborg University. Thanks also to Professor Arvid Strand at Norwegian Institute for Urban and Regional Research for valuable comments on a draft version of the book.

Petter Næss
Oslo/Aalborg, May 2006

CHAPTER 1

WHY IS KNOWLEDGE ABOUT URBAN FORM AND TRAVEL NEEDED?

1.1 INTRODUCTION

The theme of this book is how spatial planning in urban areas can be used to influence the amount of travel and the proportions carried out by different modes of conveyance. A comprehensive research study in Copenhagen Metropolitan Area will be used as the book's main case. This study has significantly improved the status of knowledge about the influence of urban structure on travel behaviour. Previous studies into this issue have been criticized for failing to control for other possible sources of influence and for not being able to establish whether a causal relationship exists between urban structure and travel behaviour. In important ways the Copenhagen Metropolitan Area study goes beyond the scope of previous investigations into the relationships between urban land use and travel. The traditional quantitative travel survey approach has been combined with qualitative interviews in order to identify the more detailed mechanisms through which urban structure affects travel behaviour. Rationales for location of activities and modal choice make up important links in these mechanisms. The statistical analyses include a broader range of urban structural, socio-economic and attitudinal variables than in any previous study. Differences between population groups in the way urban structure affects travel behaviour have also been investigated, as well as changes after moving from one residence to another.

1.2 THE SUBJECT OF THE STUDY

The primary source material of this book is an investigation of travel behaviour among inhabitants of 29 residential areas in Copenhagen Metropolitan Area¹. The study is one among several investigations conducted as parts of a research programme entitled 'Transportation and Urban Planning' at Aalborg University during the period 1998–2004. The theme of this programme is how spatial planning can be used to influence the amount of travel and the proportions carried out by different modes of conveyance, and thereby also energy use for transport. To a high extent, the purpose of spatial planning is to influence the development of the physical/spatial urban structure in a way favourable for society. In this context, the physical/spatial urban structure applies to:

- the geographical distribution and fabric of the building stock (the pattern of development);
- the mutual location of different functions (residences, workplaces, public institutions and service) within the building stock (the pattern of location);
- the transport system (road network, public transport provision, and parking conditions);
- water, sewage and energy supply and telecommunications systems;
- the urban green and blue structures (more or less natural areas within and close to the city, and lakes, rivers and creeks).

The study dealt with as the main example in this book is a case study of relationships between residential location and travel in a Northern European urban region, namely the Copenhagen Metropolitan Area in Denmark. Copenhagen Metropolitan Area includes the more or less continuous built-up area of the municipality of Copenhagen and surrounding municipalities, as well as other towns and villages south of the Roskilde Fjord within a distance of about 40 to 60 kilometres from the centre of Copenhagen. In a North European context, Copenhagen Metropolitan Area is a major city region of about 1.8 million inhabitants, with a concentration of workplaces and service facilities in the City of Copenhagen, but also with several secondary and local centres in the suburbs. The city has a well-developed public transport system with a network of urban railways as its backbone, but also several urban major arterial and ring roads. The urban structure of Copenhagen Metropolitan Area is described in more detail in section 3.3.

The focus of the Copenhagen Metropolitan Area study as well as of the other studies included in the research programme 'Transportation and Urban Planning' are the transport consequences of the location of the residence within the spatial/functional urban structure (sometimes referred to as the urban structural situation of the dwelling). Apart from the pipeline and electricity cable systems, all the above-mentioned urban structural elements are included in the study, with a main focus on the location of the residence relative to other urban functions.

1.3 RELEVANCE TO ENVIRONMENTAL POLICY

Reducing the consumption of fossil fuels (oil, coal and gas) is a key issue in the efforts to promote a *sustainable development*, as conceived by the UN World Commission on Environment and Development (the Brundtland Commission) in its report 'Our Common Future' (WCED, 1987). Motor transport in Denmark is almost entirely based on fossil fuels, either directly through the use of petrol or diesel (and in a few cases gas) to fuel the engines of the vehicles, or indirectly through the combustion of coal, oil

or gas in power plants producing the energy for electricity-driven means of conveyance (mainly the urban railways in Copenhagen Metropolitan Area). Combustion of fossil fuels pollutes the air and contributes indirectly to soil and water pollution as well, among others through acid rain. The impacts on the natural environment have their effects on a local, regional as well as an international scale.

During recent years, attention has increasingly been directed towards the accumulation in the atmosphere of so-called greenhouse gases, notably carbon dioxide (CO₂), caused by combustion of fossil fuels. According to the United Nations panel on climate change (IPCC), there has during the last 100 years been a 'discernable human influence on the global climate' due to human-made emissions of greenhouse gases. Unless the consumption of fossil fuels is reduced, present concentrations of greenhouse gases in the atmosphere will be doubled or tripled within the next 100 years. The consequences may not only be temperature increases in the range between 1.5 and 6 degrees centigrade, but also abrupt and unpredictable climatic changes (Danish Ministry of Environment and Energy, 2001: 4). Moreover, environmental problems arise both from extraction and transportation of fossil fuels (among others, oil spills in the sea). Besides, oil, coal and gas are non-renewable energy sources. The present high and increasing consumption of these limited resources, particularly in wealthy countries, contributes to increasing the risk of wars and international conflicts. American oil consumption, for example, has made the United States increasingly dependent on fossil fuel imports. In order to secure oil supplies from the Middle East and other regions around the globe, the USA by the turn of the millennium (before the Iraq war) spent some \$7000 annually per four-person family for military purposes (Hvelplund, 2002: 311).

The IPCC has suggested that the global-level CO₂ emissions should be reduced by at least 60 per cent as soon as possible. If at the same time an increase in the material standard of living is going to take place in developing countries, this will most likely imply substantial increases in the energy consumption of these countries. For such an increase to be possible within the frames of a total level of emissions that does not aggravate the greenhouse effect, industrial countries must reduce their emissions by considerably more than the 60 per cent suggested by the IPCC for the planet as a whole (cf. also WCED, 1987: 171).

The transport sector is probably one of the sectors where a reduction of greenhouse gas emissions will be most demanding and conflict-ridden. Denmark has obtained considerable improvements within other sectors, including manufacturing industry and energy use in dwellings. However, energy use and emissions from transportation have continued to increase. Indeed, transportation is the sector showing the steepest increase in greenhouse gas emissions, thus the need for policies in order to 'break the curve' is strong within this sector.

Transportation in urban areas has a number of other negative environmental and social impacts too, including local air pollution, noise, loss of valuable buildings and recreational areas due to road construction, replacement of public urban space by parked cars, the barrier effects of major roads, and traffic accidents. Pollution and noise from traffic has severe consequences to human health, particularly in the urban districts most exposed. Moreover, after a period of traffic safety improvements and reduced number of deaths on the roads, the number of traffic fatalities is again rising in Denmark, following the general increase in traffic.

For the time being, the political willingness to reduce the energy use and emissions of the transportation sector appear to be modest in Denmark. Nevertheless, research into the ways measures within different sectors of society influence the development of transport and transport-related environmental problems is of a high relevance for society. Given the current Danish transport policy, energy use and CO₂ emissions from transportation will increase substantially in the years to come. Even with optimistic assumptions about energy efficiency improvements of new cars, projections prepared by the Highways Directorate indicate that transportation will account for 32 per cent of the internationally agreed CO₂ emission level for Denmark by 2010, compared to 21 per cent in 1997 (Jespersen, 2000: 107). At the same time, the scientific uncertainty as to whether greenhouse gas emissions really affect the climate has been steadily reduced. Along with the increases in global greenhouse gas emissions there is reason to expect that the consequences of global climate change will also become gradually more evident in Denmark and other North European countries. Should the international society succeed in arriving at future climate agreements with more ambitious and binding goals than the Kyoto agreement, there will be an increasing pressure on the transportation sector to reduce its emissions. As the least conflict-ridden possibilities to reduce emissions within other sectors of society gradually become implemented, and further reductions accordingly are perceived as difficult to realize, there is reason to expect that these sectors will to a decreasing extent accept that transportation be exempted from the requirement for reduced emissions.

A number of imaginable measures exist in order to influence the amount of transport, the modal split between different means of conveyance, and the energy use and related emissions from transportation. Improving the energy efficiency of vehicles could bring about considerable reduction of the emissions from the transportation sector, but unfortunately, increased weight and engine power have so far tended to outweigh what is gained by 'lean-burn' engines. A shift to electric cars would solve many of the local pollution problems of car traffic, but in terms of greenhouse gases an electrification of the car fleet would only move the emissions from the streets to the power plant. Other measures (e.g., radical increases in petrol prices, road charges with restrictively high rates per kilometre, or the establishment

of maximum quota for each person's purchase of fuel) could potentially change transportation patterns significantly in the course of a short time. However, it has proved to be extremely difficult to gain political backing for such measures. Part of the reason for this is probably the fact that the very mobility that has given most people in modern societies increased freedom to reach a wide range of destinations and activities, has also given us a society where a high mobility is increasingly becoming a requirement. The location of built-up areas and activities in urban regions is an obvious example. During the last half of the twentieth century, it became not only possible, but also necessary for people to transport themselves considerably longer distances to reach daily and weekly activities.

In order to break the self-perpetuating interaction between increased mobility and a transport-generating land use, there will be a call for specific transport policy measures as well as a location and structuring of future urban development aiming to limit the needs for transportation. In short: coordinated land use and transport planning.

Among employees who start working at a new workplace, or residents who move into new dwellings, the location of new residential or commercial development may already in a short term influence the need for travel considerably. However, for the city as a whole, the transport consequences of changing urban structure through spatial planning will mainly manifest themselves in a long-term perspective. Usually, it takes many years to change the existing building stock of a city to an extent sufficient to change overall travelling patterns significantly. However, precisely because it takes a long time to change the built environment it is important to avoid creating a future pattern of development dependent – perhaps to an even higher degree than today – on an ample supply of cheap energy. Such a structure will be highly vulnerable to any future limitations on energy use, e.g. resulting from international quotas for or taxes on CO₂ emissions. It would also be vulnerable to failing supply stability, e.g. due to international conflicts and wars. It is not reasonable to expect any single instrument to be able in itself to induce the necessary reduction of emissions. If the reductions of transportation's environmental loads necessary to make a difference in relation to the global climatic challenges are ever to be possible, there will probably be a need to combine both more energy-efficient vehicles, fuel taxes, road charges, improved public transport in cities, and a spatial planning limiting the needs for transport.

1.4 RELEVANCE TO THE ACCESSIBILITY OF FACILITIES AND ACTIVITY OPPORTUNITIES

Besides the environmental policy relevancy of research into relationships between urban structure and travel, the topic has of course also an important welfare dimension.

An urban structure with large built-in needs for transport makes it necessary for the inhabitants to spend much time and/or money on daily travel. Those population groups who are able to pay for a high mobility (in the form of private motoring) may reduce their travel times and thereby have a less stressed daily-life schedule. However, those who do not have a car at their disposal – and this group includes both households who do not have a car at all, and persons who cannot themselves use the household's car because it is occupied by another household member – will either need to spend a long time on daily travelling, or confine their options for job opportunities and service facilities to a limited part of the urban area.

If any economical measures against the growth in car traffic are to work according to their purpose, the share of inhabitants who accept more time-consuming trips or reduced options for workplaces and service facilities must increase, while the proportion who choose to surmount the *friction of distance* (cf. section 2.1) by buying themselves a high mobility must be reduced. The more transport-requiring the spatial structure of the city, the higher losses of welfare will be the consequences of such changes in travel behaviour. On the other hand, the proportion who do not consider themselves able to reduce their transport but instead accept paying more in order to be able to continue their present travelling patterns will probably be higher, the higher dependence on (car) travel is built-in in the location of urban facilities. For the latter group of households, road charging or other economic instruments to reduce urban motoring will be an additional economic burden. This also illustrates an important relationship between economical and urban planning measures: the more transport-requiring the urban structure, the higher taxes will be necessary in order to change travel behaviour among the households causing the heaviest environmental load through their daily travelling. At the same time, taxes of a magnitude sufficient to result in the desired environmental benefits will have higher negative welfare and distributional consequences the higher 'structural compulsion' is built in to the physical and spatial urban structures.

A high amount of transportation necessitates substantial investments in the construction of high-capacity roads and public transport systems. Neither is the necessary energy to drive the vehicles free. Moreover, according to the cost-benefit models usually employed within the transportation sector, the time spent for transport might alternatively be spent on more economically profitable activities. A transport-demanding urban structure thus contributes towards increasing important entries in an economic account, even when omitting the 'externalities' in the form of transportation's environmental impacts and the distributional effect of making accessibility to urban functions and facilities dependent on a high mobility.

1.5 CONSIDERABLE RESIDENTIAL CONSTRUCTION IS EXPECTED – WHERE TO LOCATE IT?

It has been claimed that the amount of construction likely to take place within the foreseeable future is quite marginal, compared to the existing building stock. Hence, no matter which principles for development are followed, it will not be possible to create any significant changes in the urban structure, not even within a time horizon of 20 or 30 years (Skjeggedal, 1996; Kristensen, 1999). The situation in Denmark at the beginning of the 1990s, when both residential construction and the total construction of buildings was ticking over, compared to previous periods, might perhaps provide a breeding ground for such an assessment. However, since 1994 a considerable growth in construction activity has occurred. According to Madsen (2000), there will be a need to increase the Danish stock of dwellings² by close to 300,000 within the next 30 years. In autumn 2002 the Danish government presented a housing policy paper according to which more than 20,000 new residences were expected to be constructed annually (*Berlingske Tidende*, 26.08.02).

The prospects for future residential development in Copenhagen Metropolitan Area are in no way unique. In most of the larger European urban regions, considerable residential and commercial development is expected in the next decades. For example, according to South East England Regional Assembly (2004) there will most likely be a need to construct between 700,000 and 900,000 new dwellings in South-Eastern England (excluding Greater London) during the period 2001–2026. Depending on the development of housing prices, the demand for new residential construction could be as high as 1.2 million dwellings (2004).

Depending on the location and site utilization of new housing areas, residential construction of the amounts indicated above may cause considerable changes in urban spatial structures. In addition, commercial and industrial development and new public sector buildings contribute to the overall growth of the building stock.

The discussion of where to locate the future residential development of Copenhagen Metropolitan Area has important links to broader debates on sustainable spatial development. In many European countries, much of the discussion has focused on the negative environmental consequences of a land-consuming and sprawling urban development in terms of, among others, loss of natural and agricultural areas and a high energy use for transport and in buildings. To a large extent, the predominant ideas of a sustainable urban development in these countries appear to converge on the ideal of the 'compact city' (cf. among others, Commission of the European Communities, 1990; Breheny, 1992; Jenks *et al.*, 1996). Against this view, several debaters have advocated the 'green city' as the ideal sustainable urban form, focusing on local self-sufficiency, waste and water management, and

closed circuits of substances (Girardet, 1993; Kennedy, 1995). Most of these debaters have assumed that such 'urban ecological' principles require a relatively low density (cf. e.g., Orrskog, 1993). During the most recent years, the 'polycentric city' has increasingly been promoted as a more feasible alternative to the centralized and monocentric urban development associated with the compact city model (Healey and Williams, 1993; Archibugi, 1997). Similar principles of 'decentralized concentration' are also key features of the 'new urbanism' and 'smart growth' ideas that have gained considerable attention among urban planners especially in the USA (CNU, 2005; Smart Growth Network, 2005). However, the geographical scale referred to by proponents of polycentricity is often unclear: does the concept refer to a pattern of individual cities at a national scale, within a larger region, or to a pattern of centres within the individual city (Jensen and Richardson, 2004)? Defending their position against criticism of unsustainable travelling patterns, advocates of low-density and decentralized urban developmental patterns have often raised doubt about the relationships between urban form and travel emphasized by compact city proponents (see, e.g., Breheny, 1992; Frey, 1999, Williams *et al.*, 2000).

The Copenhagen Region Development Council⁹ has recently presented five models for future urban development, based to different degrees on densification or spatial expansion, and with the development concentrated to a higher or lower degree around the stations of the urban railways network (Nilas, 2003). The alternatives are likely to vary considerably in their consequences for travel patterns. Which of the alternatives are the more or less favourable ones, judged against the national goal of 'redistributing transport to more environmentally friendly modes' (Ministry of Transport, 1993: 10)? In order to make such an assessment, knowledge is needed about the influence of various land-use parameters on travel patterns.

Together with political willingness and policy instruments for implementing the preferred solutions, such knowledge is part of the necessary base for a coordinated land use and transport planning aiming to reduce the environmental problems of urban transportation. An important part of the motivation for this book is the need for knowledge about the efficiency of different urban developmental strategies, seen in relation to the goal of reducing energy use and emissions from urban transport.

Since the book's main case is the Copenhagen Metropolitan Area, the results are of course of particular relevance to the current debate on urban development in Denmark's largest city region. However, I believe that the results will also be relevant to land use and transport planning in a wider European context and for many non-European cities too.

1.6 THE STRUCTURE OF THE BOOK

In the next chapter (Chapter 2), a theoretical perspective of the influence of urban structure on travel will be offered, including a discussion of epistemological and ontological aspects of research into this issue. Chapter 3 presents the geographical context of Copenhagen Metropolitan Area and the research methods of our study in this urban region.

In Chapter 4, a first picture of typical mobility patterns among residents living in different parts of the metropolitan area is outlined. In Chapter 5 we try to find explanations of these geographical variations by means of material from qualitative interviews, searching for the causal mechanisms by which urban structure influences travel behaviour in the contexts of individual households. Special attention is given to the interviewees' rationales for location of activities and choices of travel modes, and how these rationales, together with urban structural conditions, produce certain characteristic travelling patterns varying with the location of the dwelling. Chapter 6 looks again at the aggregate-level patterns of travel behaviour, presenting the results of statistical analyses of the influences of urban structural, demographic, socio-economic and attitudinal factors on travel behaviour. Distinct from Chapter 4, where only the immediately apparent geographical variations in travelling patterns were shown, Chapter 6 seeks to identify the separate effects of urban structural conditions on travel behaviour, that is the relationships still present when the effects of the investigated demographic, socio-economic and attitudinal factors have been 'subtracted'.

Chapter 7 investigates further the relationships between residential location and the availability of facilities, location of activities, trip distances, activity participation and trip frequencies, and travel time, thus seeking to contribute to a more detailed and nuanced understanding of the relationship between residential location and daily-life travel. Chapter 8 draws the attention towards certain indirect effects of urban structure on travel behaviour via, among others, car ownership and transport attitudes. When controlling for variables whose relationship with residential location is two-way rather than unidirectional, we should at the same time take such indirect effects into consideration. In Chapter 9, the attention is drawn towards differences between population groups (e.g. workforce participants and non-participants of the workforce) in the ways that the urban structural situation of the residence influences travel behaviour. Chapter 10 addresses a hypothesis of 'compensatory travel', according to which a low amount of daily travel is likely to be compensated through more extensive leisure mobility during weekends and holidays.

Chapter 11 draws together the threads from the previous chapters and compares the results of the Copenhagen Metropolitan Area study with the findings of other research studies into the relationships between residential location and travel.

In the two last chapters, the perspective is widened. Chapter 12 discusses how well principles of a transport-reducing and less car-dependent urban development comply with other key criteria of an environmentally sustainable urban development, such as the minimizing of energy use in buildings, protection of natural areas and productive soil, establishing closed loops of substances, and providing a healthy environment for the inhabitants. In Chapter 13, the feasibility of transport-reducing and environmentally friendly urban developmental principles will be discussed, addressing, among others, investment and running costs, housing quality and residential preferences, and consequences for everyday life organizing. At the end of the chapter, planning procedural strategies are discussed in the light of the challenge of obtaining a sustainable urban development.

URBAN STRUCTURES AS CONTRIBUTORY CAUSES OF TRAVEL BEHAVIOUR – A THEORETICAL PERSPECTIVE

2.1 A MULTI-CAUSAL SITUATION

According to theories of transport geography and transport economics, the travel between different destinations is influenced on the one hand by the reasons people may have for going to a particular place, and on the other hand by the discomfort involved when travelling to this location (Beinborn, 1979; Jones, 1978). Or, in other words, by the attractiveness of the locations and the friction of distance, respectively. The concept of friction of distance refers to the impediment which occurs because places, objects or people are spatially separate: movement involves a cost (Lloyd and Dicken, 1977). By creating proximity or distance between activities, and by facilitating different modes of travelling, the urban structure makes up a set of incentives facilitating some kinds of travel behaviour and discouraging other types of travel behaviour. Still, *people* travel, not buildings or geographical distributions of urban facilities. The causes of travel behaviour of course also include individual characteristics of the travellers, such as age, gender, income, professional status, as well as their values, norms, lifestyles and acquaintances. The emerging travel habits are a result of people's resources, needs and wishes modified by the constraints and opportunities given by the structural conditions of society (see Figure 2.1). Among the structural conditions the spatial and physical urban structures of course make up only a few out of several categories, but for urban planning these very structures are of particular interest.

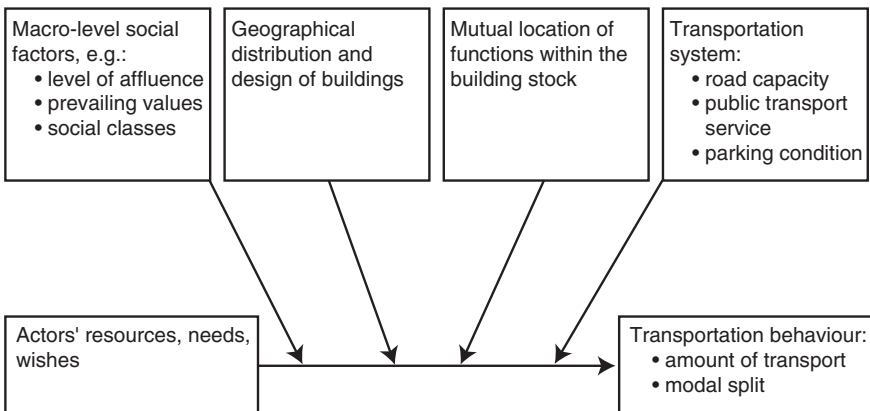


Figure 2.1 Transportation behaviour as a function of land use characteristics as well as individual characteristics of the travellers

Any study of the effects of urban structure on travel behaviour assumes – at least implicitly – that structural conditions have a potential to influence human actions. Ontologically and epistemologically, our study of residential location and travel in Copenhagen Metropolitan Area is based in particular on the philosophy of science position called Critical Realism. Critical realism, as outlined by, among others, Sayer (1992), Danermark *et al.* (2001), Bhaskar (1989) and Archer (2000), offers a platform within philosophy of science which, more than many other such platforms, appears to be relevant for research into the ways in which structural conditions (including land use, patterns of development and transport infrastructure) influence human actions (including travel behaviour). According to critical realism, the world exists independently of our knowledge of it, and this knowledge is both fallible and theory-laden. On the one hand, critical realism conceives social phenomena such as actions, texts and institutions as concept-dependent. On the other hand, these by and large exist regardless of researcher's interpretations of them. Moreover, critical realism distinguishes between three different domains of reality: the empirical (consisting of what we experience directly or indirectly), the actual (where events occur whether or not we experience them) and the real (including both experiences, events and the causal powers producing the events) (Danermark *et al.*, 2001). Part of the reason for our orientation towards critical realism is that it – as distinct from, for example, positivism, hermeneutics or radical social constructivism – allows investigations into the non-universal and non-deterministic, but still politically very important, influences of urban structure on human actions. Thus, in many ways, critical realism appears to offer a viable route between the trenches of philosophy of science, in opposition to naïve empiricism and positivism as well as to postmodern relativism.

The relationship between structures and agents is one of the most contested issues in social theory. According to Archer (2000: 6), some theorists, notably economists, consider social structures as a mere epiphenomenon of the aggregate preferences of instrumentally rational actors. An opposite position, represented by, among others, certain discourse theorists as well as parts of the capital logic tradition, considers all human properties and powers, beyond those stemming from our biological constitution, as derivative from socio-cultural systems. A third position, represented by, among others, Giddens' (1984) structuration theory, claims that structure and agency are mutually constitutive and cannot be untied. This precludes any analysis of how structures and agents influence each other, as the specific properties and powers of neither the structures nor the agents can be identified.

Distinct from these three positions, our studies are based – in line with critical realism – on the assumption that both structures and agents have particular properties and causal powers (Archer, 2000; Sayer, 1992 and 2000; Danermark *et al.*, 2001). Apart from our natural environment, the structures surrounding us are in various ways

'socially constructed'. The 'constructs' may be physical artefacts like buildings or roads, or more immaterial structures like property relations, economic conditions or prevailing belief systems and cultural traditions. Once created, the various types of structures hold emergent powers and properties different from and beyond the aggregate sum of agential powers by which they were created. Not the least, it appears as highly reasonable to assume that *material* structures exert influence on human actions. These structures (e.g. roads, buildings, the natural topography) often have a high permanence, for example, the street network of inner Copenhagen is still characterized by the street pattern established several hundred years ago.

At the same time, the structures are being reproduced, modified and changed by human actions. Such changes most often occur gradually and slowly, but sometimes more dramatically and fast. The purpose of urban planning (as well as the knowledge production informing this planning, among others, the studies dealt with in this book) is precisely to influence these transformation processes in a way that is more favourable for society.

Both in daily life and in science the term 'cause' is used in very different senses, for example about a necessary condition and as a sufficient condition. Immediately, it seems clear that urban structural conditions cannot be attributed the status as a *sufficient* condition for a certain travel behaviour. Obviously, a number of other circumstances will play a part, among others, the wishes and preferences of the traveller, the state of her/his health, obligations of being present at specific places, and access to means of transport. It appears more reasonable to attribute urban structural conditions, such as the location of the residence, the status of *contributory* (partial) causes of travel behaviour, that is as one among several causes included in a causal relationship, but without the ability to produce the effect alone.

As already mentioned, our conception of urban structure as a contributory cause of travel behaviour is to a high extent based on critical realist ontology. According to this position within theory of science, what happens in the world – in nature as well as in society – is a result of causal powers working via a number of mechanisms. Some of the mechanisms may amplify each other while others may neutralize or reduce each other's influences. On the lowest level in Figure 2.2, borrowed from Sayer (1992: 117), we find the causal powers and liabilities (termed by Sayer as 'structures'¹⁴). The latter include, for example, the political and economic structures of society and the material structures, but also the cognitive and physical abilities of individuals. Which causal powers and liabilities are relevant of course depend on which types of events we wish to explain. The causal powers and liabilities have a potential to influence observable phenomena (*events* in critical realist terminology) through a number of *mechanisms*. However, the mechanisms are only activated under certain conditions, dependent on the specific combination of influences from causal powers. Similarly, the events actually occurring (including the

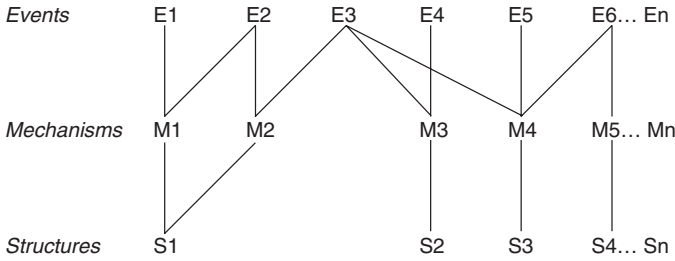


Figure 2.2 Critical Realism on structures, mechanisms and events, based on Sayer (1992: 117)

emerging state of things) depend on the combination of mechanisms at work in the particular situation.

According to critical realist understanding of the concept of causality, causes do not always result in observable phenomena. Causality is not limited to mono-causal relationships. Causes are rather seen as ‘tendencies’ that may or may not be actualized, since other, simultaneously working causal powers may both neutralize, trigger or amplify a causal tendency, and may thus both prevent and induce an event.

This way of thinking matches the multiple cause situation a researcher is facing when trying to explain travel behaviour. It also helps us understand why we can never expect to find the same kind of strong empirical regularities between causes and events in society as in some natural sciences. (For a more thorough account of the ontological and epistemological basis of our research into the relationship between land use and travel, see Næss and Jensen, 2002, and Næss, 2004; see also section 5.7 in this book.)

In his article ‘Causes and conditions’ the Australian philosopher John L. Mackie (1965) introduces the concept of an ‘INUS condition’ (an *insufficient* but *necessary* part of a condition which is itself *unnecessary* but *sufficient* for the result). In our view, the influences of urban structure on travel behaviour could be considered as INUS conditions. For example, a resident of a peripheral residential area may choose to travel several kilometres by car in the morning because this action, according to the person’s opinions, is the best means to realize a wish to reach the workplace at the scheduled hour. Another person, living in the inner-city area, may instead choose to make a short trip by bicycle in order to realize a similar wish. Thus, a common wish – to arrive at the workplace before the beginning of the working day – is realized by completely different means. Which means is the best to realize a wish will depend on the *conditions* under which the wish is to be realized.

Applying the concept of INUS condition to the above example: the long trip by car from the outer-area dwelling to the workplace in the inner-city area is the

outcome, or result, of a number of contributory causes. This trip might have been carried out as a result of conditions other than the actual ones. Therefore, the conditions resulting in this specific trip are *unnecessary*, but *sufficient*. The distance between residence and workplace (*A*) was probably an INUS condition for the commuter's choice to travel a trip of that length by car that morning (*P*). Given the circumstances (*X*), for example

- that she was employed in a company where the working hours started at 8 a.m.
- that the day in question was an ordinary workday
- that staying away from work would cut her wages and, if frequently repeated, would imply a danger of being fired, etc.

then it was a *necessary* and *sufficient* condition for the long trip that morning (*P*) that the distance from home to work (*A*) *either* had to exist in combination with the actual circumstances (*X*), *or* other conditions (*Y*) must be present that could make the person travel this distance at the given point of time.

In a similar way, the short distance between the home and workplace of a person living in the inner-city area was arguably an INUS condition for her choice to ride a short trip by bicycle that morning in order to realize her wish to reach her workplace in time.

Mackie emphasizes that the results of INUS conditions are not only of the type *occurrence or non-occurrence* of an event or a situation. The results of INUS conditions are also of the type where the *magnitude* of an effect is influenced by a partial cause. The same applies to the partial causes, where the causal condition could be that a phenomenon is present to a higher or lower *extent*. The relationships between residential location and travel activity come within this category, termed by Mackie as cases of 'functional dependence' (Mackie, 1965: 260–261).

2.2 FACILITIES, ACTIVITIES AND DESTINATIONS

In this book the term *facility* will often be used about the destinations visited by people. In urban planning terminology this concept refers to the activity possibilities or services, which the inhabitants and visitors of a city use and visit, for example stores, workplaces, public offices, cinemas and parks. *Destinations* are the geographical locations toward which our trips are directed. Destinations are typically the facilities we visit in order to carry out our activities, for example workplace, shop, kindergarten or restaurant.

The so-called activity based approach (Jones, 1990; Fox, 1995; Vilhelmson, 1999) offers a useful conceptual framework for our study. According to this

approach, nearly all travel activity is derived from the need or wish to carry out other, stationary activities. Everyday life is considered as a sequence of activities conducted by individuals at different places during the 24 hours of day and night. Activities are carried out in order to fulfill physiological needs (eating, sleeping), institutional needs (work, education), personal obligations (childcare, shopping) and personal preferences (leisure activities) (Vilhelmson, 1999: 178). During recent years, this view has been challenged by theorists who regard travel in contemporary, late modern society to be increasingly a purpose in itself, rather than an instrument to move from one place to another (Urry, 2000; Steg *et al.*, 2001). This may be true to some extent about holiday and leisure trips, but the activity-based approach is, in this author's opinion, still fruitful in order to understand and analyze daily-life travel behaviour.

The activity and travelling patterns could be considered as the results of planning processes at an individual level. In daily life, this planning is carried out only for a few activities, as many daily activities are routine actions (Vilhelmson, 1994: 35). The fact that many trips are based on routines implies that the persons do not, in their daily praxis reflect on *whether* or *how* they are going to make these trips. Giddens (1979: 56–59, quoted from Røe, 1998) distinguishes between three levels of consciousness for action: practical consciousness ('tacit knowledge', the approximately non-reflexive everyday praxis), discursive consciousness (implying reflection over one's actions), and an unconscious level of actions. Many of our daily-life travel activities are probably carried out through practical consciousness. However, this does not mean that people are never reflective over such trips. Routines have not always been there – they emerge at some time. When a routine is 'born', different alternatives of action are usually considered within a discursive consciousness. Established routines can also be changed. Actions based on practical consciousness can sometimes be reconsidered because of changes in external, structural conditions, or changes in the individual's knowledge, attitudes or preferences, and thus be brought up at a discursive level (Røe, 1998). For example, the travel mode may be reconsidered when starting at a new workplace or school. In some cases even our place of residence may be reconsidered, resulting in a move (e.g. in order to come closer to the workplace). Changes in life phase or family situation may also trigger such a re-evaluation.

Based on Vilhelmson (1999: 181) trips can be classified into four categories, depending on how fixed or flexible they are in time and space. 'Bounded trips' are trips in order to reach activities where both the time and geographical location are fixed and cannot freely be deviated from. Typical examples are journeys to work or school, and trips in order to bring or pick up children at kindergarten or school. 'Non-bounded' trips are trips where the time of the activity is flexible and the location may vary. Many leisure activities belong to this category, for example visiting

friends, jogging and outings. An intermediary group includes trips where the time of the activity is fixed but the location may vary, and trips where the location is fixed but the time may vary. An example of the former is the journeys to work of people working at different places (e.g. service mechanics), while visits to one's parents may be an example of the latter. The 'semi-bounded' trips also include a number of purposes where the destination may vary and the trip frequency is not fixed in any rigid way, but where the trips with the purpose in question must still be made relatively regularly. A typical example is grocery shopping.

According to Vilhelmson (1999: 181) 59 per cent of the trips carried out by the Swedish population aged 20–64 years on weekdays in 1990–1991 could be classified as 'bounded' trips where the spatial as well as the temporal location of the activities were fixed as routines. At the weekends, only 29 per cent belonged to this category. For the week altogether the 'bounded' trips made up 52 per cent.

Urban structures could be expected to influence travel behaviour in a stronger and more direct way for 'bounded' than for 'non-bounded' trips, since some of the destinations of the latter trips, for example recreational forests, or relatives living in other parts of the country, are located outside the urban area. The length of these trips will to a small extent be influenced by the location of the residence relative to the urban facilities. In contrast, the 'bounded' trips are to a much higher extent directed towards destinations reflecting the spatial distribution of facilities within the urban area.

For some facility types, we almost always choose the closest facility, because the various facilities are more or less equal (e.g. post offices) or have regulated catchment areas (e.g. social security offices). But for other facilities, quality differences or symbolic differences within each facility category may make people travel beyond the closest facility to a more attractive one. For example, having a cinema in the local neighbourhood doesn't help much if you are interested in Lars von Trier films and the local cinema 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 features other than proximity are also important when choosing among facilities.

Moreover, even for the group of facilities where quality differences or symbolic differences are insignificant, the distance from the dwelling is not necessarily the most important criterion influencing people's choices among facilities. Because of the possibility of linking different trip purposes, a facility located close to a destination already visited may be preferred. For example, if you need to visit the workplace each weekday, it may be more convenient to use a post office close to the workplace than the one located closest to the residence.

A person's radius of action during a given period depends on, among others, the speeds by which the person can travel through space. A person who has a car

at his/her disposal may reach a higher number of destinations during the day than a person who is left to use non-motorized modes of transport. Yet, the spatial reach of a person is not determined by travel speeds alone, but also by the time available for travelling (economic costs and inconvenience caused by travelling are additional). Torsten Hägerstrand (1970) has developed the so-called time–geographical approach as a method for understanding human activity patterns. Hägerstrand distinguishes between three types of restrictions: capability constraints, coupling constraints and authority/steering constraints. Capability constraints include limitations due to the individuals' biological properties or the ability of the tools they have at their disposal, e.g. the speeds of the various means of transport. In our context the speeds of the various means of transport (1970: 18–19) are of particular interest, cf. above. Coupling constraints are regulations requiring individuals, instruments, materials and signs to be coupled together into cooperating groups. (Cf. also Urry's (2003) concept compulsion of co-presence.) The necessity of being present at a workplace is a typical example of a coupling constraint (Hägerstrand, 1970: 21–22). The concept of authority/steering constraints includes spatial restrictions as to who is entitled to move through or stay in different places, as well as temporal restrictions, for example the length of the working hours and their location in time. The authority/steering constraints also include, among others, the layout and time schedule of public transport (1970: 25–27).

Together the different types of restrictions imply a considerable limitation on people's use of time and the spatial distribution of their activities. In particular, this is the case for workforce participants and pupils on workdays and schooldays. The scope for 'free' activities on weekdays far away from home is thus limited, in particular for those who do not have a private motor vehicle at their disposal. This limitation implies that the 'bounded trips' could be expected to account for a relatively high proportion of the amount of travel on weekdays among these population groups. The distance travelled on weekdays will then be quite closely related to the distances from the dwelling to the destinations of the fixed activities, in particular workplace or place of education. On the other hand, among car owners, the time possibly saved when living close to these destinations could be utilized by making more 'non-bounded' trips, thus outweighing some of the travel-reducing effects of proximity.

For part-time workers or non-participants of the workforce, the time–geographical restrictions will often be less tight. (The same applies to students, who often determine themselves how often and when to be present at the place of education.) Yet often, people with reduced obligations in connection with wage labour have other commitments, for example child care, including regular bringing and picking up children at kindergarten or school. In practice, such obligations may imply a considerable limitation of the scope for 'non-bounded' activities away from home.

At weekends, most Danes are less constrained by time–geographical restrictions than on weekdays. The amount of travel at the weekend could therefore be expected to be related less closely to the distance from the dwelling to a few, limited destinations. Regular leisure activities may yet imply that travel behaviour at the weekend too is considerably constrained by time–geographical restrictions. According to Tillberg (2001), there is a wide-spread social norm in contemporary Scandinavian society, according to which it is good for the personal development of children to participate in (many) organized leisure activities, for example sports clubs, bands, scouts, etc. As a result, a large proportion of the leisure time of many parents is consumed transporting children to and from leisure activities, both on weekdays and at weekends. Precisely because many other time–geographical restrictions are less tight at the weekend, many organized leisure activities take place on Saturday and/or Sunday, in particular activities involving trips to locations outside the local district (e.g. visits to summer cottages or sports meetings).

In a time–geographical perspective the location of the residence will arguably influence people's need to own private motor vehicles. If you live far away from the destinations of the 'bounded' trips and are compelled to walk, cycle or go by public transit, these trips will consume a high proportion of the time budget. The time allocated to the necessary travel in daily life may then easily replace other, desired activities such as being with the children, organized leisure activities or full-time workforce participation. By acquiring a car (or a second car) a higher speed of travel is obtained, leaving more time for other daily-life activities.

2.3 CENTRE STRUCTURES AND ACCESSIBILITY TO FACILITIES

As mentioned in the introduction, the shorter travelling distances and lower proportion of car travel among inner-city dwellers found in many empirical studies have in particular been explained by the high concentration of workplaces, shops and other facilities traditionally found in the historical urban centres. There are several reasons for this concentration. The German geographer Walter Christaller's Central Place Theory (1933/1966) offers one of the explanations. This theory has had a considerable influence on urban and regional planning in a number of countries (Berry and Parr, 1988), including Denmark.

The size of the population base necessary for retail and services to run profitably varies between different types of services and commodities. A generalist doctor does not need as large a population base as a brain surgeon, since the proportion of the population treated by an ordinary physician during a year is far higher than the fraction that have their brains operated on. Functions like retail, health services, education,

cultural activities, entertainment, etc. may therefore be graded according to the size of the geographical area usually covered by each facility. The different sizes of catchment areas form the basis for the development of a hierarchy of centres. The largest centres include both highly specialized functions and functions requiring a smaller population base, whereas the lower-level centres include only those types of functions that can survive with a small population base (Christaller, 1933/1966: 49–70; Johnsen, 1970: 125; Brown, 1995).

Figure 2.3 shows the main ideas of Christaller's Central Place Theory. While Christaller's original theory dealt with the geographical distribution of cities within a larger region, Berry and Garrison (1958a, 1958b, quoted from Brown, 1995) developed the theory further, applying central place principles to the internal spatial organization of cities. In cities, in particular the larger ones, there are usually several local centres in addition to the central business district, but these centres (ranging from street corner convenience cluster, neighbourhood shopping centre, community shopping centre, and regional shopping centre), typically offer a less varied provision of workplaces, shops and other service facilities than the historical urban core.

Within a city, the historical urban core will often approximate the geographical point of gravity of the city's stock of dwellings. This implies that stores will obtain the largest population base within a given distance by locating in the middle of the city (see, among others, Nielsen, 2002). Besides, the geographical point of gravity of the suburban workplaces and service facilities is also often situated not far from the inner-city area. The inner city is also usually the major node for the public transport

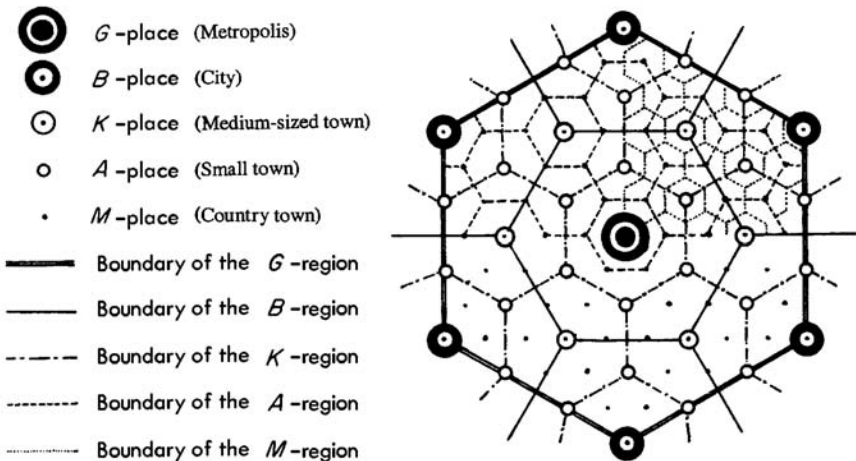


Figure 2.3 Christaller's scheme of marketing regions in a system of central places (Source: Christaller (1933/1966: 66) Explanations added by the author of the present book.)

lines. Trips from a residence in one suburb to a random destination in another suburb will thus often on average be longer, the further away from the centre the residence is located (Nielsen, 2000).

For many types of businesses, a location in the largest city of the region may offer so-called agglomeration benefits (Vatne, 1993). The advantages of being located close to other businesses in the same branch include the cost reductions of utilizing each other's competencies, as well as more qualitative relations in the form of informal contact between the companies. For an office business, for example, where the employees go to frequent meetings with public authorities or private consultancies, proximity to these agencies and services will be advantageous. Large cities are also often nodes in national and international public transport networks (railway lines, flights, express buses). The central parts of large cities are also usually well served by local/regional public transport. Businesses in the region centre thus have better opportunities for contact to local as well as non-local partners.

Employees of the workplaces in the urban core contribute to increasing the customer base of central-city stores, insofar as they do shopping in the lunch break or on the way home from work. The concentration of facilities in the inner-city area also increases the possibility for visitors of carrying out several errands within a small geographic area, which in itself increases the competitiveness of the urban core as a location for retail and other services (Christaller, 1933/1966: 43, 105).

However, the residents of a city do not visit the inner-city area only for functional reasons. The city centre is also the arena of a host of recreational and entertainment activities evolving around what Pløger (2002: 246–247) calls 'the Dionysian⁵ urban life'. According to Pløger (2002: 129), modern city dwellers increasingly emphasize the ethnic and multicultural qualities typical for the inner-city (notably restaurants, cafés, and stores), along with the 'traditional' urban qualities such as cultural facilities and a multitude of recreational opportunities. In many cities, the inner-city area thus has an attractive 'atmosphere'. Frequently, the inner-city area is the part of the city visited by the highest number of tourists, among others because it usually includes a higher presence of historical buildings, and because the city centre may be an important point of orientation and have a symbolic meaning (Albertsen, 1999; Rypkema, 2003). The customer base made up by tourists adds to the benefit for shopkeepers and other service providers of being located in the urban core. This is the location where many cultural and entertainment activities take place, both in cinemas, concert halls, in parks and on the streets. Pavement restaurants also add life to the inner-city area.

As mentioned above, cities (at least those above a certain size) usually have several lower-order centres in addition to their main centre. These centres are often located at nodes in the urban transportation system, and the areas close to such centres are often more densely built than the urban districts in-between. In urban

areas, there is a mutual interdependence between density and centrality: land values are often higher in central areas, thus making up an incitement for more intensive utilization of building sites. At the same time, a higher density of residences or workplaces in the local area increases the population base for various types of local service facilities (Christaller, 1933/1966: 45, 53).

At a macro level, the inner parts of a city are usually more densely developed than its outer parts. 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). This implies that 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. Due to the influence of local density on the provision of local service facilities (cf. above), the average distance from residences to local service will normally also be shorter in the inner districts of a city than in the outer suburbs.

Seen together, the above-mentioned conditions imply that the inner and central parts of a metropolitan area usually include the largest supply of work opportunities, the broadest range of commodities in the shops, as well as the highest diversity of service facilities. In particular, this applies to public offices, various consultants, cultural facilities, restaurants, entertainment and specialized shops. For residents in the inner and central parts of the city the distances to this concentration of facilities will be short. Inner-city residents could thus be expected on average to make shorter daily trips than their outer-area counterparts both to local and more specialized facilities.

For most people, the use of non-motorized modes of transport is highly sensitive to trip lengths (Vejdirektoratet, 1999). Therefore, the proportion of non-motorized travel could be expected to be higher among people who live close to the city centre and/or local centres, since the number of potential trip destinations accessible within a short distance is higher than in districts located further away from such centres. In particular, a higher proportion of non-motorized travel could be expected among dwellers of the inner-city, where the availability of job opportunities within walking or biking distances is higher while congested streets and scarce parking opportunities make up a deterrent against travelling by car for short trips.

Some debaters also draw attention to the fact that inner-city districts are often characterized by grid-shaped street patterns providing higher local-scale connectivity. In particular, this has been emphasized by American researchers. Compared to the curvilinear streets with frequent cul-de-sacs typical of many suburban areas, the inner-city street patterns often imply more direct travel routes, thus contributing to reduce local travel distances and enhancing non-motorized modes (Cervero, 2003).

Distinct from the distance travelled, there is little reason to believe that the use of public transport will be significantly higher among inner-city residents than the

average among those living in the outer areas. Of course, the provision of public transport services is likely to be higher in the central area, which is the main node of the public transport network in most cities. But because so many of the destinations of inner-city dwellers are within walking or biking distance, non-motorized transport will often be faster than going by transit. For short distances, the time it takes to walk to and from the transit stops and waiting for the bus or train to appear will often be long, compared to the time saved during the transit ride itself by choosing public instead of non-motorized transport. Public transport also lacks the flexibility characterizing both the car and the non-motorized modes of transport. In particular in areas with a low frequency of departures, the 'hidden waiting time' resulting from the need to adapt the times of departure and arrival to the route timetable reduces the attractiveness of the public transport mode.

A WEAKENED ROLE FOR CITY CENTRES?

Admittedly, in many cities the historical urban core has lost some of its dominant position. In America, a pronounced weakening of the Central Business Districts has taken place at least since World War II (Allpass *et al.*, 1968). In Europe, a similar, but less dramatic development has occurred, mainly during the recent 30 or 40 years (Sieverts, 1999; Omland, 2002; Hansen, 2003). Partly, the reduced role of the inner city is a result of urban planning strategies aiming to reduce the pressure against the historical cores by establishing extra-urban relief centres (Kjærdsdam, 1995: 128–133), but tendencies in the property market have also moved development outwards. Due to higher mobility and car ownership rates, the demand for workplace and service locations close to slip roads in the outer areas has increased, in particular in the USA, where the phenomenon of 'edge cities' was first described (Garreau, 1991; Knox, 1994: 138–139). This tendency is evident in Europe too (Dasgupta, 1994; UN/ECE, 1998).

The mobility changes during the more than 70 years that have passed since Christaller published his central place theory imply a general increase in the geographical catchment areas of most facilities and services. Moreover, as a consequence of mass car ownership and highway development, locations close to motorways may sometimes have a more 'central' location, measured in travel time by car, than the historical urban cores (*cf.* above). Current urban centre structures thus differ considerably from the ones described by Christaller on the basis of his studies in Southern Germany in the 1920s and early 1930s. Yet, in spite of considerable criticism raised against central place theory,⁶ in particular in the 1970s and 1980s, it is today widely accepted as a partial explanation of centre formations (Sayer, 1992: 217; Brown, 1995).

Most European cities still have a higher concentration of workplaces, retail, public agencies, cultural events and leisure facilities in the historical urban centre

and its immediate surroundings than in the peripheral parts of the urban area (cf., among others, Newman and Kenworthy, 1999: 94–95). This also applies to the Copenhagen Metropolitan Area (cf. Chapter 3). Being the capital of Denmark, Copenhagen has a number of functions and facilities not available in the centres at a provincial or regional level. Besides, the Copenhagen Metropolitan Area is the Danish region with the largest population, a fact implying that the regional centre facilities will be more extensive in Copenhagen than in the other Danish regional centres. Altogether this contributes to quite a strong concentration of retail, service functions and public agencies in the central parts of Copenhagen.

In America, the role of the inner-city area is often weaker than in European cities, in particular in the southern and western 'sun belt'. However, a lot of urban facilities are not directed primarily towards customers or users arriving by car. Among those using public or non-motorized means of transport the urban centre will still be the location that can be reached most easily by the highest number of persons.

The present concentration of workplaces and service facilities in city centres is partially a result of the location preferences of previous periods. Apart from raw material processing factories, enterprises and institutions established 100 or 200 years ago were to a higher extent than today compelled to choose a central location, because they would otherwise be too difficult to access for the population groups making up the market of their products or services, or from which employees could be recruited. Moreover, a couple of hundred years ago, the geographical extent of most Scandinavian cities was hardly any more than what today makes up the inner-city area. This can in itself explain why the urban core often has a concentration of historical buildings and institutions. In many cases, important symbolic value is attached to these buildings. This has probably worked as an incentive for the enterprises and institutions residing in these buildings to stay in their premises rather than moving to other locations.

The established, material structures thus represent an inertia tending to sustain the importance of the inner city, also in the present situation where mass automobility has reduced the need to locate workplaces and services at locations easily accessible by public or non-motorized modes of transport.

2.4 COMPENSATORY MECHANISMS?

Although the location of the residence influences the distances to different types of facilities, and the spatial location of most of these facilities suggests that average travel distances will be shortest among inner-city residents, this pattern might be counteracted by certain *compensatory mechanisms*. For example, high accessibility may create increased demands. A high accessibility may be utilized by opting

between a wider range of jobs, shops and leisure activities, rather than reducing the amount of transport.

Several authors have pointed to the fact that trip frequencies may increase if the distances to the relevant destinations are short (e.g. Crane, 1996). Conversely, if the distance from the residence to the facilities is very long, many people will find it too time-consuming, cumbersome and expensive to visit these locations regularly. Therefore, there will be 'distance decay' in the attractiveness of a large centre (Maddison *et al.*, 1996). The range of attraction will vary with the type of facility (cf. above). Beyond that range, most people will orient themselves to smaller, more local centres, even if the job opportunities and selection of service facilities are narrower than in the big city. This might form a basis for the development of more local lifestyles and activity patterns among people living in the peripheral parts of a region. The phenomenon of distance decay may thus act as a compensatory mechanism, tending to reduce some of the differences between residents of outer and inner parts of the urban region in overall travelling distances. For example, because the distances to a number of leisure facilities are shorter from dwellings in the inner city, residents of the central districts could be expected to use such facilities more frequently than their outer-area counterparts (Crane, 1996). However, this increased trip frequency could hardly be expected to balance the difference in trip distances to these facilities.

Seen in a wider perspective of energy use and greenhouse gas emissions, an important question arising is whether a modest extent of local transportation will result in extended transportation in other places (in terms of longer as well as more frequent trips), as long as the total purchasing power does not change. Is it so that, given a certain level of income, the sum of 'environmental vices' is constant, and that households managing on a small everyday amount of transportation, create even heavier environmental strain through for instance weekend trips to a cottage or long-distance holiday trips by plane? This question will be addressed in Chapter 10.

Moreover, the urban structural characteristics of residential areas could be imagined to influence people's social pattern of contact (see, e.g., Putnam, 2000: 204–215 about the possible negative impacts of urban sprawl on the social ties between people). Apart from the consequences this might have for people's well-being, such an effect might also influence the amount of travel indirectly, for example if more locally based circles of acquaintances in certain areas reduce the number of visits to friends in other districts of the city.

2.5 LIFESTYLE AND TRAVEL

As mentioned above, people's daily-life transport activity depends not only on the location of the residence relative to various facilities. The destinations we choose or

need to visit depend to a high extent on our individual resources, obligations and interests within a number of fields. Also the travel modes of course depend on a number of individual characteristics of the travellers, and not only by urban structural features. Age, gender, economy, household composition, and workforce participation may influence both people's radius of action in daily life and their choices of transport modes. The possibility as well as the need for car ownership is also unevenly distributed among the population.

In addition to the above-mentioned socio-economic factors, people may have various *attitudes* towards different travel modes and destinations. These attitudes may result from different importance being attached to factors like travel speed, comfort and flexibility, as well as the symbolic image attached to various means of transportation or districts of the city. The individual characteristics influencing how people attach different importance to such aspects of travelling, are often referred to as 'lifestyle factors' (see closer discussion below). Such factors may influence people's choice of facility within a number of facility categories, especially regarding leisure journeys, but also for example regarding shopping trips. Choices of travel modes and travel destinations are examples of situations where individuals may seek to indicate their belonging to a certain status group, or to signal their own individuality. Some individuals may also act as 'political consumers' (Lassen, 2002) within the field of transport, seeking to promote certain values through their choices of transport activities, e.g. the protection of nature and the environment (Tanner, 1999).

The term *lifestyle* is generally used in order to describe various social and cultural aspects regarding the ways people lead their lives (Berge and Nondal, 1994). In classical sociological theory, the lifestyle concept is connected to consumption in a wide sense (Veblen, 1899/1976; Weber, 1922/1971). The theories on lifestyle have been developed further by Bourdieu (1984), who regards lifestyle as a set of dispositions for actions, based on a taste code determined by the symbolic and cultural capital of each individual. These are, to a large extent, a result of hereditary dispositions (class affiliation), deciding the footing of the individual and making probable certain action patterns or sets of dispositions (*habitus*). Giddens (1991) defines lifestyle as a more or less integrated set of practices maintained by an individual.

In our context it is, however, necessary to narrow down the lifestyle concept to something relevant to and possible to deal with in relation to the research questions of the study. Vilhelmson (1994: 32) offers a conceptual model matching the activity-based approach to transport studies (cf. section 2.2). This lifestyle concept takes the individual agent as its point of origin, but does not regard the individual in isolation from his or her social and physical context. Along the first of its two dimensions, Vilhelmson's model spans from the conditions for the actions of individuals to their actual actions. The second dimension spans from the internal properties of the

individuals to the outer conditions. The lifestyle is characterized as the interplay between individual motivations (needs, values, preferences, etc.), individual resources and the structure of the surroundings, combined with the actual actions carried out by the individual. Transport activity is itself a part of these actions and is thus included in Vilhelmson's lifestyle concept. Since our aim is to find the causes of these very actions, it is problematic to include the same actions in the lifestyle concept used – together with other factors of influence – in order to explain travel behaviour. This necessitates a further narrowing of the lifestyle features used as explanatory factors in our analyses. Apart from a number of socio-economic and demographic characteristics, the lifestyle features included in our analyses will be limited to a number of attitudinal and preference variables, along with some information concerning the adolescence of the respondents/interviewees (cf. Bourdieu's concept of *habitus*). The attitudes and preferences focused on are attitudes to means of transport and transport policy issues, attitudes to environmental issues, and preferences for leisure activities.

2.6 A BEHAVIOURAL MODEL

Table 2.1 provides an overview of some of the key concepts used in the previous sections. Based on the theoretical considerations of these sections, Figure 2.4 shows a simplified behavioural model of the ways in which individual, urban structural and other social conditions are assumed to influence daily-life travelling distances through accessibility to facilities, rationales for activity participation and location of activities, frequencies of activity participation and actual location of activities.⁷ The location of the residence relative to various centres and facilities, combined with the transport infrastructure on the relevant stretches, determines how accessible these centres and facilities are from the dwelling. Accessibility will be higher the lower is the *friction of distance* (section 2.1), where the latter is a function of the time consumption, economic expenses and inconvenience involved when travelling from one place to another. Other things being equal, the accessibility will of course be highest for the closest facilities. However, what is the easiest accessible location varies with travel modes, depending on, among others, the layout of the public transport network, the driving conditions along the road network, and the conditions for walking and biking.

The residents' individual resources, motives and social environments influence their rationales for activity participation (including their trade-off between motivation for participation and friction of distance) and location of activities (notably their balancing between proximity and choice). Combined with the accessibility of various facilities, these rationales influence the frequency of activity participation as well as

Table 2.1 Overview of some of the key concepts used in this chapter

<i>Concept</i>	<i>The meaning of the term as used in this book</i>
structures	Sets of internally related objects and practices
causal power	Properties (of human individuals, society or nature) that can trigger, enforce or counteract events, usually in combination with other causal powers
INUS condition	A contributory (partial) cause of an event, defined as an <i>insufficient</i> but <i>necessary</i> part of a condition which is itself <i>unnecessary</i> but <i>sufficient</i> for the result
facility	Activity possibility or service, which the inhabitants and visitors of an area can use and visit
activities	Doings carried out by individuals at different places in order to fulfil physiological needs, institutional needs, personal obligations or personal preferences
bounded trips	Trips in order to reach activities where – due to preceding long- or medium-term decisions and commitments – both the time and geographical location are fixed and cannot freely be deviated from
time–geographical constraints	Capability constraints, coupling constraints and authority/steering constraints making limitations on people's use of time and the spatial distribution of their activities
centre hierarchy	Centres can be ranked into higher-order and lower-order centres, where higher-order centres contain more specialized and a broader range of services than lower-order centres
friction of distance	The impediment which occurs because places, objects or people are spatially separate: movement involves a cost
accessibility	The ease by which a given location can be reached, depending on its proximity, the transport infrastructure leading to it, and the visitors' individual mobility resources
distance decay	The tendency for the use of a service or facility to decrease with the distance from its location
mobility	The <i>potential</i> of movement as well as the volume of <i>actual</i> movements of persons and goods. In our use, the concept is limited to physical movement in the form of transport
amount of travel	The aggregate movement of an individual or a group of persons within a given period, measured in passenger kilometres
modal split	The distribution of the amount of travel of a given individual or population between different modes of travel
lifestyle	The interplay between individual motivations, individual resources and the structure of the surroundings, combined with the actual actions carried out by the individual
compensatory travel	Additional 'non-bounded' trips (in particular leisure trips) made possible due to time and money saved when distances to daily destinations are short, as well as leisure trips made in order to compensate for deficits in residential environments where distances to the destinations of 'bounded trips' are usually short

the actual locations chosen for the various activities. The total distance travelled is a consequence of the geographical locations chosen for the activities in which the resident participates, the distance along the transport infrastructure network from the residence to these locations, and the frequencies at which the various activities are carried out.⁸

There are also mutual influences between the urban structural situation of the dwelling (location relative to various centres and facilities, and local transport infrastructure) and the individual and household characteristics. The possibility of an over-representation in certain geographical locations of respondents with a priori socio-economic characteristics and attitudes predisposing them for a certain type of travel behaviour (e.g. a preference for local facilities and travelling by bike) necessitates multivariate control for such characteristics in order to assess the influences of urban structural variables.⁹ On the other hand, certain socio-economic characteristics and attitudes (e.g. car ownership and transport attitudes) may themselves be influenced by the urban structural situation of the dwelling. This implies that urban structure, in addition to its direct effects, may influence activity participation and travel behaviour indirectly via car ownership, transport attitudes and some other variables.

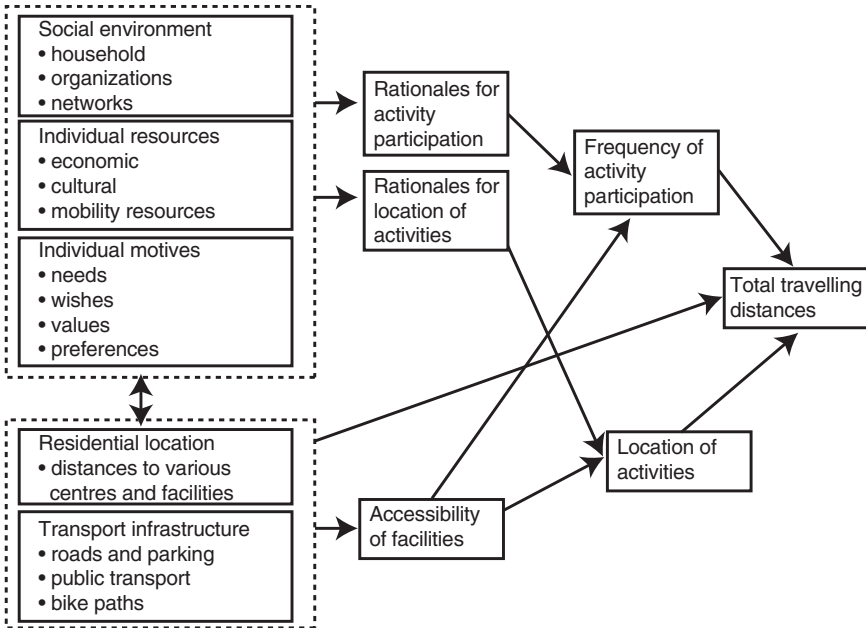


Figure 2.4 Behavioural model showing the assumed links between urban structural, individual and social conditions, accessibility to facilities, rationales for activity participation and location of activities, actual activity participation and location of activities, and total travelling distances

Due to their wide radius of action and their specialized work qualifications, the most mobile and educated parts of the population are likely to emphasize choice rather than proximity. The amount of travel will then be 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. Thus, among people who emphasize the opportunity of choosing among several work opportunities, shops and recreational facilities, people living close to the central parts of the city centre region could be expected to travel less than those who live in more remote parts of the region. In particular, this could be expected to be the case among two-income households, since it is more difficult for couples than for single breadwinners to combine peripheral residences with suitable local jobs for both spouses. Among persons less tied to the concentration of facilities found in the largest centres, notably non-participants of the workforce, the location of the residence relative to local centres may still be more important.

2.7 THE NEED FOR EMPIRICAL INQUIRY

Although theories of transport geography suggest that the location of residences relative to the central structure of an urban region may exert an important influence on travel patterns, it is not possible from theoretical considerations alone to conclude with certainty about the nature of this relationship. Many different mechanisms are at work, and it is not possible a priori to state what their net result will be. For example, how strong and common are the possible compensatory mechanisms, compared to the mechanisms contributing to a higher amount of travel among outer-area residents? And what does proximity to local centres mean to travel patterns, compared to the distance from the dwelling to the central business district?

Traditionally, urban planners and architects have tended to look at the physical surroundings as the crucial conditions determining residents' well-being and activity possibilities. Within the physically oriented urban planning tradition, this 'architectural deterministic' view (see, e.g. Chermayeff, 1982) has led planners to neglect the importance of socio-economic and lifestyle properties of those who live in and use the physical structures. On the other hand, within influential parts of social science, in particular research based on sociological or economic theories, there has been a tradition for denial of the importance of the physical/spatial surroundings to human behaviour (see Dunlap and Catton, 1983, for a discussion). The different disciplinary traditions are therefore likely to offer 'incompatible' answers to the questions of whether, how and to what extent the physical and spatial structures of cities influence the travel patterns of the inhabitants. Theoretical analyses alone are

therefore unable to answer our research questions in a satisfactory way. In order to 'shift sun and wind' between the various hypotheses derived from different theoretical perspectives, empirical inquiry is necessary.

Previous investigations in a number of cities have shown that those living in the outer parts travel considerably longer by motorized means of transportation, compared to the residents of inner and central parts of the city. The same main pattern has been found in cities as different as Paris (Mogridge, 1985; Fouchier, 1998), London (Mogridge, 1985), New York and Melbourne (Newman and Kenworthy, 1989), San Francisco (Schipper *et al.*, 1994), the Danish cities of Aalborg (Nielsen, 2002) and Frederikshavn (Næss and Jensen, 2004), as well as the Norwegian cities of Greater Oslo (Næss *et al.*, 1995; Røe, 1998), Bergen (Duun, 1994) and Trondheim (Synnes, 1990). A previous study of Greater Copenhagen (Hartoft-Nielsen, 2001) has also identified a clear correlation between the amount of travel and the distance between the residence and the inner-city area.

In spite of this evidence, it is still common among debaters on sustainability and urban form to question whether density and other urban structural factors really have any influence worth mentioning on transportation's energy use and emissions (cf. Chapter 1). Many of the early empirical studies demonstrating correlations between urban structure and travel behaviour have been criticized for not taking into consideration socio-economic factors and/or disregarding the influence of the travellers' 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 socio-economic variables in the analyses (e.g. Næss *et al.*, 1995), and in a few studies also indicators of the travellers' attitudes and lifestyles (e.g. Kitamura *et al.*, 1997; Røe, 2001; Næss and Jensen, 2004). 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 behaviour (Handy, 1996; Røe, 1998).

Earlier studies have also been criticized for ignoring possible differences among population groups in the way urban structure affects their travel. Moreover, some observers claim that in an era where leisure trips appear to replace trips to the fixed activities of daily life as the most important travel purposes, the proximity or distance between the different facilities of an urban area is no longer important to the amount of travel.

The above-mentioned doubts and points of criticism have also influenced the opinions among urban planners and policy-makers. It has been common to say that we know too little about the links between urban form and travel to base urban

developmental policies on such uncertain relationships. A relatively recently published book on sustainable urban development (Frey, 1999) concludes that no unambiguous data exist to indicate whether a compact or a more spread-out urban structure contributes to a higher or lower energy consumption. Similarly, the editors of an anthology on sustainable urban form (Williams *et al.*, 2000) write as follows in the concluding chapter:

Simmonds and Coombe found that a strategy of compaction from the Bristol area would have only a minor effect on traffic. There are a number of reasons for this, including ... the fact that proximity to a desired facility is only a weak indicator of people's choice of travel mode. ... Most authors assert that people will make more trips on foot or by bicycle, yet other research evidence counters this.

The findings ... that socio-economic characteristics may explain more of the differentiation in travel distances than land uses do, also reveals much about the different policy options in reducing car travel.

(Williams *et al.*, 2000: 'Achieving sustainable urban form: conclusions')

Frequently, however, such conclusions stem from model simulations where the results may simply reflect that the assumptions of the model do not capture the actual influence of the urban structure on travel behaviour (see, e.g., Dasgupta, 1994; Simmonds and Coombe, 2000). In other cases, the lack of relationship between urban form and transport is the outcome of studies not including the variables that, from theoretical considerations, could be expected to exert the strongest influence on each other. For example, some studies have focused on trip frequency (among others, Kitamura *et al.*, 1997; Boarnet and Sarmiento, 1998) or travel time (Gordon and Richardson, 1997; Snellen *et al.*, 1998) as transportation activity variables, without investigating the influence of urban structure on travel distances or modal split. In some other studies, including Breheny (1995), conclusions are made about an absent or insignificant relationship between urban structure and travel, based on a comparison of travel survey data from cities of varying population size. However, the number of inhabitants is hardly a good indicator in order to test whether urban structure affects travel behaviour.

In America, research into land use and transport relationships during recent years has in particular been directed towards the influence of local-scale urban structural conditions on travel behaviour, comparing traditional suburban residential areas with areas developed according to the so-called 'New Urbanism' or 'Transit Oriented Development' principles (Cervero, 2003; Krizek, 2003). However, the location of the residential areas in relation to the central structure of the urban region does not seem to be given much attention in these studies.¹⁰ Moreover, distinct from the European

literature on the topic, several American papers on land use and travel are concerned about the so-called 'self selection problem'. According to some authors (e.g. Kitamura *et al.*, 1997; Boarnet and Crane, 2001; Krizek, 2003), the possibility that people choose their residence based on their preference for a particular travel mode precludes any firm conclusions about the influence of residential location on travel.

The aim of the present study has been to dig a couple of yards deeper than has been done in previous studies of the relationship between urban land use and travel, taking into consideration a larger number of alternative explanatory factors and making stronger efforts to identify causal mechanisms through which residential location affects travel. In the next chapter, the methods of the Copenhagen area study will be described.

CHAPTER 3

THE CASE OF COPENHAGEN METROPOLITAN AREA – CONTEXT AND RESEARCH METHODS

3.1 RESEARCH QUESTIONS

With the theoretical considerations outlined in the previous chapter as a background, the study in the Copenhagen Metropolitan Area has focused on the following research questions, of which the first could be characterized as the main one and the four next as secondary questions:

- Which relationships exist between the location of the residence within the urban structure and travel behaviour (amount of transport and modal split), when taking into consideration demographic, socio-economic as well as attitudinal factors?
- Does the location of the residence within the urban structure influence the range and frequency of activities in which people engage?
- On which rationales do people base their choices of activity locations and travel modes?
- Are the relationships between residential location and travel behaviour different among different subgroups of the population?
- Is the effect of a residential situation where the need for everyday transportation is low, offset by a tendency to compensate for this by making more frequent and long trips during holidays and weekends?

3.2 LINKING RESEARCH QUESTIONS WITH DATA

In principle, both time-series investigations (comparison of the same persons' travel behaviour before and after moving from one residential address to a different one) and cross-sectional studies (comparison of travel activity among different residents living in different geographical areas) are possible strategies in order to elucidate these issues empirically. In practice, recruiting participants of time-series investigations within this field has proved difficult, in particular due to the problems of identifying the participants and registering their travel behaviour *before* they move from the old to the new residence. Through retrospective questions it is still possible to obtain some information about possible changes in travel behaviour and activity patterns after moving from one residential location to another.

Table 3.1 Research questions, information required and data sources

<i>Research questions</i>	<i>Types of information required</i>	<i>Methods/sources for acquiring the information</i>
Which relationships exist between the location of the residence within the urban structure and travel behaviour (amount of transport and modal split), when taking into consideration demographic, socio-economic as well as attitudinal factors?	<ul style="list-style-type: none"> • The location of the residence and its distances from various facilities • The residents' travel activity during a period • Socio-economic characteristics of the residents and their attitudes to relevant issues • Travel behaviour before moving to the present dwelling • Subjective opinions about needs of transport and car dependency 	<ul style="list-style-type: none"> • Studies of and measurements on maps/GIS data • Municipal statistical data • Address directories • Technical visits • Questionnaire questions about the residents' travel and the distances travelled by their vehicles, and any changes in the amount of travel after moving • Questionnaire questions about socio-economic and demographic characteristics of the residents, and transport attitudes, environmental attitudes and leisure interests • Qualitative interviews including questions about motives for choices of trip destinations and modal choices, and retrospective and hypothetical questions about travel behaviour in a different residential situation
Does the location of the residence within the urban structure influence the range and frequency of activities in which people engage?	<ul style="list-style-type: none"> • The activities in which the residents engage, their location, and possible changes compared to previous residential location and/or life situation 	<ul style="list-style-type: none"> • Questions in questionnaires and qualitative interviews about activities, their location, and the meaning attached to different places in the city by the residents. Retrospective and hypothetical questions about activity patterns in a different residential situation
On which rationales do people base their choices of activity locations and travel modes?	<ul style="list-style-type: none"> • Location of activities, use of different modes of transport, and the considerations behind these choices 	<ul style="list-style-type: none"> • Qualitative interviews including questions about destinations and travel modes, and the motivations for these choices
Are the relationships between residential location and travel behaviour different among different subgroups of the population?	<ul style="list-style-type: none"> • The information required for the above-mentioned questions 	<ul style="list-style-type: none"> • The data sources of the above-mentioned questions

Table 3.1 (Continued)

<i>Research questions</i>	<i>Types of information required</i>	<i>Methods/sources for acquiring the information</i>
Is the effect of a residential situation where the need for everyday transportation is low, offset by a tendency to compensate for this by making more frequent and long trips during holidays and weekends?	<ul style="list-style-type: none"> • The information required for the above-mentioned questions, plus • Holiday and weekend trips 	<ul style="list-style-type: none"> • Questionnaire questions about flights and trips outside Zealand (the island on which Copenhagen is located) • Questions in qualitative interviews about holiday and leisure trips, based on the present residential situation • Retrospective and hypothetical questions in qualitative interviews about holiday and leisure trips in a different residential situation

Table 3.1 provides an overview of the types of information considered necessary in order to answer each of the research questions of our study. The table also shows the data sources used in order to acquire the desired information. In addition to trying to uncover whether, and to what extent, urban structural conditions influence travel behaviour, a main purpose of our study was to gain more detailed comprehension of *how* and *why* such influences occur: which are the *mechanisms* through which residential location influences transportation? Quantitative surveys can only to a limited extent contribute to such comprehension. In order to uncover *how* and *why* urban structural conditions influence the inhabitants' travel, qualitative research methods were necessary. In particular, qualitative interviews were required to enable us to answer the questions concerning the residents' motivations and purposes for their ways of relating to their physical surroundings, notably the question about rationales for activity location and modal choice. Also for the other four research questions, qualitative interviews could contribute with deepening and more complex information than what is possible to obtain through quantitative questionnaire surveys.

However, the qualitative approach does not remove the need for quantitative analyses. Besides identifying the various causal powers and liabilities that activate the mechanisms leading to certain events, such as transport activity, there was a need for knowledge about the form of combination and proportions of causal powers and mechanisms typical for these processes. While the empirical identification of mechanisms affecting travel behaviour at the level of the individual could best be made by means of qualitative interviews, statistical analyses were needed in order to identify empirically the effects of urban structure on aggregate level travel patterns. Among the various mechanisms involved, some of which amplifying each other and

some counteracting each other's effects, we expected some mechanisms to be stronger and more common than other mechanisms. Our hypotheses and assumptions about the ways in which urban structure affects travel behaviour concern *degrees* and *strengths* of relationships. In order to identify such tendencies and differences of degree, quantifiable information about the travel activity of a relatively high number of residents was necessary. The respondents also had to be recruited from areas reflecting the variation in the urban structural factors, the effects of which we wanted to investigate.

In accordance with the above, 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. Table 3.2 provides an overview of the research methods used in the empirical collection of data. Quantitative information about residents and their travel behaviour was collected by means of travel surveys among inhabitants of 29 residential areas located in different urban structural situations within Copenhagen Metropolitan Area. Recruiting participants of our investigation from

Table 3.2 Research methods of the Copenhagen Metropolitan Area study

Qualitative interviews of 17 households

- Semi-structured, each lasting about an hour and a half
- Focus on the interviewees' reasons for activity participation, location of activities, travel modes and routes, as well as their opinions about different parts of the metropolitan area as places to visit and to live in

Questionnaire survey among inhabitants of 29 selected residential areas (1932 respondents)

- Travel distances by different modes during one whole week
- Location of any workplace or place of education
- Annual driving distance with the household's car(s)
- Changes in the amount of travel among respondents who have moved during the last 5 years
- Perception of being dependent on car travel in order to reach daily activities
- Frequency of participation in different activities
- Holiday trips
- Attitudes to transport and environmental issues

Detailed travel diary survey Saturday – Tuesday (273 respondents)

- Location of the various trip ends
- Purpose, length, mode and travel time of each trip
- Driving distance of the household's car(s) (based on odometer registration)
- Changes in activity participation and car ownership among respondents who have moved during the last 5 years
- Flights and other trips outside the local region
- Preference for leisure activities

Registration of urban structural conditions, including the distances from each respondent's dwelling to various centres and facilities

these demarcated residential areas instead of, for example drawing a random sample among the inhabitants of Copenhagen Metropolitan Area, was mainly motivated by the possibility of mapping a large number of urban structural properties in each area and including this broad range of characteristics as variables in our study. If the respondents had been randomly sampled from all over the metropolitan area it would have been far more difficult to get detailed information about the urban structural situation of each residential address. With a concentration of respondents to 29 areas the number of respondents might also be sufficiently high to make possible a meaningful comparison of average travel distances and modal shares (although the scope for random variation would be quite high, in particular for the areas with the fewest respondents). Pedagogically and with an eye to communication, we considered it important to be able to visualize relationships between urban structural conditions and travel by comparing concrete localities.

As is evident from the above, we have aimed at a 'triangulation' (Patton, 1987; Yin, 1994: 92), both regarding data sources (combination, among others, of questionnaire data and data from personal, qualitative interviews) and methods of analysis (statistical analyses and qualitative interpretation of interview material). We believe that this has given us a broader and more nuanced understanding of our research questions and contributed to more reliable and robust conclusions.

3.3 THE COPENHAGEN METROPOLITAN AREA

The Copenhagen Metropolitan Area includes the municipalities of Copenhagen and Frederiksberg (both of which also have similar status to counties), as well as the counties of Copenhagen, Frederiksberg and Roskilde.¹¹ With this demarcation, the Copenhagen Metropolitan Area has about 1.8 million inhabitants distributed over 51 municipalities. Copenhagen Metropolitan Area is one of the largest urban areas of Northern Europe and is a major node for international air and rail transport. Since the completion of the Øresund bridge in 2000 the Copenhagen area has become more closely connected to southern Sweden. Although including several smaller cities that previously played a more autonomous role, Copenhagen Metropolitan Area is today a conurbation functioning largely as one single, functional city, making up a continuous job and housing market. Its urban developmental pattern is still marked by Copenhagen's famous 'Finger Plan' of 1947 (see Figure 3.1), according to which urban development was supposed to take place along five railway lines to the north, west and south. Between these 'fingers' of developed areas, 'green wedges' of farmland and forests were set aside, ensuring that the distance to rural and natural environments would be short even for the inhabitants of the inner city.

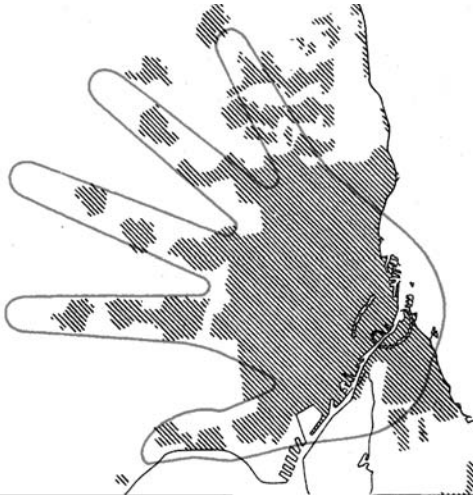


Figure 3.1 The Finger Plan of the Copenhagen region

The 'Finger Plan' has arguably had the status of a 'planning doctrine' (Faludi and van der Valk, 1994) in the Copenhagen area. Although some development has taken place in-between the fingers and some ring roads have been added, most of the urban development since the plan was launched has been in accordance with its main ideas.

As mentioned in Chapter 2, many European cities have traditionally had a concentration of workplaces and service facilities in the central parts. According to several authors, the historical urban core has lost some of its dominant position during the recent 30 or 40 years. For example, Sieverts (1998) holds that cities can no longer be fitted into a hierarchic system according to central place theory. Instead, they should be understood as a network of nodes, where there is a spatially more or less equal, scattered distribution of labour with spatial-functional specializations. This net-shaped city or city region has a polycentric instead of a monocentric or hierarchic central structure.

However, the inner city of Copenhagen still has an unchallenged status as the dominating centre of the metropolitan area. The population density in this part of the region is considerably higher than in the outer parts of the region. The central municipalities of Copenhagen and Frederiksberg, making up only 3.4 per cent of the area of Copenhagen Metropolitan Area, have one third of the inhabitants and an even higher proportion of the workplaces. As can be seen in Figure 3.2, there is a clear tendency to decreasing density of population as well as workplaces when the distance from central Copenhagen increases. In particular, the concentration in the inner-city area and its closest surroundings is strong for the workplaces.

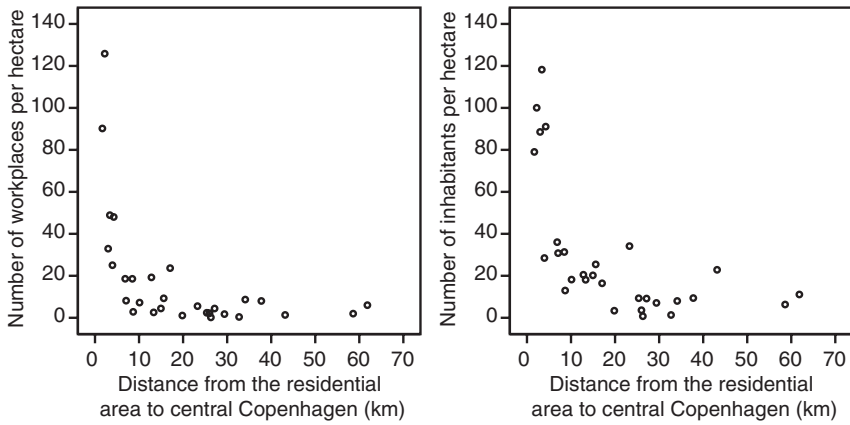


Figure 3.2 Density of workplaces and inhabitants in the local areas around investigated residential areas located at different distances from central Copenhagen

N = the 29 residential areas shown in Figure 3.1

(Source: Data from Copenhagen Region Development Council on the numbers of workplaces and inhabitants within 1,900 'traffic zones' in 1996.)

However, there are also a number of lower-order centres. The five towns of Køge, Roskilde, Frederikssund, Hillerød and Helsingør have increasingly become incorporated in the functional urban region of Copenhagen. They still have to a high extent a function as centres for their respective parts of the region. The second-order centres also include a number of concentrations of regionally oriented retail stores, some of which are in 'shopping streets' in districts immediately outside the inner-city area, some in local centres in inner suburbs, and a few in the larger among the outer-area municipal centres. In addition, a couple of major suburban shopping malls have been established in recent decades, one of which is located close to an urban railway station and the other one 600–700 metres away from the closest station.

In addition to the above-mentioned centres, there are also a number of more local centres, in particular the smaller municipal centres in some of the peripheral municipalities and the centres that have emerged in connection with the stations for the local train services, in particular the urban rail (S-train) stations.

The centre structure of Copenhagen Metropolitan Area could thus be characterized as hierarchic, with the city centre of Copenhagen as the main centre, the central parts of the five outer-area towns and the inner-city concentrations of regionally oriented retail stores as second-order centres, and the more local centre formations in connection with, among others, urban railway stations and smaller-size municipal centres at a third level.

3.4 HOW THE STUDY WAS CARRIED OUT

The location of the selected residential areas is shown in Figure 3.3. As can be seen, there is a mixture of central and peripheral areas, where the outermost ones are located 60 km away from the centre of Copenhagen. All the five 'fingers' of Copenhagen's Finger Plan are represented, thus including typical upper-income 'fingers' as well as more working class-dominated corridors. Some of the residential areas are close to urban railway stations, while others are located further away from such stations. Some of the latter are small settlements situated out in the predominantly rural areas between the urban fingers, where the public transport provision is very poor. The dwelling types and densities also vary considerably, from the dense blocks of inner-city Copenhagen to isolated settlements between the 'fingers', surrounded by open fields.

The participants of the qualitative interviews were recruited from five of the residential areas, three of which are situated in the inner-city (areas C1, C2 and C4 on the map, with a total of nine interviewee households) and two in the outer parts of the region (areas La2 and S4 on the map, with a total of eight interviewee households). The logic behind this selection was to illuminate distinctly different urban structural situations: inner-city high-density (C1 and C2), inner-city medium-density (C4), outer-area, close to local centre with urban railway station (La2), and outer-area with poor local service and transit provision (S4). 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. All interviews were tape recorded and thereupon transcribed in their entirety.

As an important tool for the analysis an *interpretation scheme* was developed. This scheme comprised more than 30 research questions which we, as researchers, tried to answer, based on the information given by the interviewees. These questions were first answered with reference to each of the separate 17 interviews. Utterances potentially suited for being quoted in the research report were noted in a separate column, stating the relevant page and line numbers from the transcribed interviews. Synthesizing from our answers about each separate interviewee, a comprehensive interpretation was written for each of our research questions, summarizing the information from all the 17 interviews. By being required to make written interpretations of each interview in the light of each of the detailed research questions, we were forced to read and penetrate the transcribed interview texts in a far more thorough way than we would probably have done otherwise. Thus, the use of the interpretation scheme has, in our opinion, contributed significantly to increasing the validity and reliability of our qualitative interpretation.

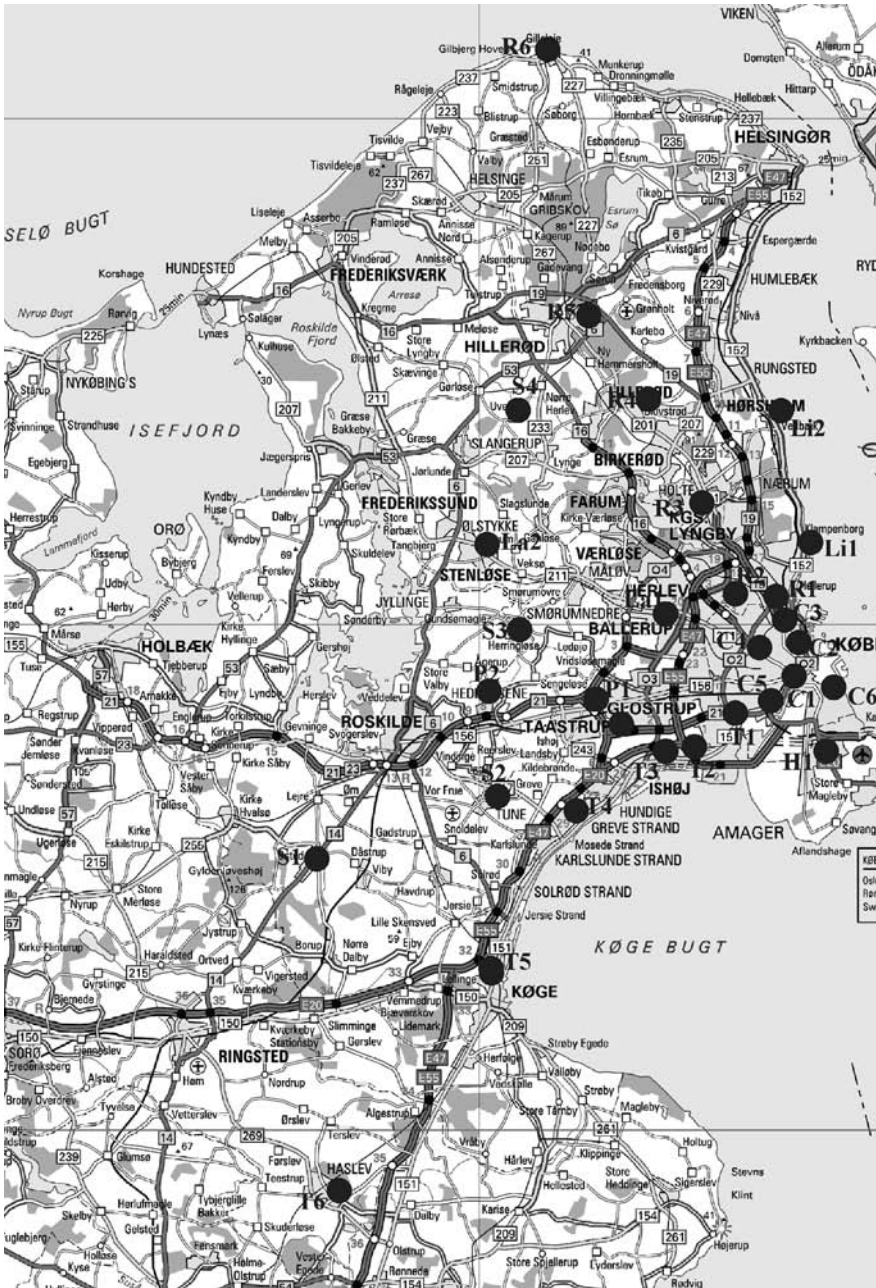


Figure 3.3 Location of the 29 selected residential areas of the Copenhagen study
Scale: 1/650,000

Questionnaires were distributed by mail to the residents of the selected residential areas (see Figure 3.3).¹² The concentration of respondents in a limited number of selected locations allows for a more in-depth account for contextual conditions in each of the chosen areas. But this method of selecting respondents also makes it problematic to carry out statistical generalizations from our sample of respondents for the populations of the Copenhagen area. Therefore, the statistical levels of significance are only indicators of the certainty of the various relationships found *within* the sample.¹³ A generalization from our samples for the inhabitants of the metropolitan area must instead rely on *qualitative* arguments to a large extent (Sayer, 1992: 103): To what extent do our residential areas, seen as a whole, deviate from the residential areas of the Copenhagen region in general with respect to characteristics relevant to our research questions? To what extent do relevant characteristics of the individual respondents, also seen as a whole, differ from the total population of the Copenhagen region? Does it appear likely and reasonable to assume that differences between the sample and the population of Copenhagen Metropolitan Area have exerted a decisive influence on the relationships found between residential location and travel behaviour?¹⁴ (For a more thorough discussion, see Næss and Jensen, 2002 or Næss, 2004.)

In the main survey a total of 5,800 questionnaires were distributed, of which 1,932 were completed and returned. Given the quite large questionnaire, requiring respondents to register daily transport over a whole week, the response rate of 33 per cent must be considered normal and acceptable. (For comparison, in a much cited American survey including questions about travel behaviour over a three-day period (Kitamura *et al.*, 1997), a net response rate of only 11 per cent was achieved.) In addition to recording socio-economic background variables and travel distances by different modes on each day during a week, the main survey included questions about frequency of participation in activities, attitudes to transport and environmental issues,¹⁵ 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. 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).¹⁶ In addition, the driving distances of the households' motor vehicles (if any) at the weekend (Saturday–Sunday) and on Monday–Tuesday were recorded, based on odometre monitoring. In the travel diary investigation, 273 persons responded out of a gross sample of 775, that is a response rate of 35 per cent.

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 (Table 3.3). The biases found were largely the same in both surveys. Persons who were neither workforce participants nor students are clearly under-represented 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 were carried out among each of the mentioned subgroups of the respondents. The comparison with census data also shows that our respondents have somewhat higher incomes, and belong to somewhat larger households on average, than the population of the respective residential areas and the metropolitan area. In the travel diary investigation, respondents living in the outer parts of the metropolitan area are also somewhat over-represented. In general, apart from the two clearly underrepresented subgroups mentioned above, the samples of the two surveys must yet be considered fairly well representative for the inhabitants of the Copenhagen area and the selected residential areas. Compared to the survey respondents, the participants of the qualitative interviews have a higher education level. Apart from this, they do not seem to deviate much from the participants of the quantitative investigation, and they include quite a wide range of professions.

In order to identify the *separate* effects of the various, potential factors of influence, multivariate regression analyses were applied on the quantitative data. This multivariate control also makes it possible to neutralize any known biases between the sample and the population of the metropolitan area. If, for example, income is included among the independent variables in the multivariate analysis, the controlled relationship between residential location and travel will not be biased by any distortion in the income levels of the sample.

Table 3.3 Comparison of demographic and socio-economic characteristics of the participants of the main survey, the travel diary investigation, and the qualitative interviews, with the inhabitants of the 29 residential areas and the Copenhagen Metropolitan Area as a whole

	<i>Interviewee households (N = 17)</i>	<i>Respondents of main survey (N = 1932)</i>	<i>Respondents of travel diary survey (N = 273)</i>	<i>Inhabitants of the 29 residential areas</i>	<i>Inhabitants of Copenhagen Metropolitan Area</i>
Average number of persons per household	2.7	2.4	2.3	2.3	2.1
Average number of children aged 0–6 years per household	0.59	0.23	0.16	0.23	0.19
Average number of children aged 7–17 years per household	0.41	0.35	0.28	0.26	0.23
Average age among respondents/interviewees	46	48	51	–	–
Proportion of workforce participants among respondents/interviewees	89%	73%	77%	63%	59%
Proportion of students/pupils among respondents/interviewees	0%	9%	8%	11%	12%
Average household income (1,000 DKK)	501	504	512	446	360
Proportion with further education	75%	27%	27%	–	–
Average number of cars per household	0.94	0.94	0.97	0.81	0.60

CHAPTER 4

THE 'CAR TYRES' AND THE 'BIKE HUB': TYPICAL MOBILITY PATTERNS IN DIFFERENT PARTS OF THE METROPOLITAN AREA

4.1 INTRODUCTION

In this chapter, we shall first take a look at key urban structural and socio-economic features characterizing the investigated residential areas with the highest and lowest values, respectively, on selected transport variables. Thereupon, differences in travel behavioural patterns between respondents living at different distances from the city centre of Copenhagen will be presented. These introductory comparisons are not adjusted for socio-economic and attitudinal differences between the areas, or for other urban structural conditions than the distance from the dwelling to central Copenhagen (this will be done in Chapter 6 and the subsequent chapters). The simple comparisons presented in this chapter may still give a first indication of relationships between travel behaviour and residential location. In the remaining part of the chapter, the spatial distribution of some of the respondents' most important trip destinations will be illuminated.

In total for the week of investigation, the respondents of the main questionnaire survey have on average transported themselves 306 km, of which 208 km during the five weekdays and 99 km during the weekend. These figures refer to the *arithmetic means*, that is the sum of the travelling distances of all respondents divided by the number of respondents. However, there are large individual differences, and a few respondents who have made long trips (among others occupational journeys) outside Copenhagen Metropolitan Area pull the arithmetic means considerably upward. We may therefore obtain a better picture of the typical travel behaviour if we instead use the *median values*, that is the travelling distances listed in the middle when ranking the respondents according to how far they have travelled. One half of the respondents have thus travelled longer than the median value (hereafter also called the typical value), and the other half has travelled shorter. The median values for the travelling distance during the whole week, on weekdays and at the weekend are 220 km, 136 km and 48 km, respectively.

For the distances and proportions travelled by different modes of travel and for commuting distances, arithmetic means will be a more relevant measure than median values.¹⁷ On average, the respondents have travelled 59 per cent of their total travelling distance on weekdays by car, 22 per cent by bike or foot and 19 per cent by bus or train. At the weekend, the corresponding shares are 64 per cent, 23 per cent and 12 per cent, respectively. The workforce participants among the

respondents live on average 14.5 km away from their workplace, while the place of education is located at a little less than 12 km on average from the dwellings of the respondents who are students or pupils.

4.2 THE TOP SEVEN AND THE BOTTOM SEVEN

What characterizes the investigation areas where the respondents transport themselves the longest distances, have the highest car usage, or are most keen on walking and biking? Table 4.1 shows selected urban structural and socio-economic characteristics of the areas belonging to the top seven and bottom seven, respectively, in a ranking of the investigation according to their values on relevant transport and transport-related variables.

A conspicuous pattern evident from our material is that the residential areas with the highest overall amounts of travel, the most extensive car transport, the least use of non-motorized modes of travel, the longest commuting distances, and the highest car ownership rates are all located in the outer part of Copenhagen Metropolitan Area. The density of population and workplaces is usually low in these areas, albeit in some cases at a medium level. Conversely, the investigated areas with the lowest overall amounts of travel, the least extensive car travelling, the most extensive travel by bike or by foot, the shortest distances between home and workplace, and the lowest car ownership rates are all, with a few exceptions, located in the central and inner parts of the metropolitan area. The density of population and workplaces is high or medium.

However, the areas with a high amount of transport, extensive car travel and a modest use of non-motorized modes usually also have higher income levels and car ownership rates than the areas where the respondents transport themselves shorter distances, use cars to a smaller extent and walk or bike more. Yet, income levels in the areas with long and short average commuting distances are very similar.

Car ownership varies according to a similar pattern as the transport variables. The areas with a high car ownership are typically situated in the suburbs, while the areas with many car-less households are either located close to the city centre or are high-rise suburban housing estates at a moderate distance from the inner-city area. Hardly surprising, the areas with a high car ownership have substantially higher income levels than the areas where the proportion of car-owning households is low. The use of public transport does not seem to be clearly related to the distance from the residential area to the city centre of Copenhagen. Yet, a tendency to a more extensive use of public transport among residents of dense local areas can be distinguished. The areas with a high and a low use of collective modes of travel do not differ much from each other in income levels.

Table 4.1 Selected urban structural and socio-economic characteristics of the investigated residential areas belonging to the top seven and bottom seven, respectively, ranked according to their values of relevant transport and transport-related variables

	<i>Distance from the residence to central Copenhagen (km)</i>	<i>Density of inhabitants and workplaces within the local area (inhab. + jobs per ha)</i>	<i>Proportion of respondents with car(s) in the household (%)</i>	<i>Average annual personal income (1,000 DKK)</i>
<i>Total travelling distance on weekdays (M)</i>				
The 7 areas with the lowest values	2–8 (4)	50–226 (132)	24–85 (49)	177–436 (270)
The 7 areas with the highest values	20–43 (29)	2–40 (11)	75–100 (86)	235–711 (342)
<i>Distance travelled by car on weekdays (M)</i>				
The 7 areas with the lowest values	2–13 (5)	21–226 (111)	24–70 (44)	177–422 (239)
The 7 areas with the highest values	20–59 (34)	4–17 (9)	78–99 (88)	238–711 (355)
<i>Distance travelled by walk/bike on weekdays (M)</i>				
The 7 areas with the lowest values	2–17 (6)	25–226 (111)	75–100 (86)	235–711 (333)
The 7 areas with the highest values	20–59 (33)	1–14 (7)	24–92 (54)	177–422 (273)
<i>Distance travelled by transit on weekdays (A)</i>				
The 7 areas with the lowest values	7–43 (22)	1–55 (18)	83–100 (90)	238–417 (300)
The 7 areas with the highest values	2–59 (22)	6–226 (69)	27–85 (68)	186–422 (286)
<i>Total travelling distance in the weekend (M)</i>				
The 7 areas with the lowest values	2–13 (5)	21–226 (118)	24–70 (40)	177–422 (246)
The 7 areas with the highest values	10–33 (22)	2–25 (12)	72–100 (89)	272–711(379)
<i>Distance between home and workplace (A)</i>				
The 7 areas with the lowest values	2–9 (5)	39–226 (130)	27–86 (58)	177–436 (275)
The 7 areas with the highest values	23–62 (39)	1–40 (11)	79–100 (88)	227–345 (277)

Table 4.1 (Continued)

	<i>Distance from the residence to central Copenhagen (km)</i>	<i>Density of inhabitants and workplaces within the local area (inhab. + jobs per ha)</i>	<i>Proportion of respondents with car(s) in the household (%)</i>	<i>Average annual personal income (1,000 DKK)</i>
<i>Proportion with car(s) in the household (A)</i>				
The 7 areas with the lowest values	2–13 (6)	18–91 (56)		177–252 (208)
The 7 areas with the highest values	7–38 (23)	1–55 (17)		275–711 (396)

Range and means (in parentheses) among the residential areas with the 7 highest and the 7 lowest values of the respective transport or transport-related variable. N = 29 residential areas including a total of 1,829–1,922 respondents, except for the distance between the residence and the workplace, where, N = 1,239, and income, where N = 1,773. A = based on arithmetic means among the respondents of each area, M = based on medians among the respondents of each area.

Since the centre–periphery dimension appears to be an important explanatory factor, the next section will be dedicated to a number of comparisons of relevant transport or transport-related variables between respondents living at different distances from central Copenhagen.

4.3 THE 'CAR TYRES' AND THE 'BIKE HUB'

In line with expectations, our material shows that those who live close to central Copenhagen travel considerably less on weekdays and carry out a much higher proportion of their transport by non-motorized modes than those who live in the outskirts of the Copenhagen area. Figure 4.1 shows arithmetic means and median values for travelling distances during the five weekdays of the week by car (to the left) and by walking/bike (to the right) in each of the 29 residential areas, with the investigated areas placed along the horizontal axis according to their distance from the city centre of Copenhagen. (Notice the different scales on the vertical axes of the two diagrams – in most of the areas, car transport is considerably more extensive than non-motorized transport.) In four out of the ten investigation areas closest to central Copenhagen, the median value for car transport during the period Monday–Friday is zero, implying that more than half of the respondents from these areas have not travelled by car at all during these five days. Conversely, the median

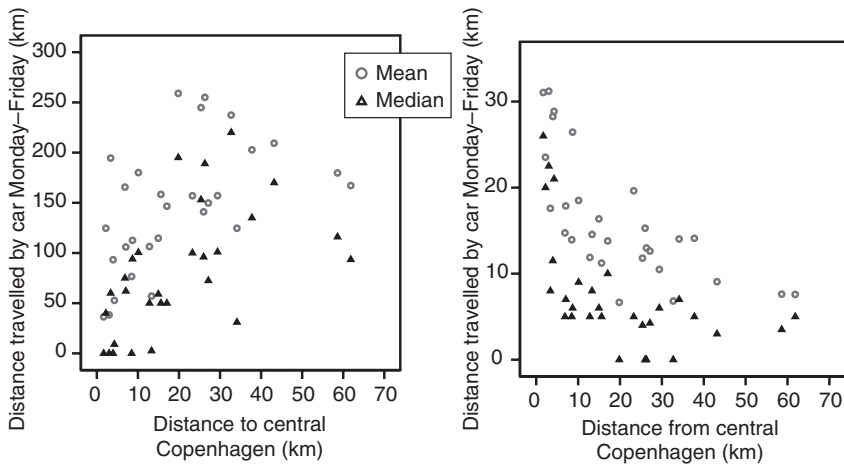


Figure 4.1 Mean and median values for travelling distance by car (to the left) and by non-motorized modes (to the right) during the five weekdays among respondents from residential areas located at different distances from the city centre of Copenhagen
 N = 1,798 in total, varying from 35 to 84 in the separate residential areas.

values for travel by non-motorized modes are zero in three out of the 13 residential areas located furthest away from the centre of Copenhagen. In these areas, thus, the majority of respondents have not travelled by non-motorized modes at all during the five weekdays of the investigation period. Both for car and walking/biking, the arithmetic means are generally somewhat higher than the median values, indicating the presence of a few respondents with considerably longer travelling distances with the respective modes than most of their fellow respondents, thus pulling the mean values upward compared to the medians.

Neither for car travel nor for non-motorized modes is the relationship between travelling distances and the distance between the dwelling and central Copenhagen linear. The highest amount of car travel and the least use of non-motorized modes are found in areas located 30–40 km from central Copenhagen. When the residential areas are located even more peripherally, the travelling distances by car tend to decrease again and the distances travelled by walking/bike to increase slightly. Still, the most peripheral areas have a considerably higher amount of car travel and a less extensive travel by non-motorized modes than the areas in the inner parts of Copenhagen.

As mentioned earlier, there may be considerable differences in the urban structural situation of residential areas located at approximately the same distance from the centre of Copenhagen. Among other things, local-area density and the location relative to urban railway stations and the various sub-regional and local centres may vary considerably, in particular among the peripheral areas. There are also

some socio-economic variations between the 'urban fingers' of Greater Copenhagen, more or less independent of any centre-periphery variations in socio-economic characteristics. By grouping the investigated residential areas in a limited number of distance belts from central Copenhagen, the above-mentioned variations will to some extent be equalized. This has been done in Figure 4.2, where the respondents have been classified into four approximately equally large groups, according to the distance from their dwelling to the centre of Copenhagen.

As can be seen to the left in Figure 4.2, the typical respondent (median value) from the residential areas located more than 28 km away from central Copenhagen travels about 15 times as long by car on weekdays as the typical respondent from the residential areas located closer to the city centre than 6 km. At the weekend (Figure 4.2, to the right), the corresponding ratio is six times longer. Conversely, the typical inner-area respondent travels six times as long by bike or by foot on weekdays as the median value among the respondents living in the outermost distance belt (Figure 4.3). Both in the central and in the peripheral residential areas there are some respondents who travel considerably longer than is common among their neighbours, for example due to recreational trips outside the metropolitan area. Therefore, the arithmetic means are higher than the median travelling distances. Measured in kilometres, the differences between outer and inner areas are about the same when comparing means and medians, but the

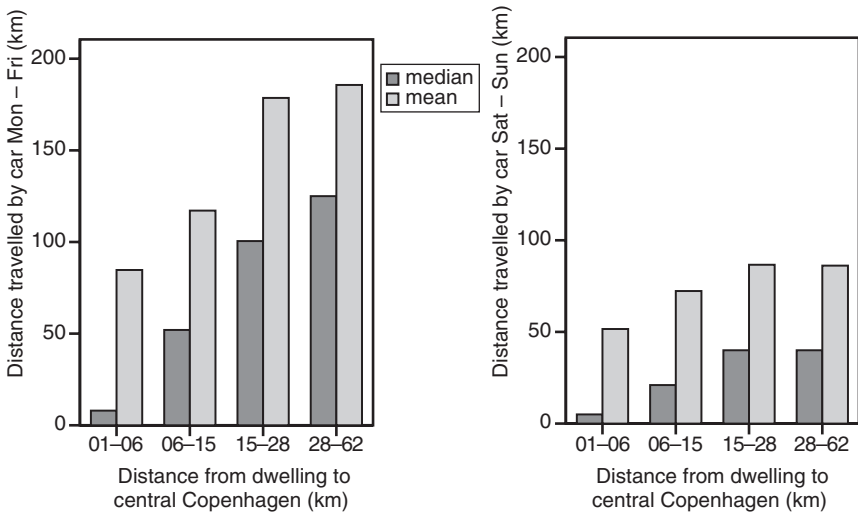


Figure 4.2 Median and arithmetic mean travel distances by car on weekdays (to the left) and at weekends (to the right) among respondents living in different distance intervals from the city centre of Copenhagen
 N = 1,837 in total, varying from 412 to 541 in the different distance intervals

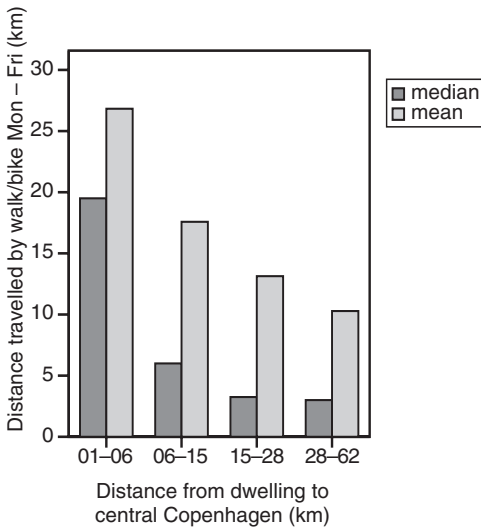


Figure 4.3 Travelling distances by bike and by foot among respondents living at different distance intervals from the city centre of Copenhagen. Medians and means N = 1,787 in total, varying from 400 to 528 in the different distance intervals.

ratios between mean travelling distances in the periphery and in the centre are smaller than the corresponding ratios based on median values.

In spite of the longer distances travelled by non-motorized modes among inner-city respondents, their total distance travelled is typically much shorter than among those living in the outer areas. The differences are larger on weekdays than on Saturday and Sunday. However, those who live in the inner part of the Copenhagen area travel shorter distances on average at the weekends too, and carry out a higher proportion of the transport by non-motorized modes. Distances travelled by public transport do not vary strongly between inner- and outer-area respondents, thus reducing the ratio of total travel distances between respondents from peripheral and central areas. Yet, for the week as a whole, the typical respondent living more than 28 km away from central Copenhagen travels more than twice as far as the median value among the respondents living less than 6 km from the centre.

Our respondents from the two outer distance belts (more than 15 km from central Copenhagen) are distinguished by a higher car ownership, a stronger perception of car-dependence (see section 8.2) and a considerably higher amount of car travel than the remaining respondents. Metaphorically, these distance belts could be called *the car tyres* of the Copenhagen Metropolitan Area. As readers will be aware, the tyres are the peripheral parts of a car wheel (as opposed to the hub), while the corresponding distance belts are clearly the most car-based ones within

the geography of Copenhagen Metropolitan Area. Conversely, the respondents from the most central distance belt (closer than 6 km from central Copenhagen) are remarkable for a high proportion of travel by bike, a low car ownership and a widespread perception of not being dependent on cars. A suitable metaphor for this distance belt, close to the spindle of the metropolitan area, could therefore be *the bike hub*.

4.4 SPATIAL DISTRIBUTION OF TRIP DESTINATIONS

As mentioned in Chapter 3, the Copenhagen Metropolitan Area has a clear concentration of workplaces and other facilities in its inner and central parts. The concentration of facilities in the inner parts of the metropolitan area is reflected in the actual distribution of the trip ends of the respondents. In line with this, there is a concentration of destinations in the inner and central parts of the metropolitan area for most travel purposes.

As can be seen in Figure 4.4, this concentration is especially pronounced as regards workplaces. The map to the left includes almost the whole island of Zealand, whereas the right part of the figure zooms in on the inner part of the Copenhagen area.



Figure 4.4 Spatial distribution of the respondents' workplaces
 Scale 1/1,950,000. N = 1,319 workforce participants among 1,932 respondents participating in the large survey. Section of the map showing in more detail the spatial distribution of the respondents' workplaces within the inner part of the Copenhagen area. Scale 1/390,000

Although a considerable number of respondents work in semi-peripheral and outer parts of the region, in particular in the sub-regional centres of Hillerød, Roskilde, Køge and Tåstrup, the main concentration of respondents' workplaces is clearly in the inner and central parts of Greater Copenhagen. A large proportion of the workplaces of the 1,319 workforce participants among our respondents are located within the area dominated by multi-storey square blocks (i.e. up to about 6–7 km from the city centre), with a particularly strong concentration in the area of the medieval city. For higher educational institutions there is also a clear tendency of concentration (with Roskilde University as the most important exception).

In Figure 4.5, the respondents' workplaces and places of education have been distributed according to their distances from central Copenhagen. The figure shows the number as well as the density of respondents with workplace/place of education

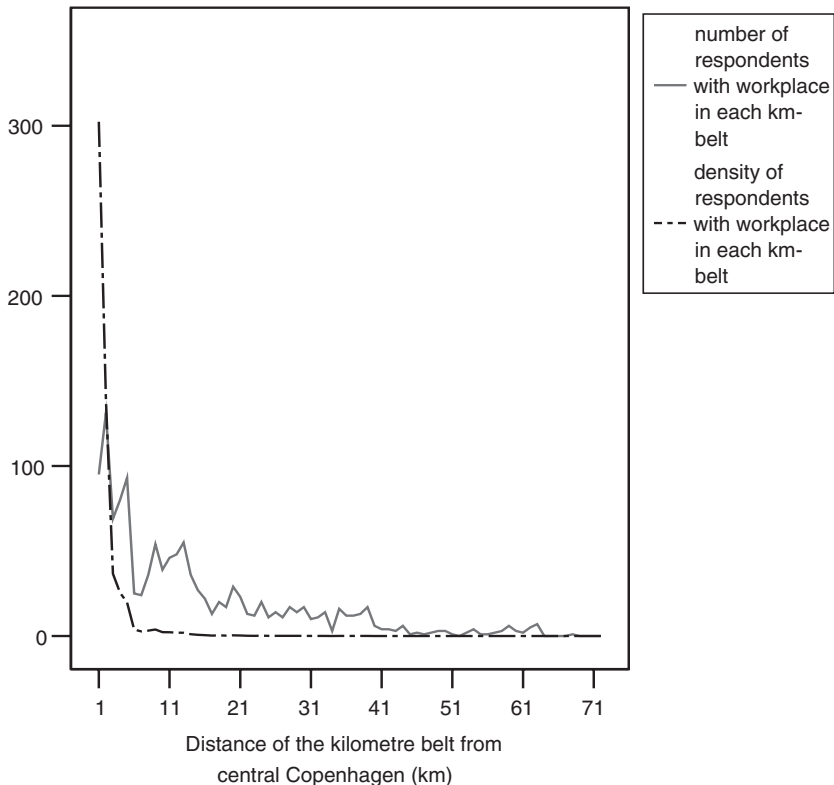


Figure 4.5 Number and density of respondents' workplaces and places of education in different kilometre intervals from central Copenhagen
 Number of respondents with workplace or place of education within concentric, 1 km-wide belts, and density of respondents with workplace or place of education (number per 10 square kilometre) within these belts. N = 1,310

within concentric, 1 km-wide belts around the centre of Copenhagen. In spite of the fact that the inner belts cover areas of a far smaller size than the outer belts, more than one sixth of the respondents' workplaces and places of education are located within the two innermost kilometre belts, and one half is located less than 10 km from the city centre. If we instead consider the density of respondents' workplaces and places of education (which is more reasonable since what we want to compare is the concentration of such trip destinations), the difference is enormous, ranging from more than 300 workplaces/places of education per 10 square kilometre in the inner ring (i.e. up to 1 km from the City Hall Square), 20 in the distance belt from 5 to 6 km, and lower than 1 in all distance belts from 16 km and outward.

Needless to say, the distances to these centrally located trip destinations will be longer if you live in the peripheral parts of the metropolitan area than if you live in one of the two central municipalities (Copenhagen and Frederiksberg). An important part of the explanation of the geographical differences in the respondents' amounts of travel shown in the previous sections probably lies in these circumstances.

Even though the dwellings in the metropolitan area also show a higher concentration in the inner parts, this concentration is stronger for the respondents' workplaces than for their residences. If respondents working more than 70 km away from central Copenhagen are excluded (a delimitation which seems reasonable, given the fact that none of the respondents' dwellings is located more peripherally than that), the respondents on average live 19.5 km away from the city centre of Copenhagen, whereas their workplaces are on average situated 15 km from the centre. The corresponding median values are 15 km and 10 km, respectively. Two thirds of the respondents work closer to central Copenhagen than where they live, while only one third work more peripherally than their place of residence. Among those respondents who live more than 10 km away from central Copenhagen, three out of four work closer to the city centre than they reside. Among those who live up to 10 km from central Copenhagen, the proportions working closer to and further away from the city centre than they dwell are equally large.

The spatial distribution of workplaces is to a high extent mirrored in the destinations of the respondents' occupational trips.

For errand/shopping trips too (Figure 4.6) there is a pronounced concentration of destinations in the inner parts of the metropolitan area. Shopping trips make up the majority of trips within this category, and the high number of trip ends in the inner-city area and the districts close to the centre reflects the strong concentration of stores in these areas, in particular special commodity stores.

Within the category of visiting trips, we also find a concentration of destinations in the central parts of the metropolitan area. This concentration mirrors the general distribution of the population, as there are more potential persons to visit in the inner districts. However, the destinations of the respondents' visiting trips also



Figure 4.6 Spatial distribution of the respondents' destinations for shopping and errand trips in the period from Saturday morning to Tuesday evening
 Scale 1/2,000,000. N = 397 shopping and errand trips carried out among the 273 respondents of the travel diary investigation. Section of the map showing in more detail the spatial distribution of the respondents' shopping and errand trips within the inner part of the Copenhagen area. Scale 1/400,000

tend to be located somewhat more centrally than their own dwellings. Among the 273 respondents of the travel diary investigation, the median distance between the dwellings and central Copenhagen is 19.5 km, whereas the median distance between the destinations of their visiting trips and the city centre is only 14.4 km. This difference is partly due to the fact that persons living in the outer parts of Copenhagen Metropolitan Area are over-represented among the participants of the travel diary investigation (section 3.4). However, it probably also reflects a tendency among those who live centrally to make more frequent visits to friends and acquaintances than those who live in the peripheral areas do.

The destinations of trips where respondents bring or pick up children appear to be concentrated to a lesser extent in the central parts of the metropolitan area. As one might expect, the density of such destinations is higher in the inner, most densely built-up and populated areas, but this concentration appears to be weaker than is the case for the destinations of visiting trips as well as for the respondents' dwellings. Possibly, this reflects higher opportunities for children living in the central districts to walk or cycle on their own to school and leisure activities because distances are shorter than in the outer areas. Since the travel diary investigation included the period from Saturday to Tuesday, trips to and from leisure activities probably make up a higher proportion of the bring/pick-up trips than for the week as

a whole. This may contribute to an increasing tendency for fewer bring/pick-up trips among inner-city respondents, as the distances to leisure trip destinations vary to a higher extent than the distances to schools and kindergartens for dwellings located within the metropolitan area (cf. also Chapter 7).

A further indication of the link between the location of the residence relative to central Copenhagen and the amount of travel is provided by so-called *desire lines* from the residences to the respective destinations. Desire lines are straight lines from a given origin (in this case the dwelling) to given addresses. Due to space constraints, only the desire lines for 12 of the 29 residential areas will be shown. The maps in Figure 4.7 include all trips the respondents of these areas have registered in the travel diary survey during the period from Saturday morning to Tuesday evening, apart from a smaller number of trips (11 per cent), where the destination addresses were too inexact to be geocoded.¹⁸ Because the weekend made up half the registration period, journeys to work or education are under-represented among the shown desire lines. The maps still give a good impression of the dominating orientation of the respondents' trips.

The residential areas from which desire lines are drawn in Figure 4.7 to the left are all located more than 26 km away from central Copenhagen. Among these respondents the vast majority of desire lines are directed inward, that is towards destinations



Figure 4.7 Desire lines for trip ends in the period Saturday – Tuesday among respondents from seven residential areas, all of which are located more than 26 km away from central Copenhagen (to the left) and from six residential areas located between 3.5 and 10 km away from central Copenhagen (to the right)
Scale 1/1,750,000

closer to central Copenhagen than the areas themselves. The residential areas to the right in Figure 4.7 are located closer to the city centre, with distances to the centre varying from 3.5 to 10 km. In these areas too most desire lines point inward. Besides, some desire lines go *through* Copenhagen's inner-city. Such trips too will be longer, the further away from the centre the residence is located. For the five most centrally located residential areas (less than 3.5 km from the centre, not shown in the figures), the potential for inward-directed trips is smaller, since only a small geographical area is located closer to the centre than the areas themselves. Yet, the proportion of inward trips is considerable. Most of the outward trips from these areas go to destinations within a radius of 10 to 15 km from the city centre. However, the inner-city residents also make a number of trips to destinations further away, some of which are outside the Copenhagen Metropolitan Area.

4.5 CONCLUDING REMARKS

The graphs and maps above have provided some preliminary indications about relationships between the location of residences within the metropolitan urban structure and the travel behaviour of the residents. Most of the respondents living in the outer and peripheral areas have a higher amount of travel and use cars to a higher extent than their counterparts living in the inner and central districts. Conversely, the respondents from the inner of the four distance belts of section 4.3 are especially distinguished by a high share of non-motorized travel, a low car ownership, and a

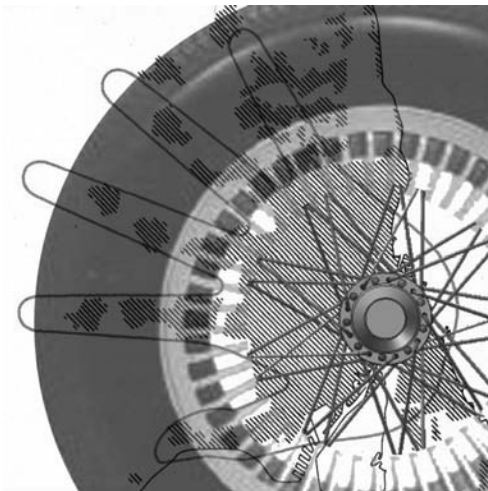


Figure 4.8 The 'car tyres' and the 'bike hub'

low total amount of transport. Metaphorically, the outer, largely car-based parts of the metropolitan area could be called *the car tyres*, whereas *the bike hub* might be a suitable metaphor for the inner part where biking and walking play a significant role in daily-life travel (Figure 4.8).

Apparently, the higher amount of transport and the longer commutes and other trip lengths among outer-area residents have something to do with the geographical concentration of workplaces and other facilities in the central and inner parts of the Copenhagen Metropolitan Area. It should, however, be noted that the results presented in this chapter have not taken into account socio-economic, demographic or attitudinal differences between the respondents. They also provide only a first hint at possible causal relationships between residential location and travel. In order to uncover such causal links, we need to know more about the considerations people make around their daily-life travel, for example concerning activity participation, and the rationales on which their choices among possible destinations and modes of transport are made. These issues will be addressed in the next chapter.

CHAPTER 5

HOW DOES URBAN STRUCTURE MOTIVATE DAILY-LIFE TRAVEL BEHAVIOUR? EXAMPLES FROM QUALITATIVE INTERVIEWS

5.1 INTRODUCTION

In the previous chapter we saw that considerable differences in transport behavioural patterns exist between respondents living in different investigation areas. Those respondents who live in the outer parts of the metropolitan area tend to travel longer distances and carry out a higher proportion of their transport by car than is common among their inner-city counterparts. On the other hand, the latter respondents travel more by bike or foot. Apparently, the shorter travelling distances among respondents living close to central Copenhagen are related to the proximity of their dwellings to the concentration of workplaces, service facilities and leisure opportunities existing in the central districts of the city.

However, showing this correlation between the amount of travel and residential location is not the same as demonstrating the existence of a causal relationship. In order to substantiate that a peripheral residential location is a (contributory) cause of a higher amount of travel and more extensive car driving than is the case among inner-city dwellers, we must show the basic mechanisms by which residential location influences travel behaviour – not necessarily every mechanism, but enough to make the influence of residential location on the amount of transportation and travel modes plausible. Examples showing the rationales on which people base their frequency of participation in out-of-home activities, the location of these activities, the modes of travel used to reach these locations and the routes followed make up important elements in this endeavour.

In order to explore the mechanisms through which residential location may influence travel behaviour, we shall now turn to the material from the qualitative interviews. First, we shall look more in detail at the daily-life trips made by interviewees of central and peripheral parts of the Copenhagen Metropolitan Area. Thereupon, we shall focus on the interviewees' rationales for choosing destinations and travel modes, and the ways these rationales contribute to the differences in travel behaviour between inner- and outer-area residents shown in the previous section.

The location of the five investigation areas from which the interviewees were selected is shown on the map in Figure 3.3. Figures 5.1 to 5.5 show orthophotos and street views from the five interview areas.



Figure 5.1 Availability of various facilities in the proximity of the residences of the Vesterbro interviewees (above) and typical street in the investigation area of Vesterbro
 In the aerial view, the following facilities are shown (to the extent that they exist within the depicted area): primary schools (squares with a dot inside), kindergartens and crèches (plain square), special commodity stores (circle with a dot inside), grocery shops (plain circle), post office (triangle) and urban railway stations (asterisk). The interviewees' dwellings are located approximately in the middle of the aerial view. Scale 1/15,200



Figure 5.2 Availability of various facilities in the proximity of the residences of the Kartoffelrækkerne interviewees (above) and typical street in the investigation area of Kartoffelrækkerne

In the aerial view, the following facilities are shown (to the extent that they exist within the depicted area): primary schools (squares with a dot inside), kindergartens and crèches (plain square), special commodity stores (circle with a dot inside), grocery shops (plain circle), post office (triangle) and urban railway stations (asterisk). The interviewees' dwellings are located approximately in the middle of the aerial view. Scale 1/15,200



Figure 5.3 Availability of various facilities in the proximity of the residences of the Frederiksberg North interviewees (above) and terrace houses from the southern part of the investigation area of Frederiksberg North

In the aerial view, the following facilities are shown (to the extent that they exist within the depicted area): primary schools (squares with a dot inside), kindergartens and crèches (plain square), special commodity stores (circle with a dot inside), grocery shops (plain circle), post office (triangle) and urban railway stations (asterisk). The interviewees' dwellings are located approximately in the middle of the aerial view. Scale 1/15,200



Figure 5.4 Availability of various facilities in the proximity of the residences of the Stenløse interviewees (above) and single-family houses from the western part of the investigation area of Stenløse

In the aerial view, the following facilities are shown (to the extent that they exist within the depicted area): primary schools (squares with a dot inside), kindergartens and crèches (plain square), special commodity stores (circle with a dot inside), grocery shops (plain circle), post office (triangle) and urban railway stations (asterisk). The interviewees' dwellings are located approximately in the middle of the aerial view. Scale 1/15,200



Figure 5.5 Availability of various facilities in the proximity of the residences of the Uvelse interviewees (above) and view towards the houses on the western part of the main street in Uvelse

In the aerial view, the following facilities are shown (to the extent that they exist within the depicted area): primary schools (squares with a dot inside), kindergartens and crèches (plain square), special commodity stores (circle with a dot inside), grocery stores (triangle) and urban railway stations (asterisk). The interviewees' dwellings are located approximately in the middle of the aerial view. Scale 1/15,200

The three most centrally located interviewee areas (Vesterbro, Kartoffelrækkerne and Frederiksberg North, marked on the map as C1, C2 and C4, respectively) are all situated less than 3.5 km from the city centre of Copenhagen (defined as the City Hall Square). In all these areas, the supply of stores, culture and entertainment facilities and public transport services in the proximity of the dwellings is high. There are also a very high number of workplaces within a short distance from the areas. The three central areas differ from each other regarding housing types (Vesterbro consists of five-storey apartment blocks, Kartoffelrækkerne of two and a half-storey terrace houses, and Frederiksberg North of a combination of two-storey terrace houses and older villas) and in their demographic composition (many young, single and childless people at Vesterbro; more families with children in Kartoffelrækkerne and at Frederiksberg).

The two peripheral interview areas (Stenløse and Uvelse) are both located far away from the large concentration of workplaces and service facilities in the central part of the metropolitan area, with distances to the city centre of Copenhagen of 27 km and 33 km, respectively. However, there is a considerable mutual difference between the two areas. The interviewees of Stenløse live close to an urban railway station and have short distances from their dwellings to a well-stocked shopping centre, and there are also a number of other local facilities in the proximity of their residences. Distinct from this, Uvelse has very few facilities: there is a small grocery store, a post office, a primary school and a church – and nothing else. The only bus route passing through the village has only one departure per hour in each direction, and no departures at all after 10 p.m. on weekdays.

5.2 THE REGULAR ACTIVITIES AND DESTINATIONS OF THE INTERVIEWEES

The most frequent types of trips made by the interviewees in connection with 'bounded' activities are trips to workplace or place of education and trips where children are transported to kindergarten or school. The most regular trips in connection with 'partially bounded' activities are trips to grocery shops. The figures on the next pages show the destinations of these 'bounded' and 'partially bounded' trips among the interviewees at Vesterbro and in Kartoffelrækkerne (Figure 5.6), at Frederiksberg (Figure 5.7), in Stenløse (Figure 5.8) and in Uvelse (Figure 5.9).

Generally speaking, the interviewees of the three central areas have most of their destinations of the above-mentioned trip categories within a relatively short distance from their dwellings, whereas most interviewees from the two peripheral areas spread their daily activities over a far wider area, seen in relation to the location of the dwelling. These differences between the central and peripheral areas are in particular



Figure 5.6 Bounded and semi-bounded trips of adult (≥ 18 years) members of interviewee households at Vesterbro and Kartoffelrækkerne
 Trip destinations are shown with the following symbols: workplace or place of education (black circle), grocery shop (white circle), places where children are brought/picked up (white square). The locations of the interviewees' residences are shown by a black triangle. Scale 1/465,000

a result of considerably longer journeys to work among the outer-area interviewees. Among the interviewees who are workforce participants or students, the weekly travelling distance in connection with the above-mentioned 'bounded' and 'partially bounded' activities is thus nearly 200 km on average for the two peripheral areas, compared to an average of 73 km for the three central areas. Among the interviewees of the two peripheral areas, almost two thirds of the distance is travelled by car, a little less than a third by public transport, and less than 5 per cent by bike or by foot. In comparison, the interviewees at Vesterbro, in Kartoffelrækkerne and at Frederiksberg cycle or walk on average half of the distance travelled in connection with the above-mentioned trip purposes, while car and public transport make up one sixth and one third, respectively.

The routine transport carried out by our interviewees thus fits well with our metaphors in Chapter 4, where the peripheral distance belts were characterized as



Figure 5.7 Bounded and semi-bounded trips of adult (≥ 18 years) members of interviewee households at Frederiksberg North
 Trip destinations are shown with the following symbols: workplace or place of education (black circle), grocery shop (white circle), places where children are brought/picked up (white square). The locations of the interviewees' residences are shown by a black triangle. Scale 1/465,000

the 'car tyres' and the areas closest to the city centre of Copenhagen as the 'bike hub'. Among the interviewees from the 'hub' closest to the 'spindle' (the City Hall Square), the bike is the dominating mode of travel in daily life, and a couple of interviewee households point at precisely the area within approximately 6 km from the centre as a specification of what they regard as the 'bike city'. Looking at the two peripheral areas together, the car is the dominating mode of travel, and the metaphor 'car tyre' thus appears to be suitable too.

However, looking at the two peripheral areas separately, there is a considerable difference in travel modes. In Stenløse, where the interviewees live close to an urban railway station, public transport accounts for 65 per cent of the distance travelled for 'bounded' and 'partially bounded' purposes. In the other peripheral area, Uvelse, where public transport services are poor, bus and train together make up only one sixth of the transport carried out in connection with the above-mentioned

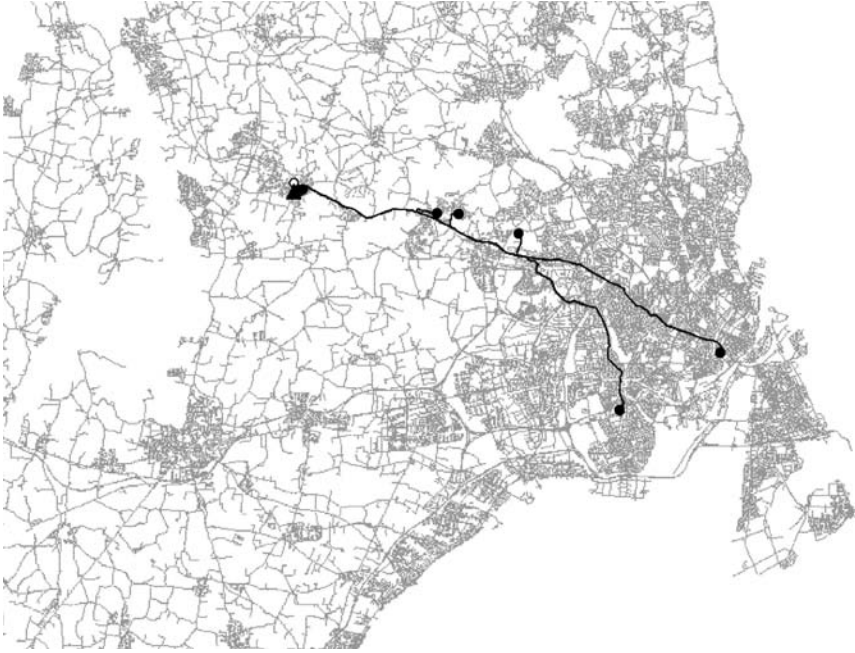


Figure 5.8 Bounded and semi-bounded trips of adult (≥ 18 years) members of interviewee households at Stenløse
 Trip destinations are shown with the following symbols: workplace or place of education (black circle), grocery shop (white circle), places where children are brought/picked up (white square). The locations of the interviewees' residences are shown by a black triangle. Scale 1/465,000

travel purposes. In their daily life, the interviewees living in Stenløse thus use public transport to an even higher extent than they travel by car. Yet, their amount of car travel is considerably higher than among the interviewees living in the three central areas. Moreover, the interviewees of Stenløse are atypical for the outer distance belts as regards the possibilities of travelling by public transport, as very few of the inhabitants of the 'car tyres' live as close to an urban railway station as our Stenløse interviewees do.

Within the separate interviewee areas there are also some deviations from the 'ideal-typical' picture presented above. For example, one of the Vesterbro interviewees travels by train and bus four times a week to and from her job in Køge, 36 km away. This interviewee moved from Køge to Vesterbro six years earlier, but continued to work in Køge. The employment in question is a specialized job as a teacher for pre-school children with hearing and language problems. This must be considered a quite atypical situation, as there is a far higher concentration of specialized jobs in the inner than in the outer part of Copenhagen Metropolitan Area (cf. section 2.3

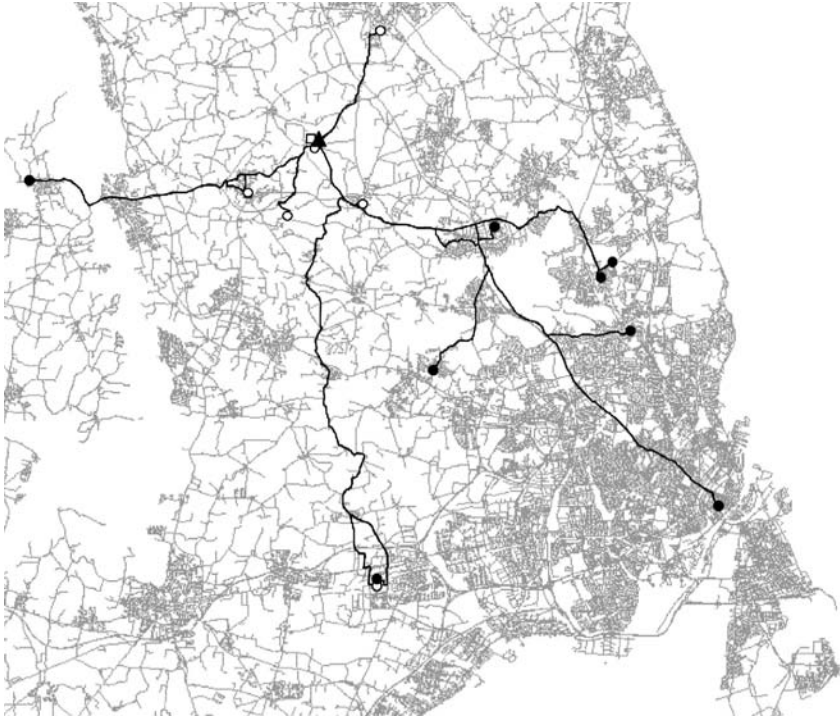


Figure 5.9 Bounded and semi-bounded trips of adult (≥ 18 years) members of interviewee households at Uvelse
 Trip destinations are shown with the following symbols: workplace or place of education (black circle), grocery shop (white circle), places where children are brought/picked up (white square). The locations of the interviewees' residences are shown by a black triangle. Scale 1/465,000

and Figure 3.2). A similar way of reasoning is relevant about a Vesterbro interviewee who has her workplace in Ballerup, 17 km to the north-west.

Likewise, one of the interviewees at Frederiksberg makes some very long trips in order to pick up/bring children and to do shopping. The interviewee in question is a grandfather who once or twice a week picks up grandchildren from a kindergarten in a little village at the western outskirts of the metropolitan area and brings them to his daughter's home in a neighbouring village. On his way home, he does shopping in a large shopping centre in one of the south-western suburbs. From the perspective of transport geography, the long distance travelled in connection with these trips must be considered a result of the dispersal of the population of Greater Copenhagen over a large geographical area, that is a result of the outward-directed and area-expansive urban growth that has taken place ('urban sprawl'). The long travelling distance cannot therefore reasonably be attributed to the central location

of the grandparents' dwelling. On the contrary, due to the fact that the inner-city is the geographical point of gravity of the housing stock of the entire metropolitan area and because population densities are higher in the central districts, the likelihood that randomly chosen grandparents will live close to their grandchildren is higher if the grandparents live in a central rather than in a peripheral area. The long distance travelled by this interviewee should therefore rather be considered a result of his daughter's remote residential location.

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. However, if you live centrally, you often travel only a short distance away from the local area. Apart from one single case, the workplaces and places of education of all the adult members of the interviewee households in Uvelse and Stenløse are located at a very long or relatively long distance from the dwelling. In contrast, only two persons among the adult interviewee household members from Vesterbro, Kartoffelrækkerne and Frederiksberg work or study at a long distance from their residence.

The interviewees choose their workplaces within a larger geographical catchment area than for any of the other 'bounded' travel purposes. Going to the workplace (or place of education) is the basic travel purpose on weekdays. Other trip purposes, like shopping or transporting children, are often 'hitched' on this trip if the locations of these activities can be reached without too long a detour from the route between home and workplace (see below).¹⁹

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 the city centre. This follows both from the generally more centralized locations of workplaces than dwellings, and from the fact that the distance along the road network to a randomly chosen address in the Copenhagen area will on average 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 influenced to the same extent by the location of the residence relative to the centre of Copenhagen. Jobs such as cashier 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 (cf. also the discussion in section 2.3 on catchment areas and centre hierarchies).

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 implies that little additional transport is required, but the day care centre or school may also be situated in a different direction from home than the workplace. Thus, two of the peripheral interviewee households had to drive a bit further away from the workplace in order to bring their children before they could start the journey to the workplace.

Among our interviewees living in the central part of Copenhagen, almost all daily-life shopping is carried out in the local area. A majority of 'non-bounded' activities, such as visits to cafés, restaurants and cinemas, visiting friends and aerobics/gymnastics exercising also 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.

5.3 RATIONALES FOR LOCATION OF ACTIVITIES

The interviewees' choices of locations for their activities are made as a compromise between two competing wishes: a wish to limit travel distances, and a wish for the best facility. The balance between these wishes differs somewhat, depending on the travel purpose. Our interviews suggest that each resident establishes an individual threshold value for the longest acceptable travel distance within each category of destination. Within these threshold values, the actual destinations are chosen more or less freely, based on other criteria than distance minimizing. In other words, the interviewees tend to practise a 'distance satisficing' rather than 'distance minimizing'. *Within* the maximum distance limits we can sometimes find examples of people preferring medium rather than very short distances, for example because a wish for physical exercise or 'clearing the mind' on the way home from work can make some interviewees prefer the trip by bike not to be too short. These examples are still quite atypical. In general, the unsatisfactory/unacceptable distances are clearly the long ones, and within the thresholds for acceptable travel distances the closest facility fulfilling the relevant quality criteria is normally preferred.

Among the different travel purposes, trips to *workplace or higher education*, along with visits to friends and relatives, are the trip purposes where the longest distances are accepted. Because the workplace or school/university is usually visited each weekday, whereas long visit trips are carried out far less frequently, this implies that journeys to work or education are clearly the travel purposes accounting for the largest proportion of the travel distance on weekdays.

One of our interviewees at Frederiksberg told us that both he and his wife chose their workplaces primarily because of the contents of the jobs. In both cases, the jobs were quite specialized (civil engineer and medical researcher). Due to the central location of the dwelling they both succeeded in finding jobs within a moderate distance from home. However, they would, if necessary, have accepted considerably longer commuting distances. For example, the husband would have chosen his present job even if the workplace had been located in Roskilde, 40 kilometres away. Another interviewee household, now living in Uvelse, said that the husband's (a computer scientist) workplace was chosen without much worry about the distance from their dwelling at that time:

No, I just thought that I wanted a job, and then we would have to see where we were going. And it didn't mean anything where it was.

(Male computer scientist, 30, living in the village of Uvelse)

He still appreciated that it was possible to reach the workplace by a direct bus. His wife's choice of workplace was to a higher extent conditioned by a wish to avoid a too long commuting distance.

The acceptable travel distance to work or education appears to increase the more specialized work qualifications you have, the more mobility resources you have at your disposal, and the further away you live from the largest concentrations of work and education opportunities.

If the distance exceeds the acceptable limit, you will either have to abstain from an otherwise attractive job or education opportunity, or move to a residence closer to the desired workplace or school. Our interviews show examples of residents moving in order to live closer to the workplace, as well as an interviewee who broke off her education because the distance between her outer-area residence and the university required too long and time-consuming journeys:

Moreover, I have been studying and actually I am right now on leave from the university. But I am going to stop going in there. I had an hour and a half of transport in each direction to and from. I spent three hours on transport each day. It was by train. Because, well, I had the car available now and then and could travel in there, but it is quite expensive, isn't it – looking at the petrol economy. No, so unfortunately I had to quit.

(Female parish council assistant, 36, living in the suburb of Stenløse)

There could of course always be a discussion on which comes first: residential location followed by workplace location, the other way round, or a simultaneous decision about both. Our interviews do not provide any unambiguous answer to this. Due to prices on the housing market, people may for economic reasons be hindered from choosing a residence close to the workplace, in particular if they want other criteria (e.g. access to

a private garden) to be fulfilled simultaneously. Possibly, the location of a particular workplace will be more important as a criterion for residential location among people with specialized skills than among unskilled labour who may more easily find suitable jobs in many different places within the metropolitan area (cf. the central place theory mentioned in Chapter 2). However, those with the most specialized education often have higher income levels and mobility resources enabling them to commute longer distances. Moreover, with the steadily increasing mobility resources among the population in general, the relative importance of proximity to the workplace is generally becoming less important as a criterion for choice of residence.²⁰

Often, there is also a good deal of inertia, as the present dwelling may once have been chosen because of, among other things, its proximity to the workplace, while subsequent employment changes have changed this into a situation requiring long commuting distances. Except for the younger respondents, who probably move more frequently in order to 'climb up the ladder of their residential career', most people probably live for a longer time in a particular dwelling than they on average work at a particular workplace. In particular, this seems to be the case under the contemporary, steadily more flexible working conditions, where short-term and project-based job contracts are becoming more and more common (Sennet, 1998). Usually, therefore, a shift of job does not lead to a simultaneous move to a different residence, as long as both the old and the new job are located within the metropolitan area. Changing workplace as a result of residential relocation is probably somewhat more common (and is also observed among some of our interviewees). However, as already mentioned, most of our respondents are willing to accept quite long commuting distances, and to a high extent the entire Copenhagen Metropolitan Area may thus be considered one single, continuous housing and job market.

Since primary schools, kindergartens and well-assorted grocery shops can usually be found closer to the residence than specialized jobs matching specialized work qualifications, the threshold values for acceptable distances to, for example, primary schools, kindergartens and grocery shops are usually shorter than for workplaces and places of higher education.

Distance limitation is thus included as an important (but not the only) rationale for most interviewees' choices of locations for daily-life activities. The wish to limit travel distances may be grounded on different reasons, often in combination, such as

- saving time
- saving money
- bodily constraints with respect to walking and biking
- a wish to support the local community and maintain local social contacts.

Thus, what counts for our interviewees is not only the two reasons associated with an 'homo oeconomicus' perspective (saving money or time), even though some

interviewees mention these considerations explicitly and they probably are included as part of the distance limitation rationale among the remaining interviewees.

In addition, several interviewees living in inner-city locations have chosen not to own a car, or choose to use the bike as their main mode of everyday transportation even if they have got a car. For these interviewees, the physical stamina of the body will enter as a reason to limit travel distances, along with a wish to save time. Thus, the choices of travel mode and the choices of activity location are to some extent interwoven. The rationale of distance limitation is in this way also indirectly influenced by, among others, environmental considerations and a wish for physical exercise, which are the reasons – along with economic concerns and a wish to avoid car driving in queues – most often mentioned for choosing the bike as the means for everyday transportation. As mentioned above, the wish for physical exercise may, on the other hand, make some people prefer somewhat further destinations to where the daily trip by bike fulfils the need for exercise, rather than the closest alternatives. Finally, the choice of local destinations may be conditioned by a wish to support the local community and establish local social contacts. This may in part be based on a political wish to support local shops, clubs etc. in order to secure their future survival, and partly on the fact that the chance of getting acquainted with other customers or users is higher if you use the local facilities than if you spread your purchases and use of services over a large geographical area. Such prioritization of local shops in spite of prices possibly being lower and the choice greater elsewhere, is probably more common in peripheral than in central areas. Inner-city residents are to a lesser extent able to obtain significantly lower prices or a better choice by travelling beyond the local area, and their 'local patriotism' and feeling of personal contact with the local shopkeeper will perhaps also be lower. However, our interviews also show that the use of local shops in inner-city locations, originally chosen because of proximity, assortment and prices, is consolidated when the interviewees have become familiar with these shops and no longer need to search the shelves for the desired commodities.

Visits to friends and relatives are probably the travel purpose where distance minimizing plays the least important role. (Possible exceptions are the cases where interviewees have chosen their residence in order to live closer to friends and relatives.) Visits, in particular to relatives, are thus the most 'specialized' activity of all, as those persons or households whom one might want to visit make up only a tiny fraction of the total number of inhabitants. Quite long travel distances are often accepted when visiting relatives – however, the frequency of such visits will usually be low. The circle of friends apart from relatives can to a higher extent be built up with the residence as a base, and trips to visit friends (non-relatives) will therefore usually be somewhat shorter. Several among our interviewees in the Copenhagen area make trips to visit relatives in other Danish regions (among others in Jutland)

some times every year, but there are no similar examples of regular visits to non-related friends. Most of the latter trips go to destinations within the Copenhagen region, and particularly within the domestic sub-region.

Our interviews provide some support to Putnam's (2000: 204–215) hypothesis saying that urban sprawl contributes to reducing people's participation in community activities. 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 café or go to a cinema together, among other things because of the atmosphere and the possibility of randomly meeting other friends and acquaintances (a finding also reported in other studies, including Hougen's (1998) study of urbanity and everyday life in Oslo). 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.

Along with distance limitation, a *wish for the best facility* (judged against the instrumental purpose of the trip) is the most important rationale for the interviewees' choices among destinations. In a way, this is the most fundamental rationale, as the trips would simply not occur if no sufficiently attractive facility existed that might be visited. Distance limitation and the wish for the best facility are two concerns pulling in opposite directions. In practical locational choices these regards must be weighed against each other. What is considered the 'best facility' will vary with the purpose of the trip and with the individual characteristics of the person in question. For workplaces, factors like job content, qualification requirements, wages and work environment will be relevant. For specialized jobs, the catchment area from which employees are recruited typically includes considerable parts of the region (cf. above) whereas the job markets for non-specialized jobs are likely to be more locally delimited.

For shopping locations the factors influencing the choices include, among others, assortment, prices and maybe parking possibilities. When living in the periphery, the local grocer is often only used for 'emergency purchases', as for instance 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 often well-stocked and are used to a higher extent for ordinary shopping. Among kindergartens, the reputation of the institution (pedagogy, etc.) and perhaps also the ethnic composition of the children may be factors of influence. The distribution of children among public primary schools is to a high extent determined through the official school catchment areas, but because private schools make up a competing alternative, the factors influencing the choice of kindergartens may to some extent also apply to primary schools.

The destinations of visiting trips are defined entirely by the traveller's family relations and circle of acquaintances (cf. above). When it comes to leisure trips, the

choice among facility categories depends strongly on the interests and lifestyle of the person in question, but quality differences within each facility category matter as well. For example, a distant, but larger and more beautiful forest may be preferred for outings rather than a local forest.

As already mentioned, some daily-life trips are more fixed and basic than other trips, as with the distinction between bounded, semi-bounded and non-bounded trips. Often, a bounded trip makes up the stock of a trip chain. Other travel purposes are then 'hitched' on this stock trip. For example, buying groceries often takes place on the way home from work or after having picked up children from the kindergarten. By choosing a well-stocked shop along the route followed anyway, the rationale of distance limitation can be combined with the rationale of choosing the best facility. In this way, the longer distances to shops, typical for residences in the outskirts of the city, can to some extent be compensated. This kind of adaptation – hitching some non-bounded or semi-bounded activities on the bounded trips, where the non-bounded activities are located to the most attractive of the facilities along the route of the bounded trip – is very common among our interviewees. In a time–geographical perspective this kind of adaptation implies that the shopping trip occupies a smaller part of the 'space–time prism', thus enabling the individual to spend more time on other activities during the day and/or travel further to reach these activities.

Besides emphasizing the possibility of choosing the instrumentally best facility (e.g. the shop where the choice and prices are the most favourable), the 'atmosphere' and aesthetic qualities at the destination are important to many of our interviewees. In particular, this applies to 'non-bounded' trips such as visits to restaurants, cinemas, theatres and other cultural facilities, and shopping (in particular non-grocery commodities). In contrast, people's choices of locations for 'bounded' activities – in particular workplaces – are to a much lesser extent influenced by the 'atmosphere' of the district where the destination is located. Indirectly, though, 'atmosphere' or aesthetic qualities may influence the destinations of journeys to work by influencing the locational choices of companies (cf. section 2).

5.4 CHOOSING MODES OF TRANSPORTATION

In our interviews, the following rationales for choices of transport modes were identified:

- constraints and possibilities set by the person's mobility resources
- time consumption
- monetary costs

- bodily constraints and a wish to avoid physical effort
- flexibility and freedom
- a wish for physical exercise
- environmental considerations
- lifestyle signalling
- habits and customs inherited through adolescence (what Bourdieu, 1984, calls 'habitus'), and to some extent
- social norms.

The above rationales are to some extent interwoven. For example, travelling by bike may be motivated by the health-bringing effect of physical exercise, by a wish not to cause pollution and noise, as well as a wish to signal a sporty and environmentally friendly lifestyle.

The *mobility resources* of the individuals define some limitations and possibilities regarding the modes of travel open for option. Persons belonging to a household without a car or a household whose car is occupied by another household member are compelled to go by public transport, bike or walking. People with low physical mobility often have difficulties in biking and walking more than quite short distances. The mobility resources depend partly on physical ability and qualifications (e.g. holding a driver's licence), partially on economic resources (affording the acquisition of a car, buying petrol or paying public transport fares), partly on values and attitudes, and partly on the need for transport (see below on the influence of residential location on car ownership). The partial overlap between the rationale of mobility resources and bodily constraints (see below) should be noticed.

Limiting *time consumption* is also a common rationale for the interviewees' choice of travel mode. For example, some interviewees choose to drive by car to central Copenhagen when travelling outside peak periods, while going by train during rush hours in order to avoid spending time in traffic queues. Together with constraints concerning the *bodily stamina* and wishes to limit physical efforts, the rationale of limiting time consumption causes the interviewees to choose motorized transport rather than biking, and biking rather than walking, for trip distances where the slow modes would take too much time (or imply too great a physical effort). As mentioned above, the wish to avoid too much physical effort also makes up part of the rationale of distance limitation for activity location, in particular among people who don't have a car at their disposal.

The rationale of limiting time consumption can also be traced in the argumentation by several inner-city interviewees that bike is faster than car to destinations within 5 or 6 kilometres from the dwelling. An interviewee at Frederiksberg thus tells the following about her trip by bike to her workplace located 3 km away from home:

It takes ten minutes. For me to go down there, yes. You nearly can't do that faster by car, because there is much traffic in the morning.

(Female dentist, 41, living in the inner district of Frederiksberg)

In the literature, the wish for time saving is often considered a rationale based on an 'homo oeconomicus' way of thinking. Indeed, we find a couple of outer-area interviewees who point out the fact that they would have to reduce their working hours if they were to manage without a car (unless they moved closer to the workplace):

If both two [cars] were at the repair shop? It would be unthinkable, wouldn't it? Then we would really have a problem. Then we would take a holiday or that kind of thing. Oh, but then we would have to go and take the train, and the bus to the station, and then we would spend really, we wouldn't be able to work more than five or six hours a day, because then we would have to go back home, you see, and pick up the children and that kind of things.

(Female computer scientist, 38, living in the village of Uvelse)

The purpose of the time saving made possible by choosing the car may thus be interpreted as to maintain two full-time jobs and the associated income. The premise for the need to reduce working hours if choosing a slower mode of travel was, however, a wish not to be too long away from the children, who would otherwise have to stay at the kindergarten during the entire opening hours:

That is, because if we, really you see, we cannot ... live a life where we have to deliver our child in a kindergarten ten or twelve hours every day in order to sit in a public transport [wagon].

(Female computer scientist, 38, living in the village of Uvelse)

The wish to save time can thus also be interpreted as emanating from a wish to be together with the family, that is from social rationality as much as economic rationality. Saving time is seen as a way of combining the wishes originating from the two different types of rationality.

Related to the wish to save time is the wish for *freedom and flexibility*. This rationale is emphasized by several interviewees as a reason for choosing individual instead of public transport, with its rigid lines and fixed times of departure. The individual transport in question still need not be the car. An interviewee of Copenhagen's central area emphasizes that she considers both the car and the bike more flexible than public transport:

And in particular the bike, for it is not gridlocked in congestion.

(Female planner, 38, living in the inner district of Kartoffelrækkerne)

The wish to limit monetary costs influences modal choice indirectly through car ownership (cf. above). Among the interviewees who have a car at their disposal, we also find examples where urban rail is preferred in spite of increased travel time, because the trip can then be made without economic expenses. (This applies to an interviewee entitled to free public transport trips as an employee of the Danish National Railways, and another interviewee who grew up as daughter of a railway employee.) Conversely, some interviewees mention the high ticket fares when going to and from central Copenhagen with a whole family as an argument for choosing the car for such leisure trips.

Several interviewees mention a *wish for physical exercise* as (part of) the reason for choosing to go by bike or to walk. In particular, this applies to inner-city, cycling interviewees, but also an elderly interviewee in the outer-area small town of Stenløse emphasizes physical exercise as one of the reasons why she walks to local destinations instead of using her car. The fact that the practical opportunities to have exercise through daily travel may be hindered by the location of the residence and the structure of the transport network is illustrated by the following example from the peripheral settlement of Uvelse. One of the two adult household members used to cycle 40 km every morning on an indoor exercise bike before she and her husband each went to work in their respective cars:

There, er, my wife, Hanne, got up around six o'clock and cycled on her exercise bike – for some 40 kilometres, I think she uses to go ... Yes, such an exercise bike, and watches the telly – Morning TV. And then I get up – about at, between eight and nine some time there, and then I hurry to eat and go to work. And meanwhile Hanne goes to work. And we have got a car each of us, so we both drive.

(Male computer scientist, 30, living in the village of Uvelse)

Environmental considerations are mentioned by some of the inner-city interviewees as part of the reason for choosing the bike as their means of transport. However, our interviewees do not emphasize this as strongly as the wish for exercise and to avoid spending time in traffic queues.

Customs established in early adolescence – that is, what according to the terminology of Bourdieu (1984) could be termed as a part of the *habitus* of the interviewees – also matter for the choices of transport modes. Some of the most eager train travellers among the interviewees had grown up in families who travelled often by train (among others because the father was a railway employee). Similarly, some interviewees explain that the foundation for their praxis of biking or walking to their daily trip destinations was laid through the parents' upbringing or had developed into a custom after many years of exercise walking as adults.

There may be some overlap between environmental considerations and *lifestyle signalling* as rationales for choosing certain modes of transport. However,

the latter rationale is more about signalling some attitudes (among others, environmental awareness, but also quite different values) to one's circle of acquaintances and fellow travellers. Among our interviewees, this rationale could in particular be traced among residents of the central part of Copenhagen Metropolitan Area. A possible explanation could be that these residents have a higher possibility than their outer-area counterparts to choose freely among transport profiles: it is possible to be a cyclist, a public transport rider and a car driver (although the latter may be troublesome due to congestion and scarcity of parking places).

One of our inner-city interviewees stated that she had consciously chosen to live without a car in order to create a less hurried lifestyle. This interviewee considered being a person without a car as a part of her style. In the peripheral parts of the metropolitan area, in particular in the areas far away from the urban railways, you are to a far greater extent 'thrown on' the car as your major mode of transport. The possibility of signalling affiliation with (or distancing yourself from) certain lifestyle groups through your choice of travel mode is therefore limited. Instead, the make of the car, its engine power, etc. may become more important as lifestyle signals. Among our interviewees, the only 'passionate car drivers' (Jensen, 1997), emphasizing speed and design as important features of their cars, were found in the peripheral settlement of Uvelse.

Social norms could also in some cases be traced as (partial) rationales for the interviewees' choices of transport modes. This was most distinct among a couple who were both employed in consulting engineering companies. At both their workplaces, an unwritten norm about 'car preparedness' existed, saying that employees should bring their cars to the workplace in order to be prepared to drive to external meetings or client visits if required. A bit more indefinable are the local 'transport cultures' apparently prevailing in some of the interviewee areas, in the form of a 'car culture' in Uvelse and a 'bike culture' in the inner parts of the Copenhagen area, the latter pointed out in particular by some of the interviewees at Frederiksberg:

In many ways some of us have perhaps a bit the same background and precisely things like that with the same education or at least close or the same values, I think. We have fairly the same, we go by bike all of us, and it is like that.

(The Olesen family)

In Uvelse, car driving is largely considered the 'normal' kind of transport, whereas biking seems to have a similar status among many of the residents of the three most centrally located interviewee areas. These prevailing attitudes could hardly be understood detached from their urban structural contexts, that is the physical and location-based facilitation for different modes of travel. Such local 'transport cultures' will probably exert a certain conformity pressure towards a travel behaviour in

accordance with what is 'normal' in each area (however probably not very strong – 'dissidents' hardly risk any sanctions).

In addition to the above-mentioned rationales, the location of activities will in many cases dictate the modal choice. For example, if the destination is a summer house situated many kilometres away from the closest public transport stop, most respondents are likely to go by car if they have one at their disposal. Thus, the extent to which people are able to choose travel modes 'freely' does not only vary with their mobility resources, but also with their location of activities. Similar to the way rationales for modal choice, for instance environmental or economic considerations making a person abstain from car ownership, may influence activity location by limiting the radius of action, modal choice may be influenced by the location of activities (and the rationales underlying the latter choices). This illustrates the interwoven character of the rationales, not only within one purpose category, but also across the purposes.

People's choices of transport modes may be influenced by the urban structural situation of the dwelling not only for intra-urban trips but also for trips out of the urban area. This is likely to be the case partially because people living close to railway stations can use the train mode with less inconvenience, and partly because people living in areas with few local facilities and poor public transport provision may become accustomed to using the car to a higher extent in their daily life. Such a habit may influence the choice of travel mode for trips out of the city as well.

5.5 RATIONALES FOR ROUTE CHOICE

Alongside rationales for location of activities and modal choice, the reasons influencing choices of routes and paths may contribute to our understanding of the relationship between urban form and travel. According to our material, the main rationales determining which routes our interviewees choose on their way to their destinations are:

- traffic safety
- time consumption
- distance, and
- view or aesthetics.

These considerations apply to the car drivers and bicyclists, as the routes of public transport travellers are largely determined by the layout of the public transport network, although some freedom exists, for example regarding where to shift from one route to another.

Among our interviewees, the rationales of time consumption and distance seem to be the most important ones to route choice. In particular, the rationale of

time consumption seems important in the light of the proportions of travel accounted for by the different modes. The rationales of traffic safety and aesthetics are subordinate and only influence the route choice as long as their consequences to time consumption or distance are relatively small.

In general, route choice is more emphasized among bicyclists than car drivers. The reason for this is the bicyclists' higher exposure to, on the one hand, traffic accident risks, noise and pollution, but on the other hand also their better opportunity of appreciating the aesthetic qualities of their surroundings. Bicyclists often have a better opportunity than car drivers to choose routes through aesthetically valuable landscapes, as the paths through parks and recreational areas are often reserved for non-motorized traffic. Moving by the power of their own muscles, bicyclists are also more sensitive to routes where the travel distance is increased.

Among car drivers, saving time is the most important rationale for route choice. Distinct from bicyclists, car drivers can often save time by choosing a longer route where traffic flows faster. It also happens that interviewees choose a detour in order to avoid driving in a traffic queue, even if this extension implies an increase of the total travel time. In such cases, what matters seems to be which route is psychologically perceived as the faster, rather than the actual time consumption. To some extent, car drivers also emphasize aesthetics and views, but this is only the case for leisure trips, not for daily commuting. Sitting encapsulated in their vehicles, car drivers are much less concerned with traffic safety as a criterion for their choice of route.

5.6 CONSEQUENCES OF THE RATIONALES TO THE RELATIONSHIPS BETWEEN RESIDENTIAL LOCATION AND THE AMOUNT OF TRAVEL

The above-mentioned rationales make up important links in the mechanisms by which urban structures influence travel behaviour. As mentioned above, the rationales are partially interwoven. The choice of an individual is usually not based on one single rationale, but on a combination of (and a trade-off between) several rationales. Most of the rationales identified either contribute actively to strengthen the relationships between residential location and travel, or are neutral as regards these relationships. A few of the rationales form the base of 'compensatory' mechanisms, which may contribute to weaken the relationships mentioned.

Tables 5.1 to 5.3 summarize how the various rationales contribute to the influences on travel behaviour from the location of residences relative to the main concentration of facilities and to local facilities, respectively. The different rationales have all been identified in the qualitative interviews. The texts in columns 3 and 4 from the left are based partly on the data collected in the interviews, partly on theoretical

assessments. In Table 5.1, the rationale of distance limitation has been split into two aspects, as they seem to influence travel behaviour in partly different ways: limiting geographical distances and limiting time consumption.

Table 5.1 The contributions of the various rationales for location of activities to the relationships between residential location and travel

<i>Rationales for activity location</i>	<i>Frequency of occurrence</i>	<i>Influence on the relationship between the amount of travel and the distance from the dwelling to the main centre of the metropolitan area</i>	<i>Influence on the relationship between the amount of travel and the distance from the dwelling to local facilities</i>
Limitation of geographical distances	Emphasized by all interviewees, in particular those without a car. Thresholds for acceptable distances vary between activity types and between individuals	Contributes to some extent to this relationship, both because the facilities in central Copenhagen are the closest opportunities for inner-city residents, and because of the shortage of facilities in the periphery	Contributes strongly to this relationship by increasing the likelihood of choosing local facilities rather than more distant ones
Limitation of time consumption	Emphasized by all interviewees, but thresholds for acceptable time consumption vary between activity types and between individuals	May induce some car drivers to choose, e.g., suburban shopping malls instead of central-city shops. Contributes nevertheless to some extent to the relationship between the distance from the residence to the city centre and the amount of travel, due to the function of the urban centre as geographical point of gravity	Contributes to this relationship because it will usually take a short time to go to local facilities. But because travel speeds will often be higher when going to e.g. a more distant shopping mall with ample parking space, the influence of this rationale is not as strong as the influence of the rationale of limiting geographical distances

Table 5.1 (Continued)

<i>Rationales for activity location</i>	<i>Frequency of occurrence</i>	<i>Influence on the relationship between the amount of travel and the distance from the dwelling to the main centre of the metropolitan area</i>	<i>Influence on the relationship between the amount of travel and the distance from the dwelling to local facilities</i>
Wish for the best facility (judged against the instrumental purpose of the trip)	Emphasized by all interviewees, but its importance varies between activity types and between individuals	Contributes strongly to this relationship by increasing the likelihood of travelling to the large concentration of facilities in the inner parts of the metropolitan area, but also because of the city centre's role as a point of gravity for all peripheral destinations.	Contributes to a certain weakening of this relationship by increasing the likelihood of choosing distant facilities rather than local ones
Enjoying 'atmosphere' and aesthetic qualities	Emphasized by many interviewees, primarily for 'non-bounded' trips	Contributes to this relationship by directing a higher number of non-work trips to the historical urban core	May contribute to a certain weakening of this relationship by making respondents bypass facilities in local centres where the 'atmospheric' qualities are lower than in the city centre area

The relationship between the amount of transport and the distance from the residence to the *main centre of the urban region* is in particular strengthened by the rationale of being able to choose the best facility (judged against the instrumental purpose of the trip). The rationales of limiting geographical distances and time consumption also contribute to this relationship to some degree, both because the region's largest concentration of facilities will serve as local facilities for a large number of inner-city residents in the major city of the region, and because the centre is close to the geographical point of gravity even for the more peripheral destinations that might – from a rationale of time-saving – be chosen by car drivers who want to avoid congested streets. The rationale concerning 'atmosphere'/aesthetic qualities also contributes to

Table 5.2 The contributions of the various rationales for choosing transport modes to the relationships between residential location and travel

<i>Rationales for choice among modes of travel</i>	<i>Frequency of occurrence</i>	<i>Influence on the relationship between the mode of travel and the distance from the dwelling to the main centre of the metropolitan area</i>	<i>Influence on the relationship between the mode of travel and the distance from the dwelling to local facilities</i>
Constraints and possibilities set by the person's mobility resources	Of a high importance to all interviewees	Neutral	Neutral
Time consumption	Emphasized by all interviewees, in particular workforce participants with a tight time-schedule	Strengthens this relationship because the more slowly moving car traffic in inner-city areas makes up an incitement for residents of these areas to choose non-motorized modes or public transport	Neutral
Monetary costs	Emphasized by all interviewees, in particular those with low incomes	Strengthens this relationship because of a higher fuel consumption and more expansive parking in inner-city areas	Neutral
Bodily constraints and a wish to avoid a physical effort	Emphasized to varying degrees, dependent on physical fitness and attitudes	Strengthens this relationship because a higher number of potential destinations are beyond acceptable walk/bike distance when living in a peripheral area	Strengthens this relationship because a higher number of potential destinations are beyond acceptable walk/bike distance when living far away from local facilities

Table 5.2 (Continued)

<i>Rationales for choice among modes of travel</i>	<i>Frequency of occurrence</i>	<i>Influence on the relationship between the mode of travel and the distance from the dwelling to the main centre of the metropolitan area</i>	<i>Influence on the relationship between the mode of travel and the distance from the dwelling to local facilities</i>
Flexibility and freedom	Emphasized by most interviewees, but to varying degrees, dependent on values/attitudes	May strengthen this relationship because public transport is less flexible in the periphery and car traffic more hampered in inner-city areas	Neutral
A wish for physical exercise	Emphasized by some interviewees	May strengthen this relationship by realizing a potential for walk/bike when distances to facilities are moderate. May in extreme cases lead to the choice of bike even when destinations are far away.	May strengthen this relationship by realizing a potential for walk/bike when distances to facilities are moderate. May in extreme cases lead to the choice of bike even when destinations are far away.
Environmental considerations	Emphasized by some interviewees	As above	As above
Lifestyle signalling	Emphasized by a smaller number of interviewees, in particular bicyclists	As above	As above
<i>Habitus/</i> customs	Of importance to most interviewees, but new habits may also be developed	Possibly a slight weakening. May imply an inertia in the adaptation of modal choice to a different urban structural situation after having moved to a new dwelling	Possibly a slight weakening. May imply an inertia in the adaptation of modal choice to a different urban structural situation after having moved to a new dwelling

Table 5.2 (Continued)

<i>Rationales for choice among modes of travel</i>	<i>Frequency of occurrence</i>	<i>Influence on the relationship between the mode of travel and the distance from the dwelling to the main centre of the metropolitan area</i>	<i>Influence on the relationship between the mode of travel and the distance from the dwelling to local facilities</i>
Social norms	Of importance to most interviewees. Depending on individual values and the extent of social contact within the area. The content of the norms also depends on the location of the area	May contribute to a slight strengthening of this relationship, e.g. through the emergence of a 'car culture' in peripheral areas and a 'bike culture' in inner-city areas. Such 'cultures' may influence the residents' choices of travel modes	May contribute to a slight strengthening of this relationship, e.g. through the emergence of a 'car culture' in peripheral areas and a 'bike culture' in inner-city areas. Such 'cultures' may influence the residents' choices of travel modes

increasing the importance of the distance between the residence and the city centre to the amount of travel. The relationship between the amount of transport and the distance from the residence to *local facilities* is first and foremost based on the rationale of limiting geographical distances, but also on the rationale of saving time, as the local facilities will often be the ones that can be reached most quickly.

Most of the rationales for modal choices contribute to strengthening the influences of residential location on travel behaviour found in earlier studies, or are neutral as regards these relationships. The rationales of limiting time consumption and economic costs contribute mainly to the relationships between modal choice and residential location at a higher geographical scale (i.e. the distance to the main centre of the urban region). The rationale of flexibility and freedom encourages residents of outer areas where public transport services are poor to travel by car, and inner-city residents of large cities (where frequent departures and a fine-meshed net of routes makes public transport more flexible, while the free flow of cars is hampered by congestion, traffic lights, etc.) to choose public and non-motorized modes. The rationale concerning physical effort is likely to strengthen the relationships between residential location and travel mode regarding the distance from the residence to the main centre of the urban region as well as to local facilities, since a larger number of potential destinations will be located beyond acceptable walking/biking distances when living far

Table 5.3 The contributions of the various rationales for route choice to the relationships between residential location and travel

<i>Rationales for route choice</i>	<i>Frequency of occurrence</i>	<i>Influence on the relationship between the amount of travel and the distance from the dwelling to the main centre of the metropolitan area</i>	<i>Influence on the relationship between the amount of travel and the distance from the dwelling to local facilities</i>
Traffic safety	Of importance to cyclists' route choice	Neutral	Neutral
Time consumption	Of importance to the route choice of cyclists as well as car drivers	Implies that the interviewees are not apt to make long detours from the fastest route. Such detours might disturb the relationship between the amount of travel and the distance from the residence to relevant facilities. Supports the general activity-based approach to transport analysis	Implies that the interviewees are not apt to make long detours from the fastest route. Such detours might disturb the relationship between the amount of travel and the distance from the residence to relevant facilities. Supports the general activity-based approach to transport analysis
Length	Of importance primarily to cyclists' route choice	Implies that the interviewees are not apt to make long detours from the shortest route. Such detours might disturb the relationship between the amount of travel and the distance from the residence to relevant facilities. Supports the general activity-based approach to transport analysis	Implies that the interviewees are not apt to make long detours from the shortest route. Such detours might disturb the relationship between the amount of travel and the distance from the residence to relevant facilities. Supports the general activity-based approach to transport analysis
View/aesthetics	Of importance first and foremost to cyclists' route choice	Neutral	Neutral

away from the relevant facilities. The attitudinal rationales concerning physical exercise and environmental concerns may contribute to realizing a potential for walking/biking when distances to facilities are short, and thus strengthen the relationships between residential location and modal choice. On the other hand, persons with strong attitudes to these issues may choose their travel mode 'in spite of' what is facilitated by the urban structural situation of the dwelling, and thus contribute to a certain weakening of the relationship. Rationales based on 'habitus' and customs may in some situations contribute to weaken the relationships between residential location and modal choice, for example if persons who have moved omit to adapt their travel mode to the new urban structural situation. Finally, social norms could to some extent be expected to strengthen the relationships between residential location and transport by socializing the residents of an area into a 'transport culture', the content of which would presumably be influenced by the urban structural situation of the area.

Among the rationales for route choice, the rationale of traffic safety may cause bicyclists to choose somewhat longer routes than the shortest one. Imaginably, this might push a given destination beyond the acceptable biking distance. However, we believe such cases to be rare. Since the rationale of traffic safety does not seem to influence the route choice of car drivers, its influence on the relationship between residential location and the amount of travel is likely to be minimal. The rationale of aesthetics/view might induce people to take detours in order to experience more picturesque or beautiful surroundings. However, among our interviewees, this rationale was important only to the bicyclists, as long as we are dealing with daily-life transport. Among bicyclists, this rationale usually led to only slight deviations from the shortest route. Thus, the rationale of aesthetics/view is unlikely to exert much influence on the relationship between residential location and daily-life travel, although it may act as a generator of recreational trips, for instance through countryside landscapes. The amount of such travelling is unlikely to be related to the urban structural location of the residence.

The remaining two rationales, time consumption and route length, were emphasized by bicyclists as well as car drivers. These rationales imply that the interviewees are not apt to make long detours from the shortest or fastest route. These rationales thus support the general activity-based approach to transport analysis, (cf. Jones, 1990; Fox, 1995).

5.7 TENDENCIES AND NECESSITIES

In order to throw further light on the mechanisms by which residential location influences travel behaviour, the above consideration of the influences of the various rationales will be supplemented below by a discussion where the critical realist

concepts of *tendency* and *necessity* are used to illustrate some of the causal links between residential location and commuting distances. Actually, even respondents giving high priority to the rationale of travel distance limitation, and who are hence at the outset willing to renounce on the wider options available if job opportunities were considered within a larger geographical area, may be compelled to accept long journeys to work in order to have any paid work at all.

As mentioned in Chapter 2, our conception of the notion of causality is not confined to monocausal relationships. Rather, we consider – in line with critical realist philosophy of science – causes like ‘tendencies’. These may or may not be actualized since counteracting causes can neutralize, trigger as well as reinforce a causal tendency, and thus prevent or create an empirical effect or event (Danermark *et al.*, 2001: 56). Such a notion of causality might be seen as a ‘dynamic’ form of causality, as change and interaction between multiple interacting forces is interpreted in a way qualitatively different from the empiricist concept of causality, where a cause X is assumed to always result in an effect Y: ‘People’s actions are never determined by a certain structure, they are merely conditioned. [...] There is always the possibility that we “make a mistake”, intentionally or unintentionally, compared with different structural “imperatives”’ (Danermark *et al.*, 2001: 56).

Time–geographical constraints on daily-life activities (Hägerstrand, 1970) amplify the ‘structural imperative’ on travel behaviour conditioned by residential location. In our context, the concept of *tendencies* implies, for example, that a peripheral location of residence relative to the distribution of workplaces in the region tends to produce long commuting distances. Given the spatial distribution of workplaces of different types, there is a structural imperative saying that residents of the outer suburbs need to accept a long commuting distance in order to find a suitable job, unless a workplace of a relevant category happens to be located in the local area, and the resident in question succeeds in getting employed in a vacant job at this local workplace. The possibility (albeit with a low likelihood) of the latter implies that a peripheral residential location does not *always* produce long commuting distances, but it *tends* to do so. And the long commuting distances are not equally long: some may go to the inner city, some to a peripheral area at the opposite side of the city region, and some to a workplace between residence and city centre. The actual configuration is contingent on the ways people actually apply for jobs and manage to get employment within the metropolitan labour market. Still, there is a mechanism producing long commuting distances among a greater proportion of residents living a long way from the largest concentrations of workplaces than of those living close to them. Hence, residents on the periphery tend to make longer journeys (unless they forego the freedom to choose the most suitable and attractive workplace, that is, limit the number of work opportunities available for choice to a lower number than the number that can be chosen by inner-city dwellers). Given the

stronger centralization of jobs than residences within the metropolitan area, even a willingness to make such sacrifices would not prevent a considerable proportion of the peripheral residents from being forced to make long commuting journeys, or accept unemployment.

The critical realist notion of tendency is tied to the term of *necessity*. Necessity indicates the existence of internal relations between objects in reality, internal relations which are the cause of emergence or, we might also say, which determine *what* it is that exists. There are also external relationships between the social objects – relations that do not determine what exists, but do determine *whether* and *how* that which exists will manifest itself (Danermark *et al.*, 2001: 187). The actual location of dwellings of different sizes and standards over the Copenhagen Metropolitan Area, combined with the actual distribution of workplaces with different qualification requirements, results in a shortage of suitable jobs within a moderate commuting distance when living on the periphery, but not when living in the city centre. Combined with the coupling restrictions (Hägerstrand, 1970) of being present at the workplace, and the wage labour structure of our society, this *necessitates* that a high proportion of residents on the periphery make long commuting journeys, while the proportion of inner-city dwellers who need to make long commuting journeys is much smaller. This is an *internal* relationship between the location of residences and the location of workplaces within the urban area, given the requirements of the contemporary labour market. The actual way this relationship manifests itself is, however, *contingent* on the ways residents of different areas are actually able to obtain employment. For example, a resident of a peripheral settlement might be employed at a local consulting firm instead of having to commute to a similar firm in the inner-city. However, this short commuting journey, which is atypical for her local community, at the same time makes it unnecessary for a resident living closer to the centre to make an outward journey to the otherwise vacant job in the peripheral settlement.

5.8 IMPACTS OF RESIDENTIAL LOCATION ON ACTIVITY PARTICIPATION

Our interviews indicate that people's participation in activities is influenced to some extent by the distance from the residence to relevant facilities. Needless to say, people's interests, resources and commitments are of the highest importance to their activity patterns, but the distances to the places where the various activities can be carried out also has a certain significance. What appears to be influenced by residential location is first and foremost the *frequency* of activity participation. Among our interviewees, activities are seldom completely dropped as a result of long distance to the facilities where they can be performed. Yet, a few cases exist where

long travelling distance was a main cause – or at least a contributory cause – of activities being terminated. One of our interviewees had recently aborted her education at the University of Copenhagen because, according to her own statement, the trips to and from the university were too expensive and time-consuming. In another case, a married, female interviewee had given up her job after moving from a residence relatively close to the city centre to a more peripheral dwelling, because the travelling distance became too long. Apart from the latter case, moving from one urban structural situation to a different one has only to a limited extent made our interviewees take up new activities or drop pursuing previous interests/activities.

A reduced frequency of activity participation when distances are long to the locations where the activities can be performed, will contribute to a certain weakening of the relationship between the amount of travel and the location of the dwelling relative to relevant facilities. Such a 'distance decay' in the frequency of activity participation implies that there are limits to how long people are willing to transport themselves in order to be able to perform an activity with a given frequency. Where many different optional facilities are available, this may make people prefer a closer, 'second best' facility to a too remote, 'best' facility (cf. section 5.3 on the balancing and prioritization between various rationales for activity location). In situations where even the closest facility is located far away, there will instead be a prioritization between, on the one hand, the efforts, time consumption and costs of travelling, and, on the other hand, the utility or joy from participating in the activity. The freedom to abandon an activity is of course limited to the 'non-bounded' types of activities.

The disadvantages of living far away from facilities thus consist partly of the need for spending more time, money and efforts on travelling to the facilities, and partly on having to renounce some of the needs or wishes for activity participation. In other words, living far away from relevant facilities has some environmental and resource-related consequences, in the form of a high amount of transport, as well as some negative welfare consequences, in the form of unfulfilled wishes for activity participation.

5.9 CONCLUDING REMARKS

Our qualitative interviews show clear tendencies for a higher amount of travel and a higher use of private cars among outer-area residents than among the interviewees living in the central parts of the metropolitan area, whose daily destinations are usually not far from the dwelling and are often reached by non-motorized modes of travel. Among the outer-area interviewees there is a marked difference in the use of public transport between those who live close to an urban railway station and the interviewees living in a small village with poor public transport services.

Our interviewees' rationales for location of activities, choice of transport modes and route choice make up important links in the mechanisms by which urban structures influence travel behaviour. The rationales are partially interwoven. Usually, the choice of an individual is not based on one single rationale, but on a combination of (and a trade-off between) several rationales. Most of the rationales identified either contribute actively to strengthening the relationships between residential location and travel, or are neutral as regards these relationships. A few of the rationales form the base of 'compensatory' mechanisms, which may contribute to weaken the relationships mentioned.

Our interviewees' choices of locations for daily activities are made as a compromise between two different concerns: a wish to limit travel distances and a wish for the best facility. For most travel purposes, our interviewees emphasize the possibility of choosing among facilities 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 shops and, to some extent, also grocery shops. For leisure activities, the 'atmosphere' and the aesthetic qualities at the destination may also play a role, contributing to strengthening the attraction of Copenhagen's inner city.

The longer travelling distances among outer-area than among inner-area residents are mainly a result of longer commuting distances. The given configuration of residences and workplaces results in a shortage of suitable jobs within a moderate commuting distance when living in the outer parts of the metropolitan area. Outer-area residents therefore tend to make longer commutes, partly because local job opportunities often do not exist, and partly because jobs outside the local area are considered more attractive. Although the distances to shops are usually also longer when living in the suburbs, the outer-area interviewees often compensate for this by buying daily necessities along the route home from work. In this way, the rationale of distance limitation and the rationale of choosing the best facility can be combined for shopping trips and certain other errands.

Our interviewees' rationales for choosing modes of transportation usually contribute to a more extensive use of cars in the suburbs and a higher use of non-motorized modes in the inner city. The rationales for route choice imply that the interviewees are not apt to make long detours from the shortest route to daily-life destinations, and thus provide general support to the activity-based approach to transport analyses.

Our interviews indicate that people's activity patterns are to some extent adapted to the availability of facilities in the proximity of the dwelling. The interviewees still rarely give up activities completely as a result of moving to a different urban structural situation. Rather, the frequency of participation may change.

CHAPTER 6

WHICH RELATIONSHIPS EXIST BETWEEN RESIDENTIAL LOCATION AND TRAVEL BEHAVIOUR AFTER CONTROLLING FOR DEMOGRAPHIC, SOCIO-ECONOMIC AND ATTITUDINAL FACTORS?

6.1 INTRODUCTION

This chapter presents the results of multivariate regression analyses of the influences of urban structural, demographic, socio-economic, attitudinal and other control variables on the respondents' travel distances and modal split. In Chapters 4 and 5 we saw that considerable differences exist between respondents from the central and peripheral parts of the metropolitan area in terms of travelling distances as well as the proportions of travel carried out by different modes. We also identified a number of rationales and motives for location of activities, choices of travel modes and route choices. These rationales and motives make up important links in the mechanisms by which urban structure influences travel behaviour. As mentioned in Chapter 5, most of these rationales contribute to strengthen the relationships between residential location and travel behaviour. Some rationales still give rise to 'compensatory' mechanisms that may contribute to weaken the mentioned relationships.

In which parts of Copenhagen Metropolitan Area will it be favourable to locate future residential development if the aim is to limit or reduce the amount of private motoring? Needless to say, such knowledge is of a high relevance to policy-making and planning. The typical or average relationships between residential location and travel among a large number of individuals – what could be called the aggregate-level *effects* of residential location on travel behaviour – reflect the mechanisms occurring most frequently and exerting the strongest influences on the result among the respondents, seen as a group. In order to identify these effects, it will not be sufficient to compare average figures on travel behaviour in areas at different geographical locations, like the comparisons made in Chapter 4. Such simple comparisons do not take into account the fact that the residential areas differ not only in their location and other urban structural characteristics, but also regarding the socio-economic characteristics and lifestyles of the inhabitants.

In order to distinguish between the differences in travel behaviour caused by urban structural conditions from differences caused by characteristics of the residents it is necessary to conduct a statistical control for the influence of non-urban-structural factors, that is to 'keep constant' all factors of influence apart from those, the effects of which we want to examine. As mentioned in Chapter 3, multivariate regression analysis is a method for making such a statistical control.

Needless to say, the quality of this control depends on whether or not all relevant non-urban-structural factors are included in the analysis. By 'relevant' we here refer to factors of influence systematically related to both travel behaviour and the urban structural characteristics, the effects of which we wish to investigate. In our analyses, we have included most of the variables mentioned in the scientific literature as potential sources of false inferences from the immediate (non-controlled) relationships between urban structure and travel. However, it is not always easy to decide whether or not a control variable is relevant. For example car ownership among the respondents varies for a number of reasons that have nothing to do with urban structure, and should therefore be controlled for. On the other hand, the urban structural situation of the dwelling may itself influence the need for people to own a car, or to have two or more cars in the household. Our qualitative interviews show several clear examples of such effects (see Chapter 5). Arguably, the relationship between residential location and car ownership still existing when controlling for socio-economic and attitudinal factors is caused precisely by the influence of urban structure on the need for having one or more cars at the household's disposal. Similar arguments could be put forth concerning certain other characteristics of the respondents imaginably influenced – at least partially – by the urban structural situation of the dwelling. This applies to, among others, transport attitudes, environmental attitudes, and possession of a driving licence. In our main analyses, these types of 'grey zone' control variables have still generally been included among the control variables. However, this implies a risk of 'over-control', and the controlled, direct relationships between residential location and travel behaviour must therefore be considered conservative estimates. In order to take the possible influences of residential location on travel via car ownership, transport attitudes, environmental attitudes, etc. into account, separate analyses of indirect effects have been carried out. These analyses are presented in Chapter 8.

In this chapter, a number of results from multivariate regression analysis of data from the main questionnaire survey will be presented. First, the attention will be drawn to the influences of urban structural, demographic, socio-economic, attitudinal and other control variables on the travelling distances (in total and with separate modes of transport) and modal shares on weekdays, at the weekend and for the week as a whole (sections 6.3 and 6.4). In all these analyses, respondents with extreme total travelling distances have been excluded. By extreme travelling distances we mean distances more than three quartile differences above the upper quartile, that is more than, respectively, 900 km during the five weekdays of the week (31 respondents), 430 km during Saturday–Sunday (70 respondents) and 1,285 km during the investigation week as a whole (30 respondents).

Thereupon, results will be presented from an analysis of respondents who have moved to their present dwelling from another residential address within

Copenhagen Metropolitan Area during the last five years (section 6.5). Next, the effects of four key urban structural variables (see below) are compared with the effects of a number of more detail-level urban structural characteristics (section 6.6), followed by an analysis of factors influencing the annual driving distance of the cars belonging to the respondents' households (section 6.7). As a triangulation (Patton, 1987) and partially a deepening of the analysis, section 6.8 comprises a comparison of the results of the main survey with analyses of some of the same relationships based on the travel diary investigation.

6.2 METHODS OF THE MULTIVARIATE STATISTICAL ANALYSES

In most of the multivariate analyses of the data from the main survey, 23 independent variables were included:

- Four urban structural variables (location of the residence relative to the centre of Copenhagen,²¹ the closest second-order urban centre²² and the closest urban railway station,²³ and density of inhabitants and workplaces within the local area of the residence²⁴).
- Four variables describing demographic characteristics of the respondent and the household to which he or she belongs (sex, age, number of household members below seven years of age, number of household members aged 7–17).
- Eight variables describing socio-economic characteristics of the respondent (workforce participation, whether or not the respondent is a student/pupil, whether or not the respondent is a pensioner, personal annual income, whether the respondent holds a driving licence, number of cars per adult household member, whether the respondent has a higher education within technical or economic subjects (yes/no), whether the respondent has a short or medium-long education as a tradesman or industrial worker (yes/no)).
- Two attitudinal variables (indices for attitudes to transport issues and environmental issues, respectively, based on the respondents' answers to seven separate questions within each category).
- Five other control variables indicating particular activities, obligations or social relations likely to influence travel behaviour (regular transport of children to school or kindergarten, number of days at the workplace or school during the investigated week, overnight stays away from home more than three nights during the investigated week, official trips during the investigated week, and whether or not the respondent had moved to the present dwelling less than five years ago).

The four urban structural variables of the main analyses were chosen from theoretical considerations. Distances to central Copenhagen and the closest second-order centre tell something about the location of the residence in relation to the metropolitan-scale hierarchy of centres. The distance to the closest urban railway station indicates the accessibility of the residence to the main public transport system of the region (and to local centres usually located around the stations), whereas local-area density tells something about the population base as a condition for local facilities. In addition to the four main urban structural variables, another 35 more detailed urban structural variables were, as already mentioned, investigated in separate analyses (see section 6.6).

Appendix 1 provides an overview of the 23 variables included in most of the multivariate analyses, their assumed²⁵ influences on travel behaviour, and (for the control variables) the reasons why we have considered it appropriate to include the variable in the analysis. In the travel diary survey, car ownership in the household when the respondent was a child was also included among the control variables, along with place of residence during childhood and leisure preferences.

In some American and Japanese studies, specially constructed accessibility variables (e.g. 'Mean Opportunity Distance') have been used instead of more 'traditional' urban structural variables like local area density or the distance to the main city centre or other defined centres (e.g. Kitamura *et al.*, 1997; 2000). This approach may be interpreted as an adaptation to the more polycentric situation in many American cities, compared to typical European cities. This approach implies, however, that other attractive aspects of an area than the mere concentration of facilities (e.g. aesthetical and 'atmospheric' qualities typical of the central area in many cities) disappear. As guidance for urban planning it is also probably more interesting to know how the location of the dwelling relative to various types of centres affects travel behaviour, than it is to know the relationship between travel behaviour and, for example, the 'mean opportunity distance'.²⁶

The multivariate regression analyses have been carried out by means of a so-called 'backward elimination method'. First, a regression analysis is conducted, including all independent variables of the model (most often 23 variables, cf. above). Unless all variables show effects satisfying a required significance level (in our analyses set at $p = 0.15$), the variable with the weakest significance level is excluded. The process continues until the model includes only variables meeting the required significance level.

Our choice of the quite liberal significance level requirement of $p = 0.15$ is partly motivated by a wish to include all theoretically reasonable influences, also when these tendencies are somewhat weak and uncertain. A significance level of 0.15 implies that there is 15 per cent probability that the relationship in question is a result of chance – but on the other hand, this also implies that there is 85 per cent

likelihood that the relationship is *not* a result of coincidence (provided that control has been made for other, relevant factors).

The liberal required significance level could also be considered a rule of cautiousness, helping to avoid overestimation of the effects of urban structural variables due to the exclusion of relevant control variables from the regression model.

Based on the various sets of multivariate regression analyses, calculations have been made of the controlled effects of residential location on the travel activity of each respondent. This has been done by keeping all variables with effects meeting the required significance level ($p = 0.15$) constant at mean values, while inserting the respondent's actual values for all urban structural variables included in the regression model. Based on the estimates thus derived of expected travelling patterns emanating from the various residential addresses, average, expected values for travelling distances and modal shares have been calculated for each of the 29 investigated areas.

The 23 independent variables included in most of our multivariate analyses might appear to be quite a high number, possibly leading to so-called multicollinearity problems (unreliable statistical analyses because of too strong mutual correlations between some of the independent variables). However, formal collinearity diagnostics do not indicate any such problems.²⁷ Notably, there is low multicollinearity between the four urban structural and the non-urban-structural variables.²⁸

However, because of a high multicollinearity with the four main urban structural characteristics mentioned above, a number of more detailed urban structural features could not be included in the ordinary analyses. In some particular analyses, the impacts of these detail-level urban structural conditions have been investigated by replacing one or more of the main urban structural variables with a detail-level urban form variable (see section 6.6).

6.3 TRAVEL DISTANCES

Below, the results of the multivariate analyses of factors influencing travelling distances will be presented. In order to illustrate the multitude of influences at play, the analysis of variables influencing the total distance travelled on weekdays will be presented in detail. Thereupon, the results of the analyses of factors influencing distances travelled by different modes will be presented more briefly. The same applies to the influences on travelling distances at the weekend and for the week as a whole. In all these analyses, respondents with extreme travel distances have been excluded (see section 6.1). Among the remaining respondents, the mean travel distance during the five weekdays (Monday–Friday) is 188 km, of which 132 km by car, 9 km by bus, 28 km by train, 17 km by walk/bike and 2 km by motorcycles or scooters.

According to the multivariate analysis, 17 out of the 23 independent variables show effects on the travel distance on weekdays with a significance level below 0.15 (Table 6.1). Of these variables, three are urban structural, namely the location of the residence relative to central Copenhagen, the distance from the residence to the closest second-order urban centre, and the distance between the residence and the closest urban railway station. The location relative to central Copenhagen has clearly the strongest effect of the three, and the third strongest effect among all investigated variables. According to our analysis, the variables included in Table 6.1 account for 27 per cent of the variation in the respondents' travel distance on weekdays. Given the considerable scope for random variation (e.g. concerning the addresses of the acquaintances of the respondents and whether longer recreational or visiting trips are carried out during the week of investigation or in another week), this must be considered a fairly high power of explanation.²⁹

According to our analysis, the following characteristics of the respondents contribute to increasing the total distance travelled on weekdays: official trips carried out during the investigated week, high car ownership, long distance from the dwelling to central Copenhagen, many overnight stays away from home during the investigated week, long technical or economic education, not being a pensioner, few or no children below seven years in the household, car-oriented transport attitudes, high income, being a male, many days of appearance at workplace/school during the week, long distance from the residence to the closest second-order urban centre, short or medium-long 'blue collar' education, few or no schoolchildren in the household, long distance from the dwelling to the nearest urban railway station, and age not deviating much from 45 years.

Almost all these effects are in accordance with our theoretical considerations (see Appendix 1). The only effect not mentioned among the expected relationships is the influence from the number of schoolchildren in the household. From theoretical considerations it is difficult to predict how the number of children aged 7 to 17 in the household would influence travel behaviour. On the one hand, schoolchildren often need to be transported to and from school and leisure activities. On the other hand, these activities will to some extent tie the family to the local district (defined with a relatively wide demarcation), reducing their opportunities to make longer leisure and visiting trips. Maybe the geographical area considered relevant as a job market will also be reduced (in particular among women, given current gender differences in wages as well as mobility)? Our material suggests that the latter influences are stronger than the former, as the total effect of schoolchildren on the household is a reduced amount of travel.

Keeping all other variables (including the remaining urban structural variables) constant, our material indicates that respondents living at a distance of 40–45 km from central Copenhagen travel on average 65 km longer during the five weekdays than their counterparts living 1–2 km away from the city centre. Per day, this equals

Table 6.1 Results from a multivariate analysis of the influence from various independent variables on the total travel distance (km) on weekdays during the week of investigation

	<i>Unstandardized coefficients</i>		<i>Standardized coefficient</i>	<i>Level of significance (p value)</i>
	<i>B</i>	<i>Std. error</i>	<i>Beta</i>	
Occupational trips during the investigated week (yes = 1, no = 0)	83.36	10.80	0.192	0.000
Number of cars per adult household member	76.57	12.58	0.165	0.000
Location of the residence relative to central Copenhagen (non-linear distance function, values ranging from 0.66 to 3.80)	20.53	4.01	0.145	0.000
Overnight stays away from home more than three nights (yes = 1, no = 0)	83.52	15.22	0.128	0.000
Long technical or economic education (yes = 1, no = 0)	51.96	13.21	0.096	0.000
Pensioner (yes = 1, no = 0)	-42.02	16.16	-0.090	0.009
Number of household members below 7 years of age	-23.81	7.43	-0.076	0.001
Index for transport attitudes (high value = car-oriented attitudes, values ranging from -17 to 11)	2.092	0.789	0.069	0.008
Personal annual income (1,000 DKK)	0.0523	0.0210	0.068	0.014
Sex (female = 1, male = 0)	-23.57	8.83	-0.067	0.008
Number of days at the workplace or school	4.65	2.64	0.058	0.078
Logarithm of the distance (metres) from the residence to the closest second-order urban centre (log values ranging from 2.49 to 4.46)	26.40	14.84	0.055	0.075
Short or medium-long education as a tradesman or industrial worker (yes = 1, no = 0)	25.98	11.88	0.053	0.029
Number of household members aged 7 -17	-10.95	5.86	-0.047	0.063
Logarithm of the distance (metres) from the residence to the closest urban railway station (log values ranging from 1.90 to 4.47)	14.48	9.01	0.046	0.108
Age (deviation from being 'middle-aged', logarithmically measured)	-24.35	15.07	-0.045	0.106
Constant ^a	-41.23	51.35		0.422

Only variables with a level of significance of 0.15 or lower are included. The regression models included the same 23 independent variables as in Appendix 1. N = 1,414 respondents from 29 residential areas in Copenhagen Metropolitan Area. Adjusted R² = 0.269

a The constant term is a merely theoretical figure showing the calculated value of the dependent variable (travel distance) if all independent variables of the model had the value of zero. This will never occur, for example no respondent has zero income or zero as the value of the non-linear function by which the distance from the residence to central Copenhagen is measured. The negative value of the constant term thus does not reflect any real-life situation.

a difference of 13 km. The corresponding daily differences between the respondents living closest to and furthest away from a second-order urban centre and an urban railway station are 10.5 km and 7.5 km, respectively.

Figure 6.1 shows how the total travel distance during the five weekdays of the week vary with the location of the residence relative to central Copenhagen, controlling for the above-mentioned other factors of influence. The photos show examples of housing environments typical for different locations.

The curve in the middle depicts the relationship when all the control variables, including other urban structural characteristics than the distance from the residence to the city centre, are kept constant at mean values. This is, however, not quite a realistic situation, because other urban characteristics such as the distances to second-order urban centres and urban railway stations are typically much longer in

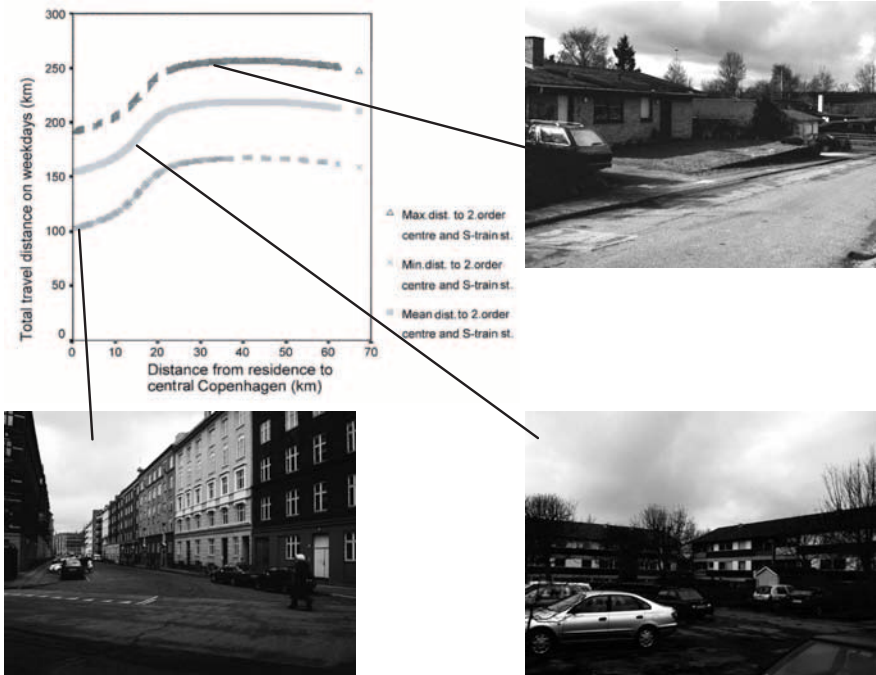


Figure 6.1 Average daily travelling distances over weekdays (Monday–Friday) among respondents living at different distances from the centre of Copenhagen, controlled for a number of socio-economic, attitudinal, urban-structural and other control variables. Examples of typical housing environments at various distances from the city centre are shown in the pictures
The relationship is shown for three different situations regarding the location of the residence relative to second-order urban centres and local centres with urban railway (S-train) stations. In all three curves, the non-urban-structural variables have been held constant at mean values. N = 1,414, p = 0.000

the outer parts than in the inner city. The upper curve shows the relationship between travel distance and the location of the dwelling relative to central Copenhagen when the distances to the closest urban railway (S-train) station and the closest second-order urban centre are kept constant at *maximum* values, and the socio-economic and attitudinal variables are kept constant at mean values. Conversely, the lower curve shows the relationship when the distances to the closest urban railway station and the closest second-order urban centre are kept constant at *minimum* values, and all the other control variables are kept constant at mean values. Because very short distances to urban railway stations and second-order centres do not occur in the peripheral parts of the region, and very long distances to such destinations do not occur in the inner city, the respective parts of the lower and upper curves have been dotted.

In order to illustrate the total effect of residential location on the amount of travel on weekdays, Figure 6.2 shows the average, expected distances travelled

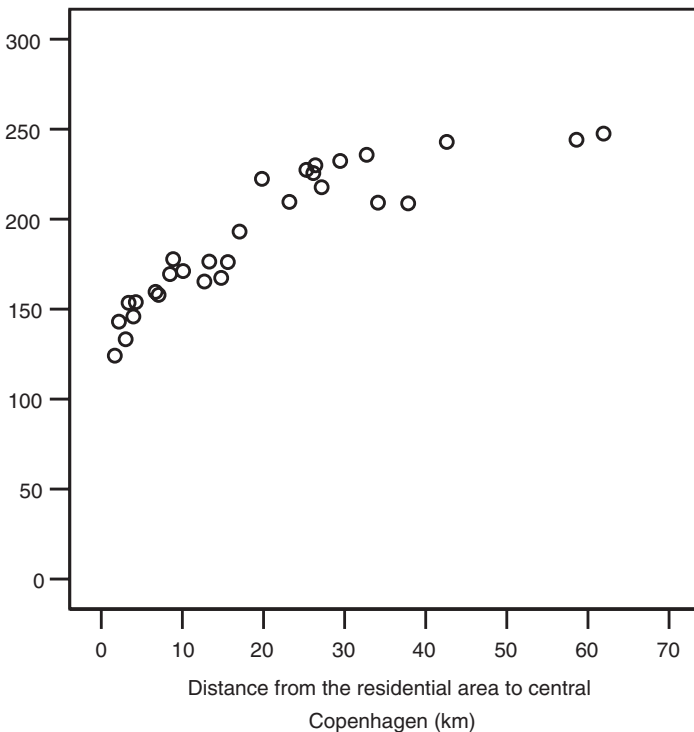


Figure 6.2 Average expected travel distances (km) over the five weekdays for each of the 29 investigated areas, based on the respondents' actual values on each of the three urban structural variables of the regression model, and with all other independent variables kept constant at mean values
 N = 1,414, p = 0.000

during the period Monday – Friday for each of the 29 residential areas of the study, based on the respondents' actual values on each of the three urban structural variables of the regression model, and with all other independent variables kept constant at mean values. In the figure, the residential areas have been sorted according to their distance from the city centre of Copenhagen.

Keeping the values of the non-urban-structural variables constant at mean values, the expected average travel distance over the five weekdays is 124 km at Vesterbro, where the respondents live on average 1.7 kilometres from the city centre. In the most peripheral area, Haslev, the expected distance travelled is twice as high (248 km). Per weekday this implies a controlled difference between the inner-city location and the outer periphery of 25 km.

Table 6.2 shows the influences of the four main urban structural variables on travel distances by different modes on weekdays, as well as on the total distance travelled at the weekend and over the whole week. In general, transport on weekdays is much more influenced by urban structure than transport at the weekends. Compared to weekend and holiday travel, trips on weekdays are to a much higher extent a result of routine tasks and obligations such as going to the workplace or

Table 6.2 Results from multivariate analysis of the influences of the four main urban structural variables on travel distances by different modes on weekdays, and on the total travel distances at the weekend and for the week as a whole

<i>Urban structural variables</i>	<i>Dependent variables</i>					
	<i>Travel distance by car on weekdays</i>	<i>Travel distance by walk/bike on weekdays</i>	<i>Travel distance by train on weekdays</i>	<i>Travel distance by bus on weekdays</i>	<i>Total travel distance at the weekend</i>	<i>Total travel distance during the whole week</i>
Location of the residence relative to central Copenhagen	0.114 (0.000)	-0.094 (0.000)	0.119 (0.000)	(n.s.)	0.045 (0.102)	0.119 (0.000)
Logarithm of the distance from the residence to the closest second-order urban centre	(n.s.)	(n.s.)	(n.s.)	0.065 (0.019)	(n.s.)	(n.s.)
Logarithm of the distance from the residence to the closest urban railway station	0.059 (0.016)	(n.s.)	(n.s.)	(n.s.)	(n.s.)	0.052 (0.048)
Density of inhabitants and workplaces within the local area of the residence	(n.s.)	(n.s.)	(n.s.)	(n.s.)	(n.s.)	(n.s.)

Standardized regression coefficients, significance levels in parentheses (n.s. = not significant at the 0.15 level). Only effects with a level of significance of 0.15 or lower are included. The regression models included the same 23 independent variables as in Appendix 1, except for days of appearance at workplace/school, which were not included in the analysis of travel at the weekend. N = 1,414 respondents from 29 residential areas in Copenhagen Metropolitan Area

school, taking children to daycare, etc. In other words, the proportion of 'bounded trips' is higher on weekdays. At the weekend, the location of the residence relative to central Copenhagen is the only urban structural variable influencing the distance travelled. At the weekend too, living in the outer parts of the metropolitan area contributes to an increase in the amount of travel, but the effect is weak. Yet, the fact that a peripheral residential location contributes to increase the distance travelled both on weekdays and at the weekend indicates that there is no general tendency to 'compensatory' weekend travel.

The location of the residence relative to central Copenhagen stands out as a key urban structural factor exerting a strong impact on the residents' patterns of travelling. This variable influences travelling distances on weekdays by all modes except bus, and the total distance travelled both on weekdays, at weekends and for the week as a whole. Apart from its effects on the total distance travelled on weekdays (cf. Table 6.1), the distance from the residence to the closest second-order urban centre only influences the distance travelled by bus on weekdays, whereas the distance to the closest urban railway station influences travel distance by car on weekdays as well as the total distance travelled over the week. According to our analysis, the local area density exerts no direct, controlled effect on travel distances. However, local area density influences the provision of local service, for example in second-order urban centres and around urban railway stations. Local area densities also add up to the overall density of the city. The higher the population density of the city as a whole, the lower will be the average distance between the residences and the central area. In this way, local area densities indirectly influence the urban structural variable that, according to our studies, exerts the strongest influence on travelling distances.

Similar to Figure 6.2, Figures 6.3 to 6.5 show average expected values for each of the 29 investigated areas in terms of total travel distance at the weekend, travelling distances by car on weekdays and at the weekend, and by non-motorized modes and by train on weekdays. The diagrams are based on the respondents' actual values on each of the urban structural variables of the regression models, with all non-urban-structural variables kept constant at mean values.

According to our material, the *total distance travelled at the weekend* is influenced by only one urban structural variable, namely the location of the dwelling relative to central Copenhagen. The effect is quite modest and somewhat uncertain ($p = 0.10$). When the remaining investigated factors of influence are kept constant at mean values, the average distance travelled at the weekend is 82 km among respondents living 35–50 km from the city centre of Copenhagen, compared to 72 km among the respondents living closest to the inner-city area. This equals 5 km per day during the weekend, whereas the corresponding difference on weekdays was 25 km. The analysis shows that the investigated variables can explain variation in travelling

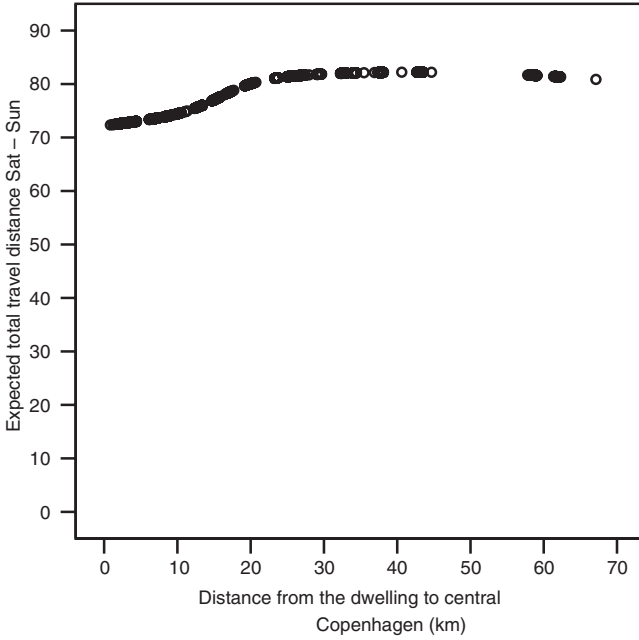


Figure 6.3 Average daily travelling distances at the weekend among respondents living at different distances from the centre of Copenhagen, controlled for a number of socio-economic, attitudinal, urban-structural and other control variables. Non-urban-structural variables have been kept constant at mean value. N = 1,387, $p = 0.102$

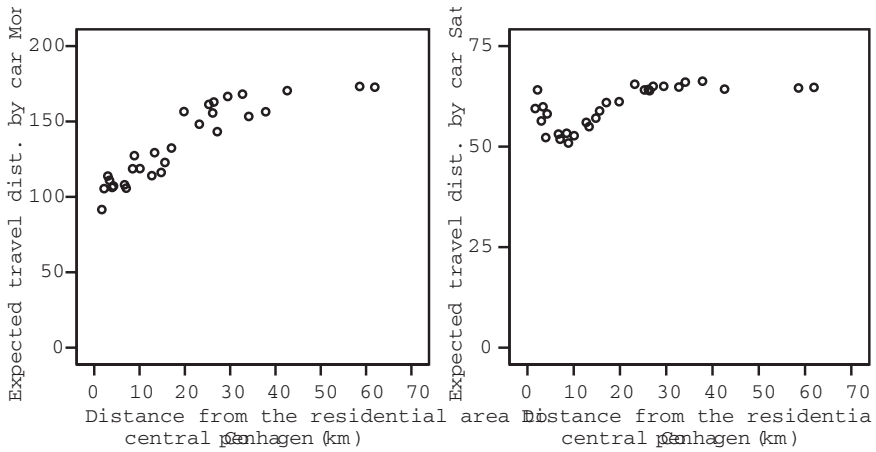


Figure 6.4 Average expected distances (km) travelled by car on weekdays (to the left, $p = 0.000$) and at the weekend (to the right, $p = 0.000$) for each of the 29 investigated areas, based on the respondents' actual values on each of the two urban structural variables of the regression model, and with all other independent variables kept constant at mean values. N = 1,414 and 1,387, respectively

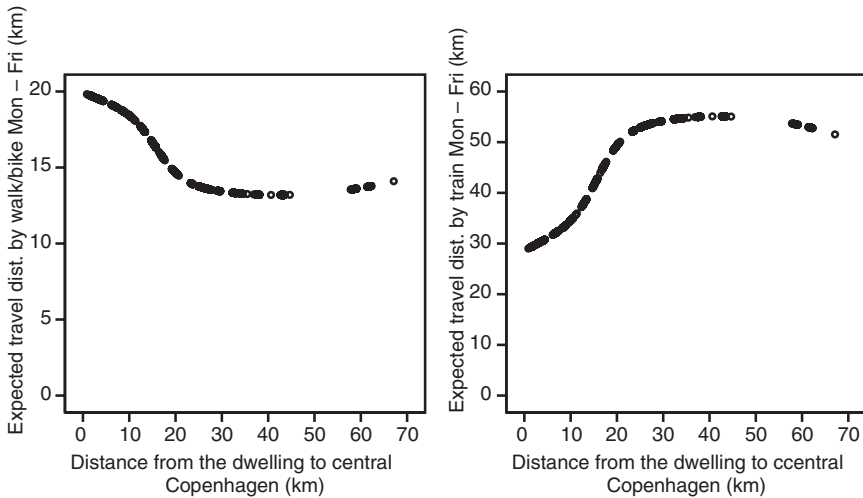


Figure 6.5 Average expected distances (km) travelled on weekdays by walking/bike (to the right, $p = 0.000$) and by train (to the left, $p = 0.000$) among respondents living at different distances from central Copenhagen. Control for non-urban-structural variables. $N = 1,414$

distances to a considerably lower extent at the weekend than on weekdays. According to our material, only 8 per cent of the variation in the amount of weekend travel is attributable to the investigated variables, while the corresponding percentage is 27 per cent on weekdays. This difference mirrors the fact that weekend travel consists of a far higher proportion of 'non-bounded' trips. Compared to the more routine-based weekday travel, these trips are more often subject to random variation and spontaneous decisions about destinations, and can therefore to a lesser extent be explained by urban structural and other more 'static' characteristics of the respondents.

The *travelling distance by car* during the five weekdays is, according to our material, influenced by two urban structural variables: the location of the dwelling relative to central Copenhagen and the closest urban railway station, respectively. Out of these variables, the location relative to the city centre of Copenhagen has the strongest effect. Keeping the investigated non-urban-structural variables constant at mean values, the expected average distance travelled by car on weekdays is 92 km in the most central among our residential areas (Vesterbro). In the two most peripheral areas (Haslev and Gilleleje) the corresponding travelling distance is 173 km, almost 90 per cent higher. Per weekday this implies a difference in car travel of 16.3 km per respondent.

At the weekend too, the expected travelling distance by car is longest in the peripheral areas. However, it is also quite high in the densest and most central parts

of Copenhagen. The lowest expected amounts of weekend travel by car are thus found in areas located within the interval from 4.5–11 km from the city centre of Copenhagen. This reflects a tendency for the distance travelled by car at the weekend to increase the more peripherally the residence is located, but also the higher the local area density. Arguably, the latter is an example of 'compensatory' travel behaviour (cf. Vilhelmson, 1990; Tillberg, 2001; Schlich and Axhausen, 2002). Those who live in dense urban districts may feel a stronger need for travelling to summer cottages or natural areas at the weekend in order to compensate for the absence of a private garden and a general lack of green areas in the local neighbourhood. (This topic will be addressed in depth in Chapter 10.) The tendency to increasing car travel with increasing density is, however, somewhat uncertain and quite weak.

The distance travelled by bike or by foot on weekdays appears to be influenced by only one urban structural variable, namely the location of the residence relative to central Copenhagen. Controlling for the remaining investigated variables, respondents living in the areas closest to the city centre of Copenhagen travel on average about 20 km by non-motorized modes during the period from Monday to Friday, compared to approximately 13 km among respondents living 40–45 km away from central Copenhagen. This implies a daily difference of approximately 1.3 km, that is 50 per cent more walking/biking among respondents living in the city centre than among their peripheral-area counterparts.

At the weekend, the relationship between residential location and travelling distance by non-motorized modes is less clear, with urban structural characteristics partly counteracting each others' effects. Thus, the amount of walk/bike weekend travel tends to be reduced the further away the residence is located from central Copenhagen as well as from the closest second-order centre. On the other hand, living close to an urban railway station also seems to reduce the distance travelled by non-motorized modes at the weekend – possibly because trips by train will then replace some of the bike trips (especially among respondents without a car), and because of shorter walking/biking distances from the home to the train station. A high local-area density also appears to reduce the amount of non-motorized weekend travel, perhaps reflecting a higher propensity among high-density area residents to make overnight trips by car to summer cottages at the weekend (see Chapter 10).

According to our material, the *distance travelled by train on weekdays* increases the further away from central Copenhagen the dwelling is located. Keeping the remaining variables constant at mean values, the average travelling distance by train during the five weekdays is 55 km among respondents living 40–45 km away from central Copenhagen, compared to 29 km among the respondents living closest to the city centre of Copenhagen. Per weekday this translates into a

differential of 5.2 km. The *travelling distance by bus on weekdays* also tends to increase the more peripherally the residence is located, but in this case the urban structural factor of influence is the distance from the residence to the closest second-order centre. Probably, this reflects a tendency where the longest bus trips on weekdays are typically made to suburban sub-regional centres where the passengers either work or change to an urban rail service. Compared to the difference between centre and periphery in travelling distances by train, the corresponding daily difference in travelling distance by bus is smaller (2.3 km). Our results show that the general tendency to a higher amount of travel on weekdays when living in the peripheral areas applies not only to car driving, but also to travel by train and bus.

At the weekend, none of the urban structural variables turn out with effects worth mentioning on travelling distances either by bus or by train.

6.4 MODAL SHARES

Similar to the analyses of variables influencing travel distances, we will go deeply into the analysis of factors influencing the proportion travelled by one group of modes (walking and cycling), while dealing more briefly with the relationships between urban structural characteristics and the proportions of other modes of travel. Table 6.3 shows the 13 variables that, according to our analysis, show effects on the proportion of distance travelled by foot or bike with a significance level below 0.15. All our main urban structural variables show significant effects on the share of non-motorized travel. The proportion travelled by non-motorized modes tends to increase the closer the residence is located to a second-order centre as well as to central Copenhagen, the higher the density is in the local area, and the further away the residence is located from an urban railway station. The first three of these effects are no surprises (see Appendix 1). The tendency of a lower proportion of walking/biking among respondents living close to an urban railway station may need some explanation, since intuitively a high number of walking/biking trips to local facilities could be expected among those respondents. However, respondents who live close to an urban railway station are likely to choose the train rather than the bike for some of their trips. Besides, the trips by foot or bike between the dwelling and the station (or the service facilities often located in its proximity) will be shorter when you live close to the station. This contributes to reducing the proportion of *distance* travelled by walking/biking, although the proportion of *trips* may increase.

However, the influences of the urban structural variables are considerably lower than the effects of car ownership and transport attitudes. Not unexpectedly, the proportion of non-motorized travel tends to decrease if car ownership is high

Table 6.3 Results from a multivariate analysis of the influence from various independent variables on the proportion of distance travelled by foot or bike on weekdays during the week of investigation

	<i>Unstandardized coefficients</i>		<i>Standardized coefficient</i>	<i>Level of significance (p value)</i>
	<i>B</i>	<i>Std. error</i>	<i>Beta</i>	
Number of cars per adult household member	-0.226	0.023	-0.258	0.000
Index for transport attitudes (high value = car-oriented attitudes, values ranging from -17 to 11)	-0.0126	0.001	-0.221	0.000
Logarithm of the distance (meters) from the residence to the closest second-order urban centre (log values ranging from 2.49 to 4.46)	-0.113	0.030	-0.124	0.000
Location of the residence relative to central Copenhagen (non-linear distance function, values ranging from 0.66 to 3.80)	-0.0227	0.009	-0.085	0.010
Density of inhabitants and workplaces within the local area of the residence (inhabitants + workplaces per hectare)	0.00041	0.000	0.075	0.032
Occupational trips during the investigated week (yes = 1, no = 0)	-0.0598	0.019	-0.073	0.002
Overnight stays away from home more than three nights during the investigated week (yes = 1, no = 0)	-0.0847	0.028	-0.068	0.002
Student/pupil (yes = 1, no = 0)	0.0737	0.026	0.067	0.005
Logarithm of the distance (meters) from the residence to the closest urban railway station (log values ranging from 1.90 to 4.47)	0.0352	0.017	0.059	0.035
Number of household members below 7 years of age	0.0324	0.013	0.055	0.015
Number of household members aged 7-17	0.0183	0.011	0.042	0.091
Age (logarithmic deviation from being 'middle-age')	0.0372	0.026	0.037	0.146
Long technical or economic education (yes = 1, no = 0)	-0.0357	0.023	-0.035	0.122
Constant	0.557			0.000

Only variables with a level of significance of 0.15 or lower are included. N = 1,406 respondents from 29 residential areas in Copenhagen Metropolitan Area. Adjusted R² = 0.311

and/or the respondent has car-oriented attitudes. In addition, the following characteristics of the respondents contribute to a high share of walking/bike travel: no official trips during the investigated week, being a student or pupil, not having stayed overnight away from home most of the nights of the week, many children in the household (preschool as well as schoolchildren), age close to 45 years, and not having a long technical or economic education. Most of these relationships are in line with our theoretical expectations. Given the widespread practice of driving children to school or kindergarten, it might surprise that having children in the household contributes to increasing the share of travel distance accounted for by non-motorized modes on weekdays. This effect probably partly results from the fact that some parents walk or bike together with their children to school, kindergarten or leisure activities. Besides, it will often be costly and time-consuming for families with children to go by public transport. The resulting lower share of public transport is likely to increase the share of walking/biking, in particular among those who do not have a car at their disposal. Finally, as we have seen in Table 6.1, children in the household contribute to reducing the total amount of travel on weekdays (and also the distance travelled by car). The trips by foot or bike will then increase their relative importance.

The tendency to a lower share of walking/biking among respondents with a long technical or economic education is consistent with findings in the analyses of travel by car and bus that those respondents (many of whom live in high-income suburbs outside the prime service areas of the urban rail) tend to travel longer by the two mentioned motorized modes. Belonging to this educational category also contributes to a higher total amount of transport on weekdays (mirroring a tendency to increased commuting distances among this specialized-skills group of respondents) (cf. Table 6.1). If this increased amount of transport is first and foremost covered by means of motorized modes, the share of walking/biking will automatically decrease. A more speculative, supplementary explanation might be that people within this educational category often work in companies where the 'business culture' (e.g. concerning dress code or 'car preparedness', see Chapter 5) discourages commuting by bike.

Keeping the non-urban-structural variables constant at mean values (see Figure 6.6), the expected walking/biking share of the distance travelled on weekdays is 40 per cent in the residential area of Amager North, where distances are short both to central Copenhagen and the closest second-order urban centre, local-area density high, and the distance to the nearest urban railway station quite long. In the area least oriented towards walking/biking, Stenløse (one of our interviewee areas, cf. Chapter 5), the expected share of walking/biking is only 10 per cent. This area is located far away from central Copenhagen as well as the closest second-order urban centre, and has a low local-area density of inhabitants and workplaces. Besides, the respondents from this area all live close to an urban railway station.

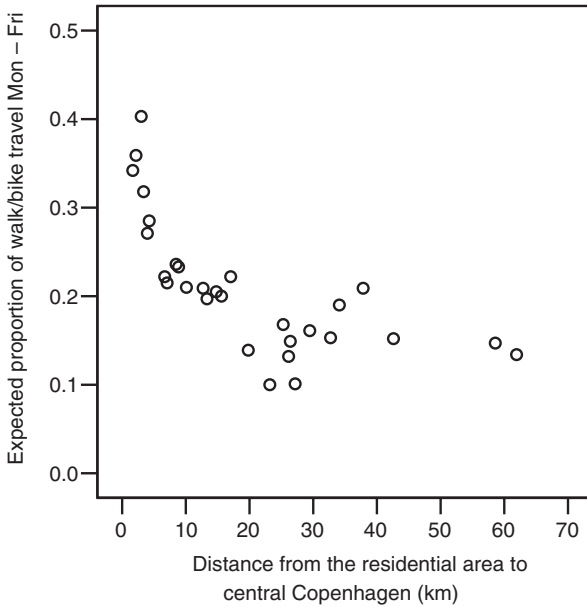


Figure 6.6 Average expected proportions of distance travelled by walking/bike on weekdays for each of the 29 investigated areas, based on the respondents' actual values on each of the four urban structural variables of the regression model, and with all other independent variables kept constant at mean values
N = 1,406, p = 0.000

Table 6.4 shows the results of the analyses of the four main urban structural variables on the proportions of distance travelled by car and public transport on weekdays, walking/biking, car and public transport at the weekends, and walking/biking over the whole week. As can be seen, the location of the residence relative to central Copenhagen has a significant influence on most of the modal shares shown in the table. The further away the respondents live from central Copenhagen, the more important is the car to their transport on weekdays as well as at the weekend, and the less important are the non-motorized modes. The distance from the dwelling to the closest second-order centre exerts similar influences on modal shares as the distance to the city centre, with somewhat stronger effects on the proportions of walking/biking and slightly weaker effects on the proportion of distance accounted for by private cars. All these effects are in line with our theoretical considerations (see Appendix 1). At the weekends, living far away from central Copenhagen also contributes to a smaller share of public transport, in contrast to the situation on weekdays where no such relationship was found.

Living close to an urban railway station does not seem to affect the proportions travelled by car or public transport sufficiently strongly to produce significant effects.

Table 6.4 Results from multivariate analyses of the influences of the four main urban structural variables on the proportions of distance travelled by different modes

<i>Urban structural variables</i>	<i>Dependent variables</i>					
	<i>Share of distance travelled by car on week-days</i>	<i>Share of distance travelled by public transport on week-days</i>	<i>Share of distance travelled by walk/ bike at the weekend</i>	<i>Share of distance travelled by car at the weekend</i>	<i>Share of distance travelled by public transport at the weekend</i>	<i>Share of distance travelled by walk/ bike during the whole week</i>
Location of the residence relative to central Copenhagen	0.069 (0.003)	(n.s.)	-0.052 (0.077)	0.080 (0.002)	-0.122 (0.001)	-0.116 (0.000)
Logarithm of the distance from the residence to the closest second-order urban centre	0.045 (0.058)	(n.s.)	-0.099 (0.000)	0.063 (0.018)	(n.s.)	-0.146 (0.000)
Logarithm of the distance from the residence to the closest urban railway station	(n.s.)	(n.s.)	(n.s.)	(n.s.)	(n.s.)	0.064 (0.020)
Density of inhabitants and workplaces within the local area of the residence	(n.s.)	-0.101 (0.000)	(n.s.)	(n.s.)	-0.101 (0.007)	(n.s.)

Standardized regression coefficients, significance levels in parentheses (n.s. = not significant at the 0.15 level). Only effects with a level of significance of 0.15 or lower are included. The regression models included the same 23 independent variables as in Appendix 1, except for days of appearance at workplace/school, which were not included in the analysis of travel at the weekend. N = 1,414 respondents from 29 residential areas in Copenhagen Metropolitan Area

For the week as a whole, a long distance to the closest urban railway station contributes to a somewhat higher proportion of walking/biking, reflecting the above-mentioned, similar effect on weekdays. Maybe a bit surprisingly, a high local-area density contributes to reduced proportions of public transport on weekdays as well as at the weekends. Below, we shall take a closer look at the influences of urban structural variables on the proportions of distance traveled by the various modes. In this discussion, some plausible explanations of the above-mentioned counter-intuitive effects will also be offered.

Similar to the previous figures, Figure 6.7 shows the expected average *proportions of distance travelled by car* on weekdays (to the left) and at the weekend (to the right) in each of the investigated areas, keeping non-urban-structural variables constant at mean values. Both on weekdays and at the weekend, the proportion of car travel is influenced by the same two urban structural characteristics: the location of the residence relative to central Copenhagen and to the closest urban railway station. In both cases, the distance to central Copenhagen has the stronger effect. As we can see from the diagrams, the relationship between residential location and proportion of

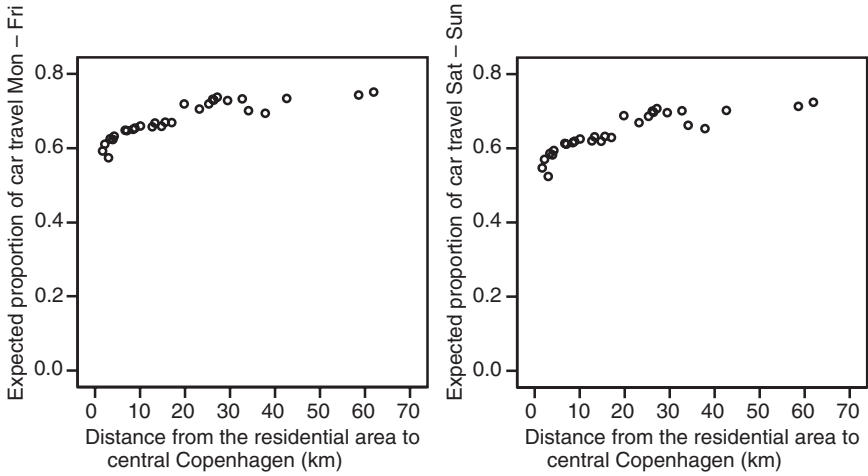


Figure 6.7 Average expected proportions of distance travelled by car on weekdays (to the left, $p = 0.003$) and at the weekend (to the right, $p = 0.001$) for each of the 29 investigated areas, based on the respondents' actual values on each of the two urban structural variables of the regression models, and with all other independent variables kept constant at mean values
 N = 1,406 and 1,387, respectively

car travel is almost identical on weekdays and at the weekend, apart from a couple of per cent higher general proportion of car travel at the weekend.

Controlling for non-urban structural variables there is an expected difference of 18 percentage points in the proportion of distance travelled by car on weekdays between the respondents living most peripherally (i.e. with the longest distances to central Copenhagen as well as to the closest second-order centre) and their counterparts living closest to both the city centre of Copenhagen and the closest second-order centre. The expected proportions of car travel are about two thirds and slightly below one half of the travelling distance, respectively. At the weekend (Figure 6.7, above, to the right) the expected proportion of car travel is 52 per cent in the latter residential area, compared to 71 per cent and 72 per cent in the two most peripherally located areas.

Figure 6.8 shows the expected proportion of walking/biking travel at the weekend, keeping non-urban-structural variables constant at mean values. According to our analysis, the proportion of distance travelled by non-motorized modes at the weekend is influenced by the same urban structural variables as the proportion travelled by car: the location of the residence relative to central Copenhagen and to the closest second-order centre. The effect of the latter variable is the stronger of the two. The proportion of walking/biking travel at the weekend tends to be reduced the further away the dwelling is located from the closest second-order centre as well as

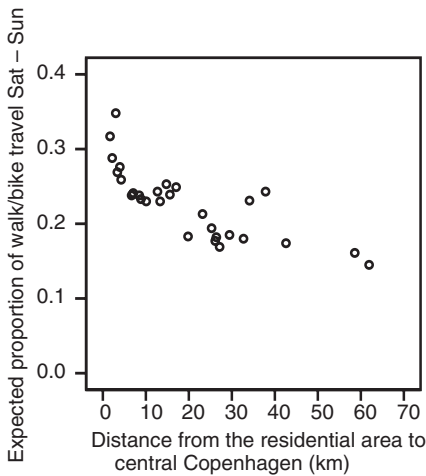


Figure 6.8 Average expected proportions of distance travelled by walking/bike at the weekend for each of the 29 investigated areas, based on the respondents' actual values on each of the two urban structural variables of the regression model, and with all other independent variables kept constant at mean values
N = 1,387, $p = 0.000$

from central Copenhagen. Thus, at the weekend too there is a clear tendency to higher proportions of non-motorized travel among respondents living in the inner and central parts of the region. The most important nuances in this pattern are the two peripheral residential areas located close to the outer-region towns of Køge and Hillerød, where the expected shares of walking/biking travel are considerably higher than in the remaining peripheral areas. Among the central residential areas, the expected proportion of walking/biking travel is especially high on Amager North, due to the proximity of this investigation area to the second-order centre around Amager Boulevard. (This residential area was also the one with the lowest expected proportions of car travel both on weekdays and at the weekend, cf. Figure 6.7.)

According to our material, the *proportion of distance travelled by public transport on weekdays* is influenced by only one urban structural variable, namely the density of inhabitants and workplaces in the local area of the residence. Maybe a bit surprising, the relationship is negative: the higher the density, the lower the proportion of distance travelled by collective means of transport tends to be. Intuitively, the opposite tendency might perhaps be expected, as the most extensive provision of public transport services usually exists in the densest parts of the city. However, in the same quarters, the distances to a host of workplaces and service facilities are also short enough often to make many respondents prefer non-motorized modes rather than walking to the bus stop or train station, waiting for the public transport

vehicle to appear, travelling a short distance of one or two station intervals, and finally walking from the station of arrival to the destination of the trip. When these respondents' destinations are beyond acceptable walking or biking distances, the trip ends are often located in outer parts of the region with poorer accessibility by public transport (less frequent departures, longer walking distances to and from stations and bus stops). Those respondents who have a car at their disposal will then often prefer the car to bus or train for such trips.

At the weekend too, we find a tendency for lower shares of travel by public transport, the higher the local-area density. At the same time, location of the residence close to central Copenhagen contributes to increasing the proportion of distance travelled by collective modes. This difference between weekdays and weekends might possibly reflect the location of a higher proportion of weekend destinations in the outer parts of the metropolitan area. Respondents living in the inner and central areas would then have a higher need for motorized travel at the weekend than on weekdays, when this need is reduced due to the high concentration of workplaces and service facilities in inner-city Copenhagen. Due to the structure of the public transport network, with most of the lines 'radiating' out from the central area of Copenhagen, it is considerably easier to reach a random destination in the outer parts of the region by public transport from the inner-city of Copenhagen than from trip origins in the outer suburbs. The simultaneously working tendency for a reduced share of public transport at the weekend the higher the local-area density may, in addition to the mechanisms discussed above in connection with weekday travel, also reflect a certain 'compensatory' transport behaviour among residents of dense urban areas (e.g. trips to summer cottages, cf. Chapter 10). Such trips are typically made by car and will, both due to their length and because they replace other trips where public transport might have been more relevant alternatives, contribute to reduce the proportion of weekend transport carried out by collective modes of travel.

The combined impacts of the oppositely directed effects of the two urban structural variables can be seen in Figure 6.9. The highest expected proportions of travel by public transport we find among respondents living some 5–11 kilometres away from central Copenhagen, where densities are usually not high enough to trigger 'compensatory' travel behaviour, but with public transport services still sufficiently high to contribute to fairly high proportions of travel for trips to outer-area destinations. These areas are also located at a sufficiently long distance from central Copenhagen to create a need for motorized transport to cinemas, restaurants, dancing facilities and other central destinations at the weekend. This too will contribute to increasing the proportion of public transport at the weekend among respondents living in the inner suburbs.

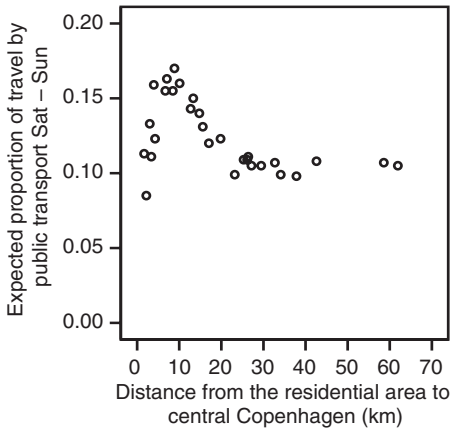


Figure 6.9 Average expected proportions of distance travelled by public transport at the weekend for each of the 29 investigated areas, based on the respondents' actual values on each of the two urban structural variables of the regression model, and with all other independent variables kept constant at mean values
N = 1,387

6.5 TRANSPORT CONSEQUENCES OF HAVING MOVED

An examination of those respondents who had moved from one residence within the Copenhagen Metropolitan Area to another during the last five years (485 respondents) brings additional support to the results presented in section 6.3 concerning the influence on the amount of travel from the location of the dwelling relative to central Copenhagen. Figure 6.10 shows how the numbers of these respondents who, according to their own judgement, had experienced increased and decreased amounts of transportation, respectively, *due to the move*, varies according to changes in the distance between the residence and central Copenhagen.

Although many respondents, in particular among those who had not changed their distance from the city centre significantly, have experienced no significant change in the amount of travel, there is a clear tendency for increasing amounts of transport when moving outward and decreasing when moving closer to the city centre. Among those respondents who have moved to a dwelling more than 15 km closer to central Copenhagen than the previous one, the proportion who consider that the move has led to a reduced amount of travel is more than three times as high as those who consider the opposite. Among those respondents who have had the distance between their residence and the city centre of Copenhagen reduced by less than 15 km, the corresponding ratio is one and a half times.

Among those respondents who have moved outward to a dwelling located more than 15 km further away from central Copenhagen than the previous one,

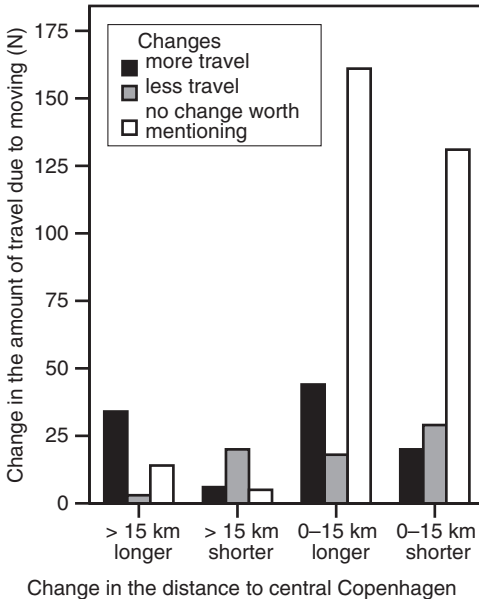


Figure 6.10 Numbers of respondents who, according to their own judgment, have experienced increased, decreased or unchanged amounts of transportation due to moving closer to or further away from central Copenhagen
N = 485, p = 0.000

almost none have reduced their amount of travel, while approximately two thirds have increased their amount of travel due to the move. Among the outward-moving respondents who have had more modest (less than 15 km) changes in the distance from central Copenhagen there is also a clear majority who have increased their amount of travel due to moving, compared to the proportion who travel less after the move. The ratio between these two fractions is two and a half times.

It should still be noted that among the respondents who had increased or reduced the distance from their dwelling to the city centre of Copenhagen by less than 15 km, the move had most commonly not caused any change worth mentioning in the amount of travel (see below).

The pattern shown in Figure 6.10 is consistent with the stories told by several of the interviewees of the qualitative interviews about increasing daily amounts of travel after having moved from more central parts of the region to outer-area suburban settlements. In particular, this applies to the interviewees of the most remote interviewee area (Uvelse), where all the eight adult persons belonging to the four interviewee households had increased their amount of travel compared to their previous place of residence, except one interviewee who had moved to Uvelse from a

dwelling located in an even more peripheral part of the metropolitan area. According to the interviewees, increased commuting distances was a major cause of the increases in the overall amount of travel. Material from the travel diary investigation shows that distances to several non-work trip destinations also tend to increase when moving to more peripheral parts of the region, whereas the opposite is true when moving closer to central Copenhagen (see also section 7.4). It should be noted that the number of travel diary respondents who had moved is low, and the relationships must therefore be quite strong in order to obtain statistical significance. In spite of this, we find a very clear pattern where moving toward the periphery of the metropolitan area tends to increase trip distances to 'urban' entertainment and cultural facilities like discotheques, etc. (Pearson's $r = 0.86$, $p = 0.000$) and theatres/cinemas (Pearson's $r = 0.45$, $p = 0.004$). There also appears to be a slight tendency among the travel diary respondents to increasing trip distances to cafés/restaurants after having moved outward in the region, but this relationship is weak and much more uncertain ($p = 0.28$). On the other hand, moving to a more peripheral dwelling has a clear effect in terms of reduced trip distances to forest and shores (Pearson's $r = 0.78$, $p = 0.000$). However, such trips are not carried out often enough to counterbalance the clear tendency to increased trip lengths for journeys to work and a number of non-rural leisure activities as a result of moving outward. Trip distances to grocery shops do not seem to be affected by whether or not the new dwelling is located further away from or closer to central Copenhagen. The latter lack of relationship probably reflects the wide-spread practice among suburban respondents to do grocery shopping somewhere along the route home from work, thus avoiding any additional transport worth mentioning in connection with these tasks.

As can be seen in Figure 6.10, a majority of all respondents who had moved considered that the move had not caused any change worth mentioning in their amount of travel. This must be seen in the light of the fact that a large proportion of the respondents' new residences are located at a distance from central Copenhagen deviating only slightly from the distance from the previous dwelling to the city centre. Among the 485 respondents who had moved, 186 persons (i.e. 37 per cent) had changed their distance to central Copenhagen by less than half a kilometre in either direction. For comparison, the proportion who had the distance from their residence to the city centre increased or decreased by more than 9 km due to the move was only 125 respondents (i.e. 25 per cent).

Multivariate logistic regression analyses show that the relationship between the direction of the move and the change in the amount of travel also holds true when controlling for demographic, socio-economic and attitudinal variables (the significance level of all the following probabilities is 0.000). When the new residence is located 20 km further away from the city centre than the former one, the

likelihood that the move has led to increased transport is 44 per cent. If the distance from the dwelling to the city centre has increased by 40 km, the likelihood of having experienced increased transport due to the move is 75 per cent. Conversely, a move to a residence 20 km closer to the city centre than the original one implies a 32 per cent likelihood of having experienced a reduced amount of transportation due to the move. When the move has brought the household 40 km closer to the centre of Copenhagen, the likelihood of having experienced a reduced amount of transport due to the move is 63 per cent. When the new residence is located at the same distance from central Copenhagen as the former, the likelihood of having experienced increased transport due to the move is 17 per cent, while the likelihood of having experienced a reduced amount of transport is 12 per cent. This difference illustrates the fact that moving in itself often leads to increased needs for transport (e.g. because the family decides to keep the children in the old kindergarten or school for the remaining part of the period) – a point also noted in the qualitative interviews.

6.6 THE ROLE OF MORE DETAILED URBAN STRUCTURAL CONDITIONS

In America, research into land use and transport relationships during recent years has in particular been directed towards the influence of local-scale urban structural conditions on travel behaviour, comparing traditional suburban residential areas with areas developed according to the so-called 'New Urbanism' or 'Transit Oriented Development' principles (Cervero, 2003; Krizek, 2003). In the Copenhagen area study too, a number of detail-level urban structural characteristics were investigated.

As mentioned earlier, high multicollinearity with the four main urban structural variables precluded a number of more detailed urban accessibility and density characteristics from being included in the ordinary analyses. Instead, separate analyses have been made of the relationships between these detail-level variables and travel behaviour. These analyses also include variables where the four main urban structural variables have been measured in alternative ways (e.g. with non-logarithmic instead of logarithmic values).

Table 6.5 shows the results from analyses of the relationships of each of a total of 38 urban structural variables with the respondents' total distance travelled on weekdays, controlling for socio-economic, attitudinal and other non-urban-structural variables but not for any of the other urban structural variables. The urban structural variables have been grouped into six categories: location of the residence relative to the overall centre structure in the metropolitan area, location of the residence in relation to rail-bound public transport, local area density, service facility accessibility in

Table 6.5 Results from separate analyses of the relationships of various detail-level urban-structural variables with the respondents' total distance travelled on weekdays, controlling for non-urban-structural variables

<i>Location of the dwelling relative to the metropolitan-level centre structure:</i>	
Location of the dwelling relative to central Copenhagen (non-linear function)	0.191***
Linear distance along the road network from the dwelling to central Copenhagen	0.179***
Logarithmic dist. along the road network from the dwelling to the closest second-order centre	0.151***
Linear dist along the road network from the dwelling to the closest second-order centre	0.141***
Logarithmic dist. along the road network from the dwelling to the closest regional shopping mall	0.148***
<i>Location of the dwelling relative to railway stations:</i>	
Logarithmic dist. along the road network from the dwelling to the closest urban railway station	0.130***
Linear dist. along the road network from the dwelling to the closest urban railway station	0.134***
Linear dist. along the road network from the dwelling to the closest 'well-serviced' interchange station	0.147***
Linear dist. along the road network from the dwelling to the closest interchange station	0.136***
Linear dist. along the road network from the dwelling to any railway station	0.115***
Residential location less than 500 m away from closest urban railway station (yes = 1, no = 0)	-0.045
Residential location less than 1000 m away from closest urban railway station (yes = 1, no = 0)	-0.079**
Residential location less than 500 m away from any railway station (yes = 1, no = 0)	-0.033
Residential location less than 1000 m away from any railway station (yes = 1, no = 0)	-0.060*
Residential location less than 500 m away from closest interchange station (yes = 1, no = 0)	-0.043
Residential location less than 1000 m away from closest interchange station (yes = 1, no = 0)	-0.047
<i>Density in the surroundings of the dwelling:</i>	
Density of inhabitants & jobs in the local area of the dwelling (inhab.+jobs within a radius of 800 m)	-0.150***
Population density in the local area of the dwelling	-0.143***
Job density in the local area of the dwelling	-0.133***
Density of inhabitants and jobs in the narrowly demarcated residential area	-0.125***
Population density in the narrowly demarcated residential area	-0.126***
Dwellings per hectare in the narrowly demarcated residential area	-0.119***
Job density in the narrowly demarcated residential area	-0.066**
<i>Availability of service facilities in the proximity of the dwelling:</i>	
Combined index for availability of service facilities in the proximity of the dwelling	-0.148***
Index for availability of shopping opportunities in the proximity of the dwelling	-0.144***
Index for availability of primary schools, kindergartens and crèches in the proximity of the dwelling	-0.106***
Index for availability of public sector offices in the proximity of the dwelling	-0.089***
Number of grocery shops within 1.5 km distance from the dwelling	-0.141***
Number of special commodity stores within 1.5 km distance from the dwelling	-0.108***
Linear dist. along the road network from the dwelling to the closest grocery shop	0.093***
Linear dist. along the road network from the dwelling to the closest post office	0.057*
Linear dist. along the road network from the dwelling to the closest town hall	0.081**
Linear dist. along the road network from the dwelling to the closest primary school	0.091***
Linear dist. along the road network from the dwelling to the closest kindergarten	0.028
Linear dist. along the road network from the dwelling to the closest crèche	0.132***

Table 6.5 (Continued)

<i>Local green recreational areas:</i>	
Availability of a recreational area of at least 10 hectares within 0.5 km distance from the dwelling	-0.059*
Availability of a recreational area of at least 10 hectares within 1 km distance from the dwelling	-0.069**
<i>Local street pattern:</i>	
Grid structure (1) or other street patterns (0)	-0.151***

Standardized regression coefficients (Beta values). One separate multivariate analysis has been made for each of the 38 urban structural variables, controlling for the same 19 socio-economic, attitudinal and other non-urban-structural variables as in sections 6.3 and 6.4. but without control for other urban structural variables. Three asterisks after the standardized regression coefficient indicates that the relationship is statistically significant at the 0.001 level. two asterisks that it is significant at the 0.01 level. and one asterisk that it is significant at the 0.05 level.

the proximity of the dwelling, availability of local green recreational areas, and local street structure.

As can be seen in Table 6.5, with one exception, the ‘main urban structural variables’ used in the previous analyses in this chapter are the ones within their respective groups that are most strongly related to travelling distance, as long as control is made for non-urban structural variables. However, the logarithmic distance between the dwelling and the closest urban railway station is less closely related to travelling distance on weekdays than three alternative measures of accessibility to rail-bound public transport, namely the non-logarithmic distance to the closest urban railway station, and the distance to the closest ‘well-served’³⁰ train station (measured logarithmically as well as in ordinary metric values). We still consider it more relevant to include the logarithmic distance to the closest urban railway station among the ‘main urban structural variables’ than any of the above-mentioned alternative measures of public transport accessibility. For one thing, the distance to the closest ‘well-served’ station is quite strongly correlated with the distance to central Copenhagen, and multicollinearity problems would therefore probably occur in the statistical analyses if this variable were chosen. Moreover, limiting the scope to ‘well-served’ stations would imply that the function of ordinary urban railway stations as local centres would largely be missed. Finally, the logarithmic measure appears to be theoretically more well-founded than simply measuring the metric distance to the station, and the latter would also be inconsistent with the way the distance to the closest second-order centre has been measured (where logarithmically measured values also showed a stronger relationship with travel behaviour than ordinary metric values).

As can be seen in Table 6.5, various accessibility index variables show quite a strong relationship with travelling distances when controlling for non-urban-structural

variables only. The accessibility to shopping facilities shows the strongest relationship with travel distances, while differences in the accessibility to schools/ kindergartens and public offices appear to play a lesser role. However, as soon as control is made for the location of the dwelling relative to central Copenhagen, index variables for the accessibility from the dwelling to shopping facilities, primary schools and kindergartens, public authority offices, as well as a composite index including all these facilities show only weak and uncertain effects on weekday travel distances. Even more, this is the case if local area density or the distance to the closest second-order centre is included as a control variable together with the location of the dwelling relative to the city centre.

In line with expectations we find that the proportion travelled by public transport decreases and the share of walking/biking increases, the more accessible various service facilities (in particular shopping) are from the dwelling. Moreover, the proportion of car travel appears to increase and the proportion of walking/biking to decrease, the closer the respondent lives to a large, regional-scale shopping mall. This relationship, also found in a study in the provincial Danish city of Randers (Masoud and Hansen, 2001) might be caused by a tendency to more frequent visits to shopping malls among respondents living in the proximity of such centres. Since these centres are to a high extent facilitating car transport, both in the form of ample parking space and inconvenient access by foot and bike, many customers may choose to drive even if they live quite close to the shopping centre.

Interestingly, density within the narrowly demarcated residential area has quite a strong influence on the proportion of distance travelled by car as well as on car ownership. These effects are stronger than the corresponding effects of density within the larger local area. Limited parking opportunities in the densest residential areas make up a possible explanation for this relationship. On the other hand, access to green recreational areas in the proximity of the dwelling appears to contribute to a slight reduction of the travelling distance, in particular on weekdays.

The detail-level urban structural variables all exert weaker influences on travel behaviour than the four higher-level urban structural variables included in the main analyses. The detailed accessibility variables nevertheless show that proximity to various categories of facilities contributes to reducing the amount of travel as well as the proportion of distance travelled by car. The relationships with travel behaviour are generally stronger, the more facility categories the accessibility indices include. The obvious interpretation of these results is that the four higher-level urban structural variables influence travel behaviour through the accessibility of the various types of facilities. Because the latter variables only capture the travel purposes associated with the facility categories included in the respective indices, their effects are still weaker than the effects of the variables representing the location of the residence relative to the main centre structure of the metropolitan area.

Interestingly, any relationship between the local-level street structure on traveling distance or mode disappears as soon as control is made for the location of the residence relative to central Copenhagen. This gives rise to suspicion that the corresponding relationship in American studies might perhaps reflect the location of the residential areas rather than the shape of the local street network.³¹ In most of the American studies that have attached a great importance to the shape of the local street pattern, control for the location of the residential area relative to the higher-level centre structure seems to be missing.

6.7 ANNUAL DRIVING DISTANCE WITH THE HOUSEHOLDS' CARS

The main questionnaire survey included questions about the annual driving distances of any cars belonging to the household. Based on this material, a multivariate analysis has been carried out in order to identify factors influencing the annual driving distance per adult household member with any cars at the households' disposal.³²

Similar to the previous analyses, control has been made for a number of demographic, socio-economic, attitudinal and other non-urban-structural variables. As might be expected, the driving distance is in particular influenced by car ownership (measured as the number of cars per adult household member). However, we also find significant effects of three urban structural variables:

- The location of the residence relative to central Copenhagen (Beta = 0.075, $p = 0.005$)
- Local-area density (Beta = -0.057 , $p = 0.024$)
- Logarithmic distance from the residence to the closest urban railway station (Beta = 0.040, $p = 0.050$).

The annual driving distance tends to increase the further away the dwelling is located from central Copenhagen as well as from the closest urban railway station, and the lower the density of inhabitants and workplaces in the local area of the residence. All these effects are in line with expectations. Controlling for the other investigated variables (including car ownership), this analysis suggests that the annual driving distance per adult household member will be about 4000 km longer among respondents living in Osted (42 km from central Copenhagen, with low local-area density and a long distance to the closest urban railway station) than among the respondents of the inner-city area of Vesterbro.

For comparison, our analyses of factors influencing the amount of travel on weekdays and at the weekend (cf. section 6.3) indicate that the difference in annual travelling distance per capita between the same two residential locations would be

approximately 6,000 km per respondent, controlling for the other investigated variables. Bearing in mind that the latter figure was person kilometres while the above referred to vehicle kilometres, the results of the two analyses appear to be reasonably consistent. A given number of vehicle kilometres by car usually implies a higher number of person kilometres (roughly 1.5 times as high) due to the average number of passengers in the cars.

As mentioned at the beginning of the chapter, the reasonableness in controlling for car ownership (and some of our other control variables) could be discussed (cf. also Chapter 8). If car ownership is excluded among the independent variables, the effects of the three above-mentioned urban structural variables become stronger and more certain (all significance levels 0.006 or lower). In addition, there is a slight and somewhat uncertain effect of the distance to the closest second-order urban centre ($p = 0.141$), that is, as expected, longer driving distance the further away from such a centre the dwelling is located. Keeping the non-urban structural variables constant, the differential in annual driving distance between Osted and Vesterbro is now more than 8,000 km per capita.

6.8 COMPARISON OF THE RESULTS OF THE MAIN SURVEY WITH ANALYSES BASED ON THE TRAVEL DIARY INVESTIGATION

In addition to the information about the respondents' travel behaviour gathered through the main questionnaire survey, the travel diary investigation also provides information about travel distances by different modes of travel at the weekend and on Monday–Tuesday. The travel diary material also includes a detailed registration of the driving distances of any cars belonging to the respondents' households during the same periods. This registration was made by reading the mileage from the odometers of the cars on Saturday morning (before the first car trip of the day), Sunday evening and Tuesday evening (after the last trip each of the latter days). The travel diary material thus provides the opportunity of conducting similar analyses as those presented in the foregoing, based on a different data material. There are several reasons why such a doubling – or *replication* – may be worthwhile. First, analysis of the same urban structural variables based on a different data material may contribute to consolidating and/or sophisticating the conclusions of the first survey (Yin, 1994; Stinchcombe, 1968). The conclusions drawn from the two data sets jointly may therefore be more solid and robust than if they were based on data from one single investigation. Some additional control variables are also included in the data from the travel diary investigation, namely leisure interests, in which geographical region the respondent grew up, and whether or not the respondent grew

up in a household with a car. Moreover, the information about the respondents' travel modes are more detailed than in the first survey, among others, there is a distinction between trips as car driver and car passenger and between trips by foot and by bike.

The analysis of odometre-based *driving distances of the cars belonging to the respondents' households* shows results highly consistent with the results of the main survey. Controlling for non-urban-structural variables (including car ownership), the expected driving distance per adult household member on Monday–Tuesday is about 24 km among respondents living less than 6 km from central Copenhagen, compared to 49 km among respondents living more than 28 km from the city centre. In the two most central areas the expected driving distance is only 19–20 km, and in the three most remote areas 52 km. Given an average weekday occupancy rate per car of 1.4 persons, this translates into average daily travelling distances by car of 14 km in the most central areas and 34 km in the most remote areas. In comparison, the corresponding figures based on the main questionnaire survey are 18.5 km and 37.5 km, respectively (cf. section 6.3). The somewhat higher overall figures of the main survey are largely attributable to the fact that the occupational trips are included in the travel distances of the main survey but not in the above figures of the travel diary investigation.

Keeping non-urban-structural variables constant at mean values, the average driving distance of the cars belonging to the respondents' households at the weekend is 26 km among respondents living less than 6 km from central Copenhagen, compared to 32 km among respondents living more than 28 km from the city centre. Assuming a somewhat higher occupancy rate at the weekend (1.8), this corresponds to a differential of about 6 km per day between respondents in the outer and inner distance belt. This is a bit more than the corresponding differential based on the main survey (3.5 km), but must still be considered fairly consistent with the latter analysis.

It should, however, be noted that the urban structural variables showing the strongest effects differ between the two data sets (see below). In the analysis of driving distances of the cars on Monday–Tuesday, local-area density and the distance to the closest urban railway station were the two urban structural variables showing statistically significant effects (of which local-area density showed the clearly strongest influence). At the weekend, only the distance to the closest urban railway station turned out with any effect worth mentioning.

The travel diary material shows that the relationship found in section 6.4 between residential location and the proportion of distance travelled by car first and foremost reflects considerably more trips as *car driver* among respondents living in the peripheral parts of the region. The further away from central Copenhagen the dwelling is located, the more often the respondents tend to sit down behind the steering wheel. On the other hand, the number of trips as *car passenger* does not

appear to be influenced to any extent worth mentioning by whether you live in a low-density peripheral area or in a dense inner-city district. Combined with the pronouncedly higher frequency of trips as car drivers among outer-area residents, this implies that solo driving makes up a higher proportion of the car trips among the latter group than among the inner-city respondents. Apparently, this reflects a pattern where inner-city respondents typically use their car for recreational purposes involving two or more family members, while commuting makes up the majority of car trips among outer-area respondents.

According to the travel diary material, the frequency of trips *by bike* is influenced by two urban structural variables, namely the location of the dwelling relative to central Copenhagen and the closest second-order centre, respectively. These variables were the urban structural characteristics found to exert the strongest influence on the total proportion of non-motorized travel in the main survey too. Moreover, the travel diary data indicate that the frequency of trips *by foot* in particular tends to increase when the dwelling is situated close to an urban railway station. Probably, this reflects the fact that a lower proportion of relevant destinations can be reached within acceptable walking distance if the residence is located far away from the concentration of local service facilities often found in the proximity of urban railway stations. At the weekend, the number of trips by foot also tends to increase the closer to central Copenhagen the dwelling is located. Somewhat surprisingly, the travel diary material also indicates that a high local area density contributes to reduce the number of trips by foot, in particular at the weekend. This relationship is difficult to explain, but might possibly reflect a tendency to compensatory travel among residents of dense local areas. If respondents living in these areas go more frequently on long leisure trips at the weekend, less time will be available to visit local facilities, regardless of whether or not these facilities are situated within acceptable walking distance.

The analyses of our different data sources all point in the same main direction: there are clear relationships between residential location and travel behaviour, also when taking into consideration a number of demographic, socio-economic, attitudinal and other relevant differences between the respondents. Living in one of the dense districts in the inner-city of Copenhagen, or close to the central area, contributes to a lower total amount of travel, a lower proportion of travel by car, and a higher number of trips by bike or by foot than if the residence is located in the peripheral parts of the metropolitan area.

For most transport variables, the relationship between residential location and travel is stronger on weekdays than at the weekend. As pointed to earlier, this illustrates the more routine character of everyday travel, where the amount of transport is to a high extent determined by the location of the residence relative to the destinations of the 'bounded' trips (in particular workplace or place of education). Travel behaviour

at the weekend varies to a lesser extent with the location of the dwelling, but here too there is an overall tendency to a higher amount of travel among residents of the peripheral parts of the metropolitan area. However, the difference between centre and periphery is considerably smaller at the weekend than on weekdays.

As mentioned above, our two surveys give slightly different answers regarding which of the four investigated main urban structural variables exert the strongest influences on travel behaviour. The importance of the various urban structural variables also varies somewhat, depending on the transport variable focused on. Taken together, however, the location of the dwelling relative to central Copenhagen stands out as a key factor. In the analyses based on our main survey, this is the urban structural variable showing the highest number of separate, controlled effects on travel behaviour on weekdays as well as at the weekend. In some of the analyses based on the travel diary, the distance from the dwelling to the closest second-order centre and/or local area density shows stronger effects than the location of the residence relative to central Copenhagen. However, the two former variables are quite closely related to the latter, as the highest local area densities and the shortest distances from the dwellings to the closest second-order centre are found in the inner and central districts of Copenhagen. Even though the distance to the closest second-order centre may also be short for some of our outer-area residents (especially those living in the investigation areas close to the towns of Hillerød and Køge), the combined effects of the urban structural variables of the travel diary investigation imply too that the amount of the travel and the car usage will on average be considerably lower if you live in the central parts of the metropolitan area than if the residence is located close to a second-order centre in the outer part of the region.

Formal analyses of so-called multicollinearity indicate that the inclusion of all four urban structural variables in the regressions would not give rise to any statistical problems affecting the reliability of the analyses (cf. section 6.2). The fact that the relative strength of the four urban structural variables varies somewhat, depending on the data set, suggests that there may still be a too high mutual correlation between these variables to enable us to identify an unambiguous mutual ranking of their effects.³³ However, when the combined effects of all four urban structural variables are calculated for the individual residential areas or within different distance belts from central Copenhagen, the data from both surveys show a clear centre–periphery variation in the total amount of transport as well as in car travel and use of non-motorized modes. The stronger effect found in the main survey data of the location of the residence relative to central Copenhagen than of local-area density is also highly plausible from theoretical considerations and best in line with the transport rationales identified in the qualitative interviews. The considerably higher number of respondents in the main survey than in the travel diary investigation also adds credibility to the results based on the former data material.

6.9 CONCLUDING REMARKS

Overall, our analyses show that the location of the dwelling relative to the centre structure of Copenhagen Metropolitan Area has a considerable influence on the travel behaviour of the respondents. Based on the main survey, Table 6.6 shows the effects of the four main urban structural variables on each of our eight transport variables on weekdays as well as at the weekend, controlling socio-economic, attitudinal and other non-urban structural variables. It should be noted that indirect effects of residential location via, for example, car ownership and transport attitudes are not included – these effects will be addressed in Chapter 8.

The situation of the residence relative to the main centre of the region (the City Hall Square of Copenhagen) appears to exert the strongest influence on travel behaviour, with effects meeting the required significance level on 12 of the 16 transport variables. All these effects are in line with what could be expected from theoretical considerations, that is living far away from central Copenhagen contributes to longer total travelling distances, longer distances travelled by car and by train, shorter distances travelled by non-motorized modes, a higher proportion of car travel and lower proportions of non-motorized and public transport. The effects of the distance to the closest second-order centre (a so-called urban centre with regionally oriented retail trade) are also in line with theoretical expectations. The distance from the residence to more local centre formations (in connection with urban railway stations) also plays a role. Maybe somewhat surprisingly, a long distance to the closest urban railway station contributes to somewhat more non-motorized travel, probably because the bike then replaces public transport as an alternative to the car.

The density of inhabitants and workplaces in the local area of the dwelling shows some quite surprising effects (generally less travel by public transport, and at the weekends more car travel and less travel by non-motorized modes). These effects counteract the effects of the other urban structural variables to a certain extent, but are not strong enough to offset the latter effects. On the other hand, local area density makes itself felt to a considerable extent in the travel diary analyses, with effects in line with what could be expected from theoretical considerations. As mentioned earlier, this difference between our two data sets may be due to the considerable correlation between local-area density, distance to central Copenhagen and distance to the closest second-order centre.

Besides, a high average density in the separate local areas of which the city consists is a precondition for obtaining an urban structure where the inhabitants live at a moderate average distance from the main centre of the city. If the city consists of districts with a low average population and workplace density, it will cover a large area, and a high proportion of the inhabitants will hence have to live far away from the city centre. On the other hand, there is neither a tradition of nor a demand for

Table 6.6 Results from multivariate analyses of the influences of the four main urban structural variables on each of the eight transport variables on weekdays and at the weekend

Effects	Total travel distance	Travel distance by car	Travel distance by train	Travel distance by bus	Travel distance by non-motorized modes	Share of distance travelled by car	Share of distance travelled by public transport	Share of distance travelled by bike or on foot
Distance between residence and central Copenhagen	Weekdays 0.145*** Weekend 0.045	0.114*** 0.098**	0.119*** (n.s.)	(n.s.) (n.s.)	-0.094*** -0.077*	0.069** 0.080**	(n.s.) -0.122**	-0.085* -0.052
Distance between residence and closest second-order urban centre	Weekdays 0.055 Weekend (n.s.)	(n.s.) (n.s.)	(n.s.) (n.s.)	0.065* (n.s.)	(n.s.) -0.118**	0.045 0.063*	(n.s.) (n.s.)	-0.124*** -0.099**
Distance between residence and closest urban railway station	Weekdays 0.046 Weekend (n.s.)	0.059* (n.s.)	(n.s.) (n.s.)	(n.s.) (n.s.)	(n.s.) 0.059	(n.s.) (n.s.)	(n.s.) (n.s.)	0.059* (n.s.)
Density of inhabitants and end work-places in the local area	Weekdays (n.s.) Weekend (n.s.)	(n.s.) 0.055	(n.s.) (n.s.)	(n.s.) (n.s.)	(n.s.) -0.094*	(n.s.) (n.s.)	-0.101 -0.101**	0.075* (n.s.)

Standardized regression coefficients. Only effects with a level of significance of 0.15 or lower are included. Three asterisks after the standardized regression coefficient indicates that the relationship is statistically significant at the 0.001 level, two asterisks that it is significant at the 0.01 level, one asterisk that it is significant at the 0.05 level, (n.s.) = not significant at the 0.15 level. The regression models included the same 23 independent variables as in Appendix 1, except for days of appearance at workplace/school, which was not included in the analysis of travel at the weekend. N = 1,406–1,414 respondents from 29 residential areas in Copenhagen Metropolitan Area

built-up environments as dense in the peripheral areas as in the central parts of the metropolitan area. The location of new residential development – on vacant and under-utilized areas close to central Copenhagen or as ‘greenfield’ development in the peripheral municipalities of the region – has a strong influence on the density levels considered appropriate.

As mentioned above, our material does not show any general tendency for a modest amount of weekday travel being counterbalanced through more extensive weekend travelling. The analysis of annual driving distances of the households’ cars also shows that any increased holiday car travel among inner-city respondents can in no way offset the considerably lower amount of travel carried out by these respondents during the remaining weeks of the year. Yet, there are some tendencies in our material pointing at certain characteristics of central urban districts as possible causes of ‘compensatory’ travel behaviour. Other things equal, inhabitants of dense local areas travel somewhat longer distances at the weekend, in particular by car. Admittedly, these effects can only be identified in statistical analyses where the other urban structural variables are kept constant. Inhabitants of dense inner-city districts thus tend to travel somewhat more by car at the weekend than residents of less densely developed districts at the same distance from the city centre, but not more than the residents of low-density areas in the outer parts of the metropolitan area. The question of compensatory travel behaviour will be discussed more in depth in Chapter 10.

CHAPTER 7

HOW DOES RESIDENTIAL LOCATION INFLUENCE LOCATION OF ACTIVITIES, TRIP LENGTHS, ACTIVITY PARTICIPATION AND TRAVEL TIME?

7.1 INTRODUCTION

In the previous chapter we saw that clear, statistical relationships exist between residential location and travel behaviour, when controlling for demographic, socio-economic, attitudinal and a number of other relevant differences between the respondents. In this chapter we shall take a closer look at the ways different partial aspects of travel behaviour contribute to the differences in the amount of travel found between respondents living in the central and peripheral parts of Copenhagen Metropolitan Area. The chapter provides a concretizing and a more detailed account of some of the relationships shown in the previous chapter. Thus, by drawing a more detailed picture of the ways the different transportation rationales, in combination with the situation of the residence, produce some characteristic patterns regarding trip distances, travel time, frequency of activity participation, and location of activities, the chapter aims to contribute to improved insight into the mechanisms through which urban structure influences the amount of transport.

The chapter focuses primarily on the aspects of travel behaviour determining the amount of transportation. Aspects included in the respondents' choices of travel modes are discussed to a higher extent in Chapter 8, where the indirect effects of urban structure through, among others, car ownership and transport attitudes are addressed. Below, we shall first take a look at the relationships between residential location and, respectively, the availability of facilities in the proximity of the dwelling, the location of activities and the length of trips with different purposes. Thereupon, the relationship between residential location and the frequency of activity participation, trip frequency and travel time will be addressed. The analyses are based partly on data from the travel diary investigation, partly from the main questionnaire survey.

7.2 DISTANCES TO FACILITIES

As mentioned in Chapter 3, the Copenhagen Metropolitan Area has a clear concentration of workplaces and other facilities in its inner and central parts. This higher concentration is illustrated in Table 7.1, based on average values among the respondents of our main survey.

Table 7.1 Mean values for some urban structural characteristics of the respondents' residences, grouped into four distance intervals from the city centre of Copenhagen

<i>Urban structural factor</i>	<i>Distance interval from the city centre of Copenhagen</i>			
	<i>under 6 km (N = 435)</i>	<i>6–15 km (N = 461)</i>	<i>15– 28 km (N = 557)</i>	<i>over 28 km (N = 457)</i>
Distance from residence to central Copenhagen (km)	3.0	9.7	21.9	41.8
Distance from residence to closest second-order urban centre (km)	2.2	5.7	7.6	10.1
Distance from residence to closest urban railway station (km)	1.4	2.3	3.0	11.2
Local area population density (inhabitants/ha)	85	24	14	10
Local area workplace density (jobs/ha)	66	11	7	5
Distance from residence to closest grocery shop (km)	0.13	0.51	0.97	0.68
Number of grocery shops within 1.5 km distance from the dwelling	150	18	12	8
Number of specialized stores within 1.5 km distance from the dwelling	218	16	15	15
Distance from residence to closest primary school (km)	0.51	0.85	1.50	1.20
Distance from residence to closest kindergarten (3–5 years) (km)	0.31	0.52	0.65	0.77
Distance from residence to closest crèche (0–3 years) (km)	0.32	0.72	1.08	2.00
Distance from residence to closest post office (km)	0.74	1.09	1.56	0.98
Distance from residence to closest town hall (km)	2.8	2.8	4.0	3.7
Proportion of residences with a green recreational area of at least 10 ha within 1 km distance (%)	36	60	55	42

N = 1,932 respondents of the main survey

The centrally located residences are in particular distinguished by a higher density of workplaces and shops in their local area. In the inner of the distance belts of Table 7.1 there are 36 per cent more jobs than workforce participants, whereas all the three remaining distance belts have fewer jobs than workers, with the largest deficit (23 per cent) in the distance belt 6–15 km from central Copenhagen and the smallest deficit (18 per cent) in the distance belt 15–28 km. According to our material, nearly half the variation in the number of workplaces per hectare in the local area (i.e. within half a mile from the centroid of the residential area) can be attributed to the location of the residence relative to central Copenhagen and the closest second-order centre.

The number of shops in the local neighbourhood – in particular grocery shops, but also special shops – can to an even higher extent be explained by the location of the residence relative to central Copenhagen and the closest second-order urban centre. The distance to the *closest* grocery shop also increases, the further away from central Copenhagen the residence is located, and to some extent also with increasing distances from the residence to the closest urban railway station. Yet, urban structural variables can account for much less of the variation in the distance to the closest grocery shop than in the number of shops within the local area around the residence. This reflects the fact that almost all small settlements in the metropolitan area have a local grocery shop, but only residents of the central parts of the region have the opportunity to choose among several grocery shops close to the dwelling.

Most of the residences of the outer of the four distance belts are located outside the service area of the urban railway system and are therefore distinguished by long distances to the closest urban railway station. However, the distances to some facility categories (grocery shop, primary school, post office and town hall) are somewhat shorter in this distance belt than in the belt immediately inside. The latter three facility categories belong to the minimum infrastructure required in every municipality.

For several other categories, where supply and accessibility are to a lesser extent influenced by municipal territories or national regulations, residents of the outer of the four zones live further away from the facilities than in any of the other distance belts. In particular, crèches (for children less than three years of age) show a centralized pattern, where the distance to the closest crèche is considerably shorter for dwellings situated close to an urban railway station and/or to central Copenhagen. Proximity to the closest second-order centre also increases the probability of living close to a crèche. The average distance to the closest kindergarten increases too, the further away the residence is located from central Copenhagen and, to some extent, from the closest urban railway station.

The only facility category where the availability is lowest in the central zone is green recreational areas. Interestingly, though, the highest proportion of respondents with access to a green recreational area above 10 hectares within 1 km from the dwelling is in the second inner distance belt, with decreasing proportions when moving further outwards across the distance belts. (If the distance limit is set to 0.5 km instead of 1 km, the highest proportion with access to a green recreational area is in fact found among the respondents living less than 6 km from central Copenhagen.) A closer analysis of the data suggests that the location of the residence relative to the closest urban railway station is the only urban structural variable with any influence worth mentioning on the availability of a green recreational area of 10 hectares or more within 1 km distance from the dwelling. Perhaps a bit surprisingly, the availability of

green recreational areas above this size increases, the closer to an urban railway station the dwelling is situated. This probably reflects the fact that the peripheral parts of the region, where the coverage of urban railways is low, are dominated by cultivated land with few recreational forests.

7.3 LOCATION OF ACTIVITIES

In Chapter 4 we saw a concentration of trip destinations for a number of travel purposes in the central and inner parts of Copenhagen Metropolitan Area. Apart from the innermost investigation areas, a clear majority of the respondents' trips were also directed toward destinations located closer to the city centre than the investigation areas themselves.

Besides the above-mentioned information from the travel diary investigation, the main questionnaire survey included questions about the location of the following activities: daily necessities shopping, purchasing clothes, books, CDs etc., visits to cafés or restaurants, and visits to cinemas. The alternative answers were: closer to the dwelling than approximately 1 km, central Copenhagen, and elsewhere.

The answers to these questions show that visits to cinemas and cafés/restaurants are taking place to a high extent in the inner-city area. One half of our respondents usually chose cinemas in the centre of Copenhagen, and an almost equally large proportion (45 per cent) prefer restaurants or cafés in this area when going out for a meal. Compared to the proportion of respondents living close to the city centre, the proportion preferring city centre shops when purchasing clothes, books, CDs etc. (31 per cent) must also be considered high. In contrast, the proportion using city centre shops for daily necessities purchases is only 3 per cent. This difference illustrates – in accordance with central place theory – the far more centralized location pattern for specialized shops than for grocery shops. The even higher concentration of visits to cinemas and cafés/restaurants in the city centre area probably reflects the 'atmospheric' qualities of the city centre (Albertsen, 1999), which may effect a concentration of entertainment and recreational activities in the city centre area beyond the reasons discussed in transport economy and transport geography.

For each of the four above-mentioned activity categories there are marked differences between inner-city and outer-area residents in the frequencies of using city centre facilities. Whereas nearly 80 per cent of those who live less than 6 km away from the city centre of Copenhagen usually choose city centre cinemas, the corresponding share is only 26 per cent among respondents living more than 28 km from central Copenhagen. A similar 'distance decay' in the use of city centre facilities can be seen for the three other facility categories as well. The proportion of respondents

who use facilities in the inner-city area in spite of living far away may be seen as an indicator of the attraction of the inner-city area (due to the range of commodities supplied, quality, 'atmosphere', etc.), compared to facilities of the same categories located elsewhere in the metropolitan area. Among residents living more than 28 km away from central Copenhagen, the proportions choosing city centre facilities are 26 per cent when going to the cinema, 21 per cent when visiting cafés/restaurants, 8 per cent when buying clothes, books, CDs, etc. and only 0.2 per cent when buying daily necessities. For inner-area respondents the distances to city centre facilities make up much less of a barrier, and the proportions choosing the above-mentioned activities in central Copenhagen are correspondingly higher. Among the respondents living closer to central Copenhagen than 6 km the proportions usually choosing city centre facilities when visiting cinemas, cafés/restaurants, purchasing books, CDs, etc. and buying daily necessities are 79 per cent, 66 per cent, 65 per cent and 8 per cent, respectively.

The friction of distance thus implies a reduced propensity of using the broad supply of facilities existing in the inner-city area the further away from the city centre of Copenhagen the residence is located. In the inner of our four distance belts, the local area often has an almost equally broad supply of facilities as the urban core. Respondents living in these areas could therefore be expected to use local-area facilities to a high extent. In the two middle distance belts, the local areas include fewer facilities within each category, and more specialized facilities may only exist in a few of the local areas. However, these distance belts also include a number of larger or smaller local centres offering opportunities to carry out all four of the above-mentioned types of activities, often with a broader supply than that which is available in the respondents' local area. In the two middle distance belts, the facilities available in the local areas are thus exposed to a high extent to competition from non-local facilities. In the outer of the four distance belts, some of the investigation areas (Holmene and Køge Vest) are located close to a second-order centre with a broad supply of activities, while some of the other investigation areas in this zone are located in smaller towns and villages (Haslev and Gilleleje) which are after all the largest centres within a relatively wide circumference. The respondents from this distance belt could therefore be expected to use local facilities to a higher extent than the respondents living in the two middle distance belts.

A simple comparison of the proportions using facilities closer to the dwelling than 1 km when buying daily necessities, purchasing clothes, books, CDs etc., going to the cinema and visiting restaurants/cafés largely confirm the above assumptions. Figure 7.1 shows the proportions of respondents living at different distances from central Copenhagen who purchase daily necessities and clothes, books, CDs etc., respectively, in shops located less than 1 km away from home. The

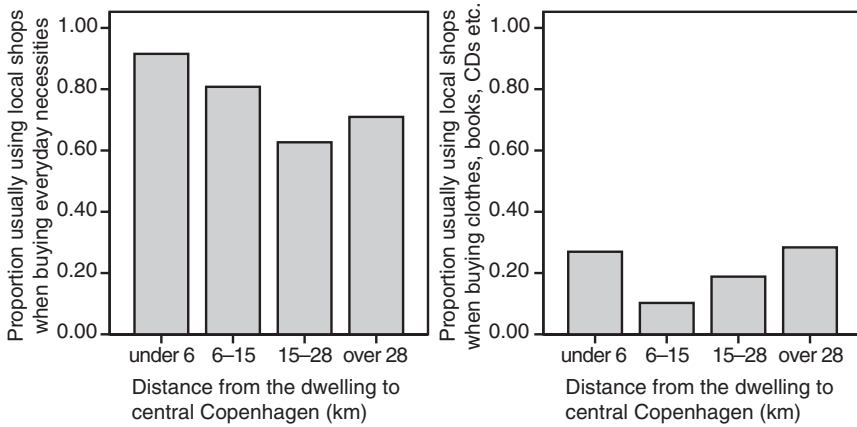


Figure 7.1 Proportion of respondents living within different distance belts from central Copenhagen who usually use shops less than 1 km away from the dwelling when buying everyday necessities (to the left) and special commodities (to the right) $N = 1,903$ and $1,884$, respectively

proportions using local grocery shops partly reflect the availability of such shops in the proximity of the dwelling (see Table 7.1), and partly the fact that the respondents living in the outer areas often do their grocery shopping on the way home from the workplace (which is typically located in a more central part of the metropolitan area). However, for visits to specialized shops, the proportions choosing local shops is nearly three times as high in the outermost distance belt than among those living between 6 and 15 km from central Copenhagen, in spite of the considerably higher availability of such stores in the latter distance belt. Indeed, the propensity of local purchases of clothes, books, CDs, etc. is slightly higher among residents living more than 28 km from central Copenhagen than among those living less than 6 km from the city centre, in spite of the fact that the latter can choose among nearly 15 times as many specialized shops within their local area as can the residents in the peripheral belt.

In order to illuminate the extent to which the differences shown in Figure 7.1 are still present after adjusting for demographic, socioeconomic and attitudinal differences between respondents, multivariate statistical analyses were carried out. Keeping non-urban-structural variables constant,³⁴ the calculated likelihood of buying clothes, books, CDs, etc. at local shops is 17–18 per cent both among those respondents who live less than 6 km away from central Copenhagen and among those who live more than 15 km away from the city centre, compared to only 8 per cent among those living between 6 and 15 km from the city centre ($p = 0.000$). For purchases of everyday necessities the propensity to use local facilities is considerably higher ($p = 0.000$) among residents living close to the city centre

of Copenhagen (86 per cent) than among those living more than 28 km from the city centre (60 per cent). Grocery shops are centralized in the inner-city area to a lesser extent than is the case for, for example, special commodities. Therefore, the 'trade leakage' from the districts immediately outside the urban core to the inner-city area is weaker.

Figure 7.2 shows the proportions of respondents within each distance belt who use facilities less than 1 km from the dwelling when visiting cafés/restaurants and cinemas, respectively. For visits to cinemas, only the respondents living between 6 and 15 km from the city centre stand out with a pronouncedly different (and lower) use of local facilities than in the other distance belts. Due to the moderate distances to the inner-city area, local cinemas in this distance belt are exposed to strong competition from the much broader choice of films in the city centre. For cafés and restaurants, the inner-city respondents are the most frequent users of local facilities, reflecting the very high concentration of places to eat in the central part of Copenhagen. The gradually higher use of local facilities when moving from the second inner to the outer distance belt probably reflects the reduced competition from city centre restaurants (and also from centres other than the local one) in the outer, low-density parts of the region.

Controlling for non-urban-structural variables, the likelihood of going to local restaurants or cafés is 25 per cent among respondents living less than 6 km from the city centre of Copenhagen, compared to only 6 per cent in the distance belt from 6 to 15 km ($p = 0.000$). Albeit higher than in the second inner distance belt,

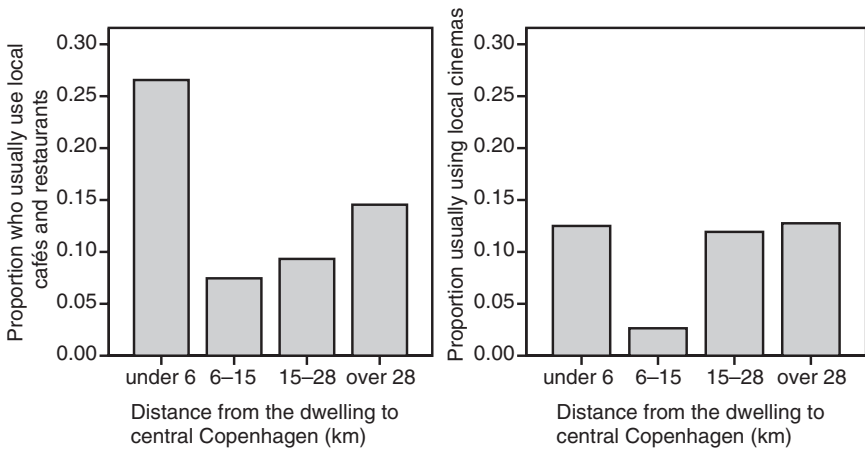


Figure 7.2 Proportion of respondents living within different distance belts from central Copenhagen who usually use facilities less than 1 km away from the dwelling when visiting cafés or restaurants (to the left) and going to cinemas (to the right) N = 1,876 and 1,870, respectively

the likelihood of going to local eating places is considerably lower on the periphery (14 per cent) than close to the city centre, in spite of the low competition from city centre restaurants. The less frequent use of local restaurants/café among residents of the peripheral suburbs primarily reflects the fact that in many cases, no restaurant or café exists in the proximity of the dwellings of these respondents.

Similarly, the calculated likelihood of going to a local cinema is 14 per cent in the distance belt between 15 and 28 km from central Copenhagen, compared to 7 per cent in the innermost distance belt and only 3 per cent in the interval from 6 to 15 km from the city centre. These differences mirror the fact that the competition from city centre cinemas will be stronger the closer to the city centre the residence is located. This competition also manifests itself in a lower occurrence of local cinemas in the second inner distance belt.

For all four activity types, the above analyses show a higher influence from urban structural variables than from any of the non-urban-structural control variables on the propensity for using local facilities. However, the effects of residential location on the propensity for locating the activities to the local area depend much on the activity type. The likelihood of shopping locally is highest among the respondents from the high density and central districts. In particular, this is the case for grocery shopping. The respondents from the inner parts of Copenhagen Metropolitan Area also have the highest propensity for using local cafés and restaurants. Distinct from this, the probability of using a local cinema is highest among respondents living in the outer parts of the region, albeit close to an urban railway station and in a local area with density above a certain level.

Our material shows that the propensity for using local facilities depends partly on which facilities *exist* in the proximity of the dwelling, and partly on the *competition* from non-local facilities. In the districts next to the inner-city area, a relatively broad supply of local facilities often exists, but at the same time there is strong competition from facilities in the city centre. Conversely, the local supply of facilities is often more modest in the outer parts of the metropolitan area, but the long distance to the concentration of facilities found in central Copenhagen at the same time weakens the competition from the latter facilities.

The two above-mentioned factors reflect the rationales for location of activities identified in Chapter 5. The wish to limit geographical distances and time consumption for travel motivates respondents to use local facilities, while the wish to choose the best facility (judged against the instrumental purpose of the trip as well as the atmosphere and aesthetic qualities of the facility) draws them out of the local area and inward to central Copenhagen. The mutual prioritization between the rationales, as well as the actual occurrence of local and competing external facilities, varies between different facility categories. Which of the two factors of influence – the occurrence of local facilities or the competition from external facilities – is the

stronger thus varies between the different facility categories as well as between the different distance belts from central Copenhagen.

For daily necessities the concentration of stores decreases gradually from central Copenhagen outward to the peripheral parts of the urban region. In the districts next to the inner-city area, the supply of grocery stores is almost as high as in the city centre itself, and the competition from the central area is hence not so strong. The residents of the districts immediately outside the inner-city area therefore have both the possibility and incentives for using local grocery shops. For shops selling special commodities the concentration in the inner-city area itself is stronger. The residents of the districts immediately outside the inner-city area can therefore, by travelling a few kilometres, reach a considerably broader supply than that which exists in the local area. This reduces the propensity for local shopping. A similar and even stronger tendency exists for visits to cinemas. In some of the outer districts, the supply of both special shops and cinemas may be more limited than in the districts close to the inner-city area, but because of the friction of distance the competition from the city centre is so weak that the propensity for choosing local facilities is nevertheless higher than in the districts immediately outside the inner-city area. For visits to cafés and restaurants, the propensity for using local facilities is highest in the inner distance belt, lowest in the second innermost, and slightly increasing when the distance from the dwelling to the city centre increases further. The strong concentration of places to eat in the inner districts of Copenhagen makes it convenient for respondents from the inner distance belt to eat locally and also attracts many visitors from the second innermost distance belt. Among residents of the latter distance belt this contributes to reduce the number of visits to local cafés and restaurants. On the other hand, the supply of local restaurants and cafés is lower the more peripherally the residence is located. At the same time, the outer area districts are only to a small extent exposed to competition from the city centre. These circumstances pull in opposite directions and their combined result is a propensity for using local cafés and restaurants varying as described above.

7.4 LENGTH OF TRIPS WITH DIFFERENT PURPOSES

In the following section, results of analyses of the relationship between residential location and the distances travelled *per trip* with different purposes will be presented. The analyses are mainly based on the travel diary investigation, and extreme trip distances, that is single trips above 50 km, have been omitted. The purpose of these analyses is to illuminate whether the urban-structurally conditioned differences between the residential areas regarding their supply of and accessibility to various types of facilities also manifest themselves in the actual length of trips to

such facilities. Together with the analyses of trip frequencies presented later in the chapter, these analyses can provide a more detailed picture of the ways residential location influences the amount of travel: the location of the residence → distances to various types of facilities → average length and frequency of trips with different purposes → total distance travelled.

Below, simple, bivariate comparisons of average distances travelled per trip with different purposes among respondents living within different distance intervals from the city centre of Copenhagen will be presented. Thereupon, for one travel purpose, namely journeys to work, the results of multivariate analyses of factors influencing trip distances will be presented. The latter analysis is based on the main questionnaire survey.

The *errand/shopping* trips of the travel diary respondents divide themselves relatively evenly between Monday–Tuesday and Saturday–Sunday, yet with somewhat more trips at the weekend (325) than during the two first weekdays (256). We expected the length of errand/shopping trips to be more closely related to residential location at the weekend than on weekdays, as special goods shops and well-assorted grocery shops, both of which often visited on Saturdays, are to a high degree concentrated in the central parts of the metropolitan area. Contrary to expectations we find that the length of errand/shopping trips is more strongly associated with the distance between the residence and central Copenhagen on Monday–Tuesday than at the weekend. On Monday–Tuesday, the average trip distance rises from 4–5 km in the two inner distance belts to 8 km among respondents in the second outer of the four distance belts, with a drop to 7 km when the residence is located more than 28 km away from the city centre of Copenhagen. In particular, average trip distances are considerably lower in the five most peripheral of the 29 residential areas than among the remaining outer-area respondents.

The more close relationship of errand/shopping trip lengths with the location of the residence relative to central Copenhagen on Monday–Tuesday than at the weekend may be partially an artefact of the way trip purposes were recorded, that is according to the activity carried out by the respondent at the location where the trip ends. This way of trip registration, which is the usual one in travel surveys in Denmark as well as internationally, implies that a respondent buying groceries on the way home from work will have the stretch from the workplace to the shop registered as a shopping trip. Our qualitative interviews show that interviewees living in the outer areas often do their shopping for daily necessities in one of the local centres on the way home from work (see Chapter 6). Hence, these respondents, often living far away from their workplaces, will be recorded with (too) long shopping trips.

The weaker relationship at the weekend between residential location and the length of errand/shopping trips also reflects the fact that a number of respondents

in the second inner distance belt are distinguished by long errand/shopping trips at the weekend. It is precisely in this distance belt – or just outside – we find some of the large, regional shopping centres apart from the inner city of Copenhagen, among others City 2 and Lyngby Storcenter. At the same time, congestion occurs to a far lesser extent on the roads within this distance belt than in the inner city, thus making up less of a barrier against travelling by car to a shopping mall.

The drop in the average distances of errand/shopping trips in the five most peripheral residential areas probably reflects the fact that four of the most peripheral areas are located in towns and villages large enough to sustain a relatively broad supply of stores. At the same time, these residential areas are located relatively far away from the closest competing concentration of stores. For the respondents in these five areas, the option will therefore be either to use the local, relatively broad supply of shopping opportunities, or travel to stores at a considerable distance from the dwelling (e.g. one of the regional shopping centres in the suburbs of Copenhagen, or the concentration of stores in inner-city Copenhagen). The friction of distance probably causes the respondents of the five investigation areas mentioned to choose the latter alternatives quite seldom.

Our travel diary respondents have carried out about the same number of trips to *transport children* on Monday–Tuesday (117) as on Saturday–Sunday (111). We expected the length of these trips to vary only moderately with the distance between the dwelling and central Copenhagen, as the differences between the central and peripheral residential areas in terms of distances to primary school, kindergarten and crèche (and probably also to sports centres, music schools, Scout meetings, etc.) are smaller than is the case for, for example, workplaces, culture and entertainment facilities, and shopping opportunities.

However, among our respondents, the length of trips to bring or pick up children to/from kindergarten, school or other activities is on average considerably longer when living on the periphery than if the residence is located close to central Copenhagen. This applies to Monday–Tuesday as well as the weekend, albeit more pronouncedly on the two weekdays. In the latter period, average trip distances rise from 3 km and 4 km, respectively, in the two inner distance belts to 11 km among respondents living between 15 and 28 km from central Copenhagen, with a drop to 8.5 km when the residence is more than 28 km away from the city centre.

For transporting children too, the difference between centrally and peripherally living respondents in trip distances is probably partially an artefact of the ways different trip purposes have been recorded. A parent picking up his/her child from the kindergarten or school on the way home from work will have the stretch between the workplace and the kindergarten/school registered as a bring/pick-up trip. These trips may thus be recorded as quite long even if the school or kindergarten is located close to the dwelling.

Up to a distance between the residence and central Copenhagen of approximately 30 km there is a clear tendency for longer bring/pick-up trips, the more peripherally the residence is located. However, the three outermost residential areas are distinguished by very short trips for this purpose on weekdays. Thus, a similar pattern can be found for bring/pick-up trips as for errand/shopping trips. However, this tendency is present to a far lesser extent on Saturday–Sunday, indicating that transporting children at the weekend, more often than on weekdays, is to facility categories not available in the peripheral local communities.

Compared to shopping and transporting children, the source of error caused by the method of trip purpose registration probably has far less influence on the recorded trip distances for the remaining trips, as the destinations of these trips are less often visited on the way home from the workplace or place of education.³⁵

Our travel diary respondents have made nearly twice as many *leisure trips* at the weekend (254) than on Monday–Tuesday (146), and these trips are also on average longer at the weekend than on the two first weekdays. If Monday and Tuesday do not deviate too much from the travel on Wednesday, Thursday and Friday, the leisure trips at the weekend probably make up a similar share of the total weekly travelling distance as the leisure trips during all the rest of the week.

Apart from the outermost distance belt, we find a clear tendency for longer leisure trips on Monday–Tuesday, the further away from central Copenhagen the residence is located. In the inner zone, the average leisure trip distance is 3.5 km, compared to 7 km in the distance belt second farthest out. In the most peripheral zone (over 28 km from central Copenhagen), the average trip distance drops again to slightly above 5 km. At the weekend there is an even clearer tendency to

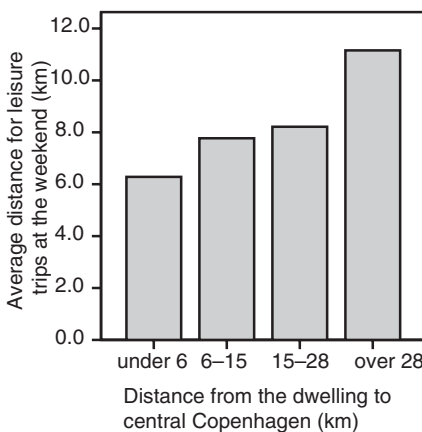


Figure 7.3 Average distances (km) for leisure trips at the weekend among respondents living within different distance belts from central Copenhagen
N = 254 trips, $p = 0.005$

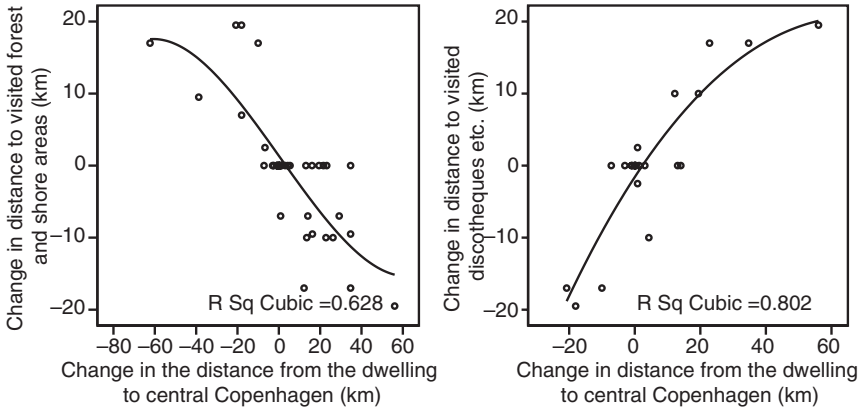


Figure 7.4 Changes in distances from the dwelling to the visited forests and shores (to the left, $p = 0.000$) and the visited discotheques, etc. (to the right, $p = 0.000$), among respondents who have moved to new residences located further away from or closer to central Copenhagen
 $N = 39$ and 23 , respectively

increasing leisure trip lengths with increasing distances between the dwelling and the centre of Copenhagen (Figure 7.3). Average trip distances increase from 6 to 8 km across the three inner distance belts, with a further increase to 11 km in the outermost zone. There is a slight tendency to a drop in trip distances when moving from the inner to the outer part of the outer distance belt, that is the longest average trip distances are found among respondents living about 30 km away from central Copenhagen.

The strong relationship between the location of the residence relative to central Copenhagen and the length of leisure trips at the weekend is in line with expectations. Admittedly, inner-city dwellers have longer average distances than residents of outer suburbs to forests and shores. However, the supply of entertainment and cultural facilities is far more extensive in the central parts of the metropolitan area, and people's possibilities for making use of these opportunities are highest at the weekend. Figure 7.4 shows how moving closer to or further away from central Copenhagen has influenced trip distances of travel diary respondents to locations for outings to forests/shores and visits to discotheques, etc, respectively. Even though the respondents of the most central distance belt have poorer accessibility to forests and shores than those living in the other three zones, our material shows that this influences the average length of leisure trips far less than inner-city Copenhagen's broader supply of other leisure and recreation opportunities.

On weekdays, respondents living more than some 25–30 km away from central Copenhagen appear to stick mainly to the local leisure opportunities, most likely

because it takes too much time and is too inconvenient on a hurried weekday to travel all the way in to the facilities in the central parts of the metropolitan area.

Our travel diary respondents have made *visiting trips* more than three times as frequently on Saturday–Sunday as on Monday–Tuesday. In spite of the fact that the weekend makes up only two of the seven days of the week, the visiting trips at the weekend are probably of a higher importance to the total weekly amount of travel than the visiting trips during all the weekdays, the latter also being somewhat shorter on average than the visiting trips on Saturday–Sunday.

At the weekend, the average trip length for visiting trips is 11.5 km in the innermost distance belt, compared to slightly below 16 km in the outermost. Again, we see a drop in trip distances in the most peripheral part of the outer zone, in particular in the furthest residential areas (about 60 km from central Copenhagen), where visiting trips at the weekend are very short.

On Monday–Tuesday we find considerably shorter visiting trip distances in the most central distance belts (5.5 and 7.5 km, respectively) than among the remaining respondents (slightly above 10 km in both of the two outer zones). The shorter visiting trips among the respondents living most centrally probably reflects the pronouncedly higher population density in this distance belt than in the three remaining zones. The likelihood that someone in your circle of acquaintances lives within a short distance from the dwelling is therefore higher among these respondents. In a busy daily routine, travel time will be a limiting factor and, especially in the inner districts where slower modes of transport are predominant and the cars travel at lower speeds than in the periphery, this too will reduce the length of visiting trips. At the weekend, more respondents have more time to make longer visiting trips, and trip distances could therefore be expected to vary to a lesser extent – at least measured in relative figures – with the distance from the dwelling to central Copenhagen. The good public transport services in inner-city Copenhagen make it easy to travel by train or bus to friends and relatives living in the outer parts of the metropolitan area. The latter may, in particular at the weekend, counteract some of the effect of the shorter average distance from inner-city addresses to other dwellings in the metropolitan area than from residences in the outer suburbs.

7.5 FACTORS INFLUENCING COMMUTING DISTANCES

In Chapter 5 we saw that the journey to work was the most fixed and basic travel purpose on weekdays among many of our interviewees. Other travel purposes, for example shopping, were sometimes ‘hitched on’ this main purpose. For workforce participants, the daily amount of travel was therefore to a high extent determined by

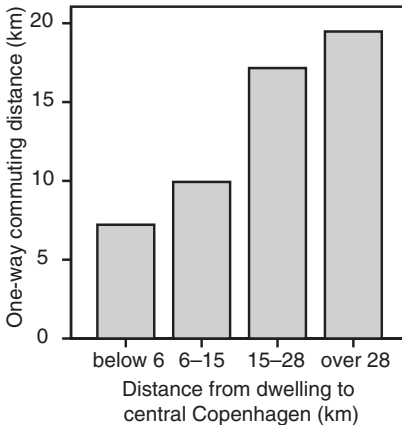


Figure 7.5 Mean trip lengths for journeys to work among respondents living within different distance intervals from central Copenhagen
 N = 1,227, $p = 0.000$

the distance between the dwelling and the workplace. Our interview material also showed large differences between central and peripheral interview areas in commuting distances.

Figure 7.5 shows average trip lengths for journeys to work among respondents of the main survey living within different distance intervals from central Copenhagen. The commuting distances have been measured accurately along the road network between the residential and workplace addresses of workforce-participating respondents. Residents of the outer parts of Greater Copenhagen have journeys to work on average two and a half times as long as those living less than 6 km away from the city centre.

The strong relationship between residential location and commuting distances holds true also when controlling for demographic, socio-economic and attitudinal variables.³⁶ Table 7.2 shows the ten variables which, according to our material, influence commuting distances with effects satisfying a significance level (p value) of 0.15. Three of the ten variables are urban structural characteristics. The distance between the dwelling and the jobsite tends to increase the further away the residence is located from central Copenhagen as well as from the closest second-order urban centre and urban railway station. The location of the residence relative to central Copenhagen is the factor exerting the strongest influence of all variables on the distance between the residence and the workplace (Beta = 0.327, $p = 0.000$). The effects of the distances from the dwelling to the closest second-order urban centre and the closest urban railway station are weaker (Beta = 0.069, and 0.052, respectively, with p -values of 0.047 and 0.128).

Table 7.2 Results from a multivariate analysis of the influence from various independent variables on the daily one-way commuting distance (km) of workforce-participating respondents

	<i>Unstandardized coefficients</i>		<i>Standardized coefficient</i>	<i>Level of significance (p value)</i>
	<i>B</i>	<i>Std. error</i>	<i>Beta</i>	
Location of the residence relative to central Copenhagen (non-linear distance function, values ranging from 0.66 to 3.80)	3.326	0.351	0.327	0.000
Sex (female = 1, male = 0)	-2.598	0.767	-0.102	0.001
Number of household members aged 7 –17	-1.384	0.488	-0.087	0.005
Has moved to the present dwelling less than 5 years ago (yes = 1, no = 0)	2.139	0.770	0.080	0.006
Personal annual income (1000 DKK)	0.0044	0.018	0.076	0.017
Logarithm of the distance (metres) from the residence to the closest urban railway station (log values ranging from 1.90 to 4.47)	2.452	1.296	0.069	0.059
Age (deviation from being 'middle-aged', logarithmically measured)	-2.635	1.330	-0.063	0.048
Index for transport attitudes (high value = car-oriented attitudes, values ranging from -17 to 11)	0.127	0.066	0.057	0.055
Logarithm of the distance (metres) from the residence to the closest second-order urban centre (log values ranging from 2.49 to 4.46)	1.239	0.814	0.052	0.128
Long technical or economic education (yes = 1, no = 0)	1.948	1.117	0.051	0.082
Constant	-4.495	4.472		0.315

Only variables with a level of significance of 0.15 or lower are included. N = 1,026 respondents from 29 residential areas in Copenhagen Metropolitan Area. Adjusted R² = 0.203

None of the effects of the three urban structural variables is surprising. The tendency to increasing commuting distances, the further away from central Copenhagen the residence is located reflects the location of a large proportion of the workplaces of the metropolitan area in the inner and central parts of Copenhagen. To some extent, the commuting distances to outer-suburban workplaces too will increase if the dwelling is situated far away from central Copenhagen. This will be the case for residents living in a different suburban sector (e.g. in the North) from the sector in which the workplace is located (e.g. the Køge bay corridor).

The second-order urban centres also contain a number of workplaces, attracting employees both from a local and regional catchment area. Some of those who live close to such a centre may therefore find suitable jobs close to their residence. The effect of the distance to the closest urban railway station probably reflects the fact that the immediate surroundings of such stations often contain a number of local service facilities and in many cases also a broader supply of workplaces. This local supply of workplaces will presumably be of a high importance to those groups of workforce participants with the least specialized jobs and/or lowest possibilities of making long journeys to work.

A number of previous investigations have shown that women more often than men combine a low degree of professional specialization with non-access to a car for daily use (Jørgensen, 1992; Hjorthol, 1998; Lee and McDonald, 2003), and hence have lower average commuting distances (see also Chapter 9). The impact of gender is therefore in line with our expectations. The same applies to the effect of school-children in the household, where childcare and activities together with the children may put constraints on the parents' opportunity to spend time on long daily commuting journeys (cf. Hägerstrand, 1970). A high income, on the other hand, enables respondents to spend more money on travelling and thus increases the respondents' general radius of action, including the possibility of choosing workplaces and residences spaced a long distance apart. The effect of income may also be due to the choice of some respondents to accept longer commuting distances in order to obtain the most well-paid employment. The longer average commuting distances among respondents who have moved relatively recently to their present dwelling reflects the fact that many other criteria are often considered more important than proximity to the workplace when people move to a new residence (see section 13.6). After the move, some people may try to find a job closer to the new residence, but since this can take some time, the likelihood of living far away from the workplace is higher among recent movers than among those who have lived in their present dwelling for several years. The effects of the three remaining non-urban-structural variables are also in line with expectations. Middle-aged respondents with high technical or economic education and car-oriented attitudes tend to be more able and willing than other respondents to commute a long distance.

Keeping non-urban-structural variables constant at mean variables, the average distance between the home and the workplace is 16 km longer among the respondents of the two most remote investigated areas (Gilleleje and Haslev) than among the respondents of the inner-city area of Vesterbro. This differential is larger than the bivariate difference between residential areas in the respective distances from central Copenhagen (14 km).

Similarly, a separate analysis among the proportion of our respondents who are students/pupils shows that the distance between the residence and the place of

education increases clearly, the further away from central Copenhagen the dwelling is situated. In spite of the quite small size of this sub-sample ($N = 124$), the effect has a high degree of statistical certainty ($p = 0.000$).

We have also investigated how the location of the *workplace* relative to central Copenhagen influences commuting distances. Employees at inner-city workplaces have on average somewhat shorter journeys to work than their outer-area counterparts, except for the outermost distance belts, where the average commuting distance drops to a level slightly below that of the most central of the distance belts (12.6 km, 14.2 km, 14.7 km and 11.9 km, respectively, in the inner, second inner, second outer and outer of the four distance belts). It should be noted that the number of respondents' workplaces is considerably higher in the inner distance belts than in the two outer, with nearly 40 per cent of all the workplaces located in the innermost of the belts (cf. Figures 4.4 and 4.5). Nevertheless, the correlation between commuting distance and the linear distance from the workplace to central Copenhagen is far from being statistically significant ($p = 0.654$). This is also true if we transform the distance from the residence to the city centre by means of a non-linear function similar to the way the distance from the residence to central Copenhagen was measured. Apparently, a slight quadratic curve provides the best description of the correlation between the commuting distance and the distance from the workplace to central Copenhagen ($R\text{ Square} = 0.008$).

Controlling for the same non-urban-structural variables as in Table 7.1, but without making any control for the location of the residence,³⁷ we find a slight tendency to reduced commuting distances among respondents working at the most remote workplaces. This tendency is, however, not statistically significant ($p = 0.228$).

7.6 ACTIVITY PARTICIPATION

As mentioned above, the phenomenon of 'distance decay' could be expected to result in lower participation in activities that can only be performed far away from the dwelling. In order to investigate this, questions about activity participation were asked in both the main survey and the travel diary investigation, including questions about present frequency of participation as well as any changes after moving from one residence to a different address. Activity participation was also a topic of the qualitative interviews.

The activity patterns among our 17 interviewee households appear to be adapted to some extent to the availability of facilities in the proximity of the dwelling. It still seldom occurs that people who have moved from one residential location to another completely abandon regular activities or start participating in new activities

as a result of the move. Neither do the interviewees' answers to hypothetical questions about this indicate that such changes will occur to any degree worth mentioning. However, our interviews show clear examples of changing activity *frequencies* due to moving. Since the day and night have a limited number of hours, increase in one type of activity will usually imply that time consumption for some other activity must be reduced. If the distances to other facilities (in particular those facilities where 'bounded' activities take place) are at the same time increased, with resulting higher time consumption in order to reach these activities, a change in the activity profile of the household is likely due to the move. Activities which, according to the interviewees, would be performed more frequently if living closer to the inner city or more seldom if living more peripherally, include chatting to neighbours, visits to cinemas, and participation in organized exercise and cultural activities. On the other hand, visits to forests and other green areas, jogging, gardening and inviting friends or family members home for dinner would occur more frequently if living in the suburbs than in a centrally located residence.

Among the 273 respondents of the travel diary investigation, 39 had moved to their present dwelling from a different address in the Copenhagen area less than five years ago. The respondents who had moved were asked to state whether the move had influenced their participation in the following six activity types:³⁸ purchasing everyday necessities; going to discotheques, etc.; going to restaurants, cafés, etc; going to see theatre performances or films; outings to the woods, at the shore, etc.; and watching TV or videos. For all activity categories, the majority of movers had not experienced any change worth mentioning in activity frequencies. Still, clear relationships can be seen between activity participation and the direction of the move (towards the periphery or closer to the city centre). Moving closer to the city centre seems to contribute to less frequent visits to forests and shores and more frequent visits to theaters/cinemas, restaurants/cafés, discotheques, etc. – and slightly more TV/video watching. The frequency of purchasing everyday necessities does not seem to be influenced. Figure 7.6 shows how changes in the frequencies of visits to restaurants/cafés and to forest/shores, respectively, due to the move, vary according to changes in the distance between the residence and central Copenhagen.

Our main survey largely confirms the impressions given by the interviewees and the travel diary investigation (Table 7.3). Other things being equal, residents of the central parts of Copenhagen Metropolitan Area go more frequently to restaurants, discotheques, cinemas, theatre performances, concerts, ballets, etc., and are visited more frequently by friends and neighbours in their home. Respondents living close to central Copenhagen buy everyday necessities as well as special commodities more often than their outer-area counterparts do. On the other hand, the frequency of shopping for everyday necessities is also increased when living far

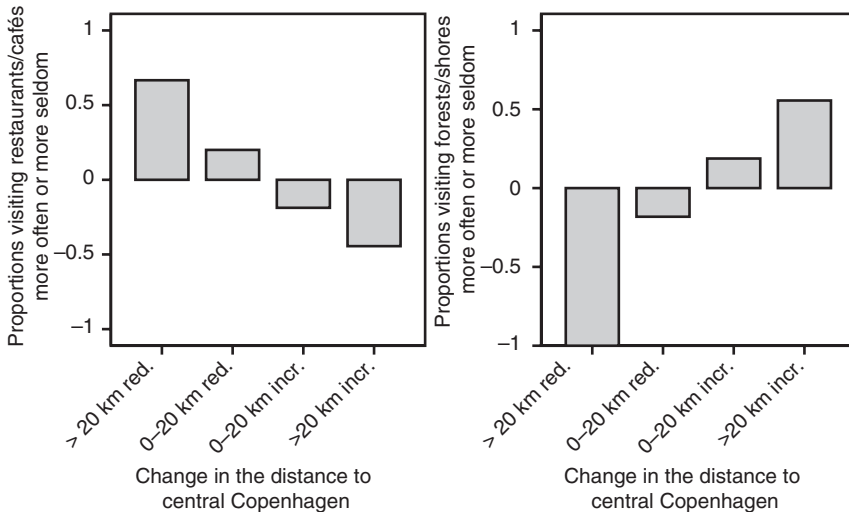


Figure 7.6 Variation in the proportions who visit restaurants/café (to the left) and forests/shores (to the right) more often (positive numbers) or more seldom (negative numbers) among groups of respondents having moved closer to or further away from central Copenhagen
 N = 38 and 39, respectively; $p = 0.001$ for restaurants/café and 0.000 for forests/shores

away from the closest second-order centre (possibly because residents living far away from the shopping facilities in such centres more often develop a routine of doing shopping on the way home from work). Together, these two oppositely directed effects are fairly consistent with the above finding that moves further away from or closer towards central Copenhagen had no significant influence on the frequency of shopping for everyday necessities.

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 socio-economic, attitudinal and other investigated variables, respondents of the main survey living close to central Copenhagen do shopping (in particular for 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 too contributes to more frequent shopping, along with 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 neighbourhood, there is a tendency for a lower frequency of outdoor sports and recreational activities among respondents living in a densely populated area, in particular visits by foot or bike to natural areas.

Table 7.3 Effects of four urban structural variables on the frequency of participation in 18 different activity categories

	<i>Location of the residence relative to central Copenhagen (non-linear distance function)</i>	<i>Logarithm of the distance from the residence to the closest second-order urban centre</i>	<i>Logarithm of the distance from the residence to the closest urban railway station</i>	<i>Density of inhabitants and work-places within the local area of the residence</i>
Purchasing everyday necessities (on average 157 times annually)	-0.108 ($p = 0.000$)	0.064 ($p = 0.034$)	($p > 0.15$)	($p > 0.15$)
Purchasing clothes, sports outfits, cosmetics etc. (on average 13 times annually)	($p > 0.15$)	-0.079 ($p = 0.002$)	($p > 0.15$)	($p > 0.15$)
Going to the cinema (on average 7 times annually)	($p > 0.15$)	($p > 0.15$)	($p > 0.15$)	0.117 ($p = 0.000$)
Repair/maintenance of house, car and garden (on average 64 times annually)	($p > 0.15$)	($p > 0.15$)	0.055 ($p = 0.037$)	-0.155 ($p = 0.000$)
Going to restaurant, café etc. (on average 16 times annually)	-0.070 ($p = 0.048$)	-0.050 ($p = 0.133$)	($p > 0.15$)	0.102 ($p = 0.008$)
Going to discotheques etc. (on average 5 times annually)	-0.057 ($p = 0.028$)	($p > 0.15$)	($p > 0.15$)	($p > 0.15$)
Theatre performances, classical concerts, opera, ballet etc. (on average 5 times annually)	-0.054 ($p = 0.041$)	($p > 0.15$)	($p > 0.15$)	($p > 0.15$)
Musicals, rock concerts etc. (on average 4 times annually)	-0.049 ($p = 0.126$)	-0.065 ($p = 0.056$)	0.053 ($p = 0.096$)	($p > 0.15$)
Being visited by friends (on average 39 times annually)	($p > 0.15$)	($p > 0.15$)	($p > 0.15$)	0.090 ($p = 0.001$)
Visiting family members (on average 38 times annually)	($p > 0.15$)	($p > 0.15$)	($p > 0.15$)	-0.093 ($p = 0.000$)
Inviting a neighbour in for a chat or coffee (on average 17 times annually)	($p > 0.15$)	($p > 0.15$)	($p > 0.15$)	0.070 ($p = 0.008$)
Participation in organizations (on average 14 times annually)	0.045 ($p = 0.088$)	($p > 0.15$)	($p > 0.15$)	($p > 0.15$)
Walks in the neighbourhood (on average 101 times annually)	0.089 ($p = 0.012$)	($p > 0.15$)	($p > 0.15$)	0.055 ($p = 0.132$)

Table 7.3 (Continued)

	<i>Location of the residence relative to central Copenhagen (non-linear distance function)</i>	<i>Logarithm of the distance from the residence to the closest second-order urban centre</i>	<i>Logarithm of the distance from the residence to the closest urban railway station</i>	<i>Density of inhabitants and work-places within the local area of the residence</i>
Walking/cycling in natural areas (on average 62 times annually)	($p > 0.15$)	-0.074 ($p = 0.041$)	0.055 ($p = 0.066$)	-0.192 ($p = 0.000$)
Team sports (on average 16 times annually)	($p > 0.15$)	($p > 0.15$)	-0.044 ($p = 0.110$)	-0.045 ($p = 0.105$)
Jogging or running exercise (on average 21 times annually)	-0.048 ($p = 0.074$)	($p > 0.15$)	($p > 0.15$)	($p > 0.15$)
Other exercise and outdoor activities (on average 44 times annually)	($p > 0.15$)	($p > 0.15$)	($p > 0.15$)	-0.053 ($p = 0.045$)
Watching football, handball, ice-hockey matches etc. (on average 6 times annually)	($p > 0.15$)	($p > 0.15$)	($p > 0.15$)	-0.056 ($p = 0.030$)

Multivariate regressions including 14 demographic, socio-economic and other control variables^a. Standardized regression coefficients and levels of significance (in parentheses). For each activity type the average annual frequency of participation is also shown. $N = 1,516-1,539$.

a The same control variables as mentioned earlier, except variables indicating particular activities likely to influence travel behaviour during the period of detailed travel registration.

There is a weak tendency to more frequent jogging and running among inner-city dwellers. On the other hand there is a clear tendency among outer-area residents for more frequent visits by foot or bike to natural areas. Not surprisingly, suburbanites do repair work or maintenance on house, car or garden more frequently than their inner-area counterparts. Moreover, apart from jogging and running outer-area residents tend to carry out exercise and outdoor activities somewhat more frequently than those respondents living in the central part of the region. They also watch sports events more frequently.

Suburbanites tend to visit family members more frequently and are slightly more involved in organizations, whereas inner-city residents tend to be more in contact with neighbours and friends than their outer-area counterparts. The more frequent visits to cafés and restaurants among inner-city dwellers must also be assumed to occur to a high extent together with friends and acquaintances. In the central city, friends most often meet at a café or go to a cinema together, among other things because of the atmosphere and the possibility of randomly meeting

other friends and acquaintances. When living in the outer areas, contacts with friends typically occur in the form of pre-invited visits in each other's homes. 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. The efforts associated with visiting these contacts will therefore be higher than among residents of central and densely populated areas, where it is much more common to have a large proportion of one's acquaintances within a few kilometres distance from the dwelling. Moreover, compared to single-family home areas, the layout of access roads and paths in more densely developed residential areas often implies an increased likelihood of meeting neighbours randomly.

There is a weak tendency for higher time consumption on TV watching as well as on leisure use of computers among respondents living close to central Copenhagen. This tendency only exists on weekdays and may possibly reflect the fact that these respondents, due to their lower time consumption on weekday travel, have more time available to spend in front of the TV or computer screen.

7.7 TRIP FREQUENCIES

Below, we shall take a look at the ways activity patterns and distances to various facilities manifest themselves in the number of trips made on weekdays and at the weekend. Our analyses of trip frequencies are based on data from the travel diary investigation.³⁹ In general, a close interdependence between trip frequencies and frequencies of activity participation could be expected. However, because of the possibility of combining several activities or errands at the same trip destination (e.g. shopping and transporting children), making several trips in connection with the same activity (e.g. visiting shops at different locations during a shopping activity) or replacing a trip with internet-based activities (e.g. e-shopping), the relationship between activity frequency and trip frequency will not necessarily be one to one.

On average, the travel diary respondents have made 3.5 trips per day during the two investigated weekdays (Monday and Tuesday). Controlling for socio-economic, demographic and attitudinal factors, our material indicates that the respondents of the most peripheral residential area tend to make 1.5 more trips daily than their counterparts living in the area closest to central Copenhagen ($p = 0.000$). This relationship may appear a bit surprising, as the costs of making a trip is lower when the destination is close to the origin, and a large number of facilities will be available within a short distance from the dwelling when living in the inner-city. A possible explanation of our finding is that residents living on the periphery have fewer opportunities to carry out several errands during the same trip, for example when shopping, and therefore have to carry out a higher number of separate trips.

At the weekend, the respondents have on average made three trips per day. The total number of trips appears to be influenced by two urban structural variables: local area density ($p = 0.005$) and the location of the dwelling relative to central Copenhagen ($p = 0.022$). The number of trips made at the weekend tends to increase the lower the local area density is, and the closer the residence is located to central Copenhagen. The latter effect is in line with expectations (cf. above). The effect of local area density on the number of trips at the weekend is more difficult to explain, but it might reflect a tendency found among residents of dense, inner-city areas to reduce the number of shopping and visiting trips carried out at the weekend. It might also reflect a higher propensity among inhabitants of dense areas to make long weekend trips to cottages etc. (cf. chapter 10), replacing a number of shorter trips that might otherwise have been made. The net result of the influences of the two urban structural variables is virtually no difference between central and peripheral residents in the propensity of trip-making at the weekend.

The trip purpose where the frequency appears to be influenced by residential location to the highest extent is *visits to relatives and friends*. Both on the two investigated weekdays and at the weekend a central residential location contributes to increasing the number of visiting trips. On weekdays, the effect of centrality refers to proximity to the closest urban railway station ($p = 0.045$), while the location of the dwelling relative to central Copenhagen exerts the strongest influence on the number of visiting trips at the weekend ($p = 0.003$). On the other hand, a high local area density appears to have the opposite effect on the number of visiting trips on Saturday–Sunday ($p = 0.027$). However, at the weekend too, the net result of the two urban structural variables is a higher propensity for making visiting trips among inner-city dwellers.

If you live in the outer part of the metropolitan area the average distance to the homes of friends and family members will tend to be longer than for inner-city dwellers, unless the relatives and acquaintances are concentrated in the segment of the urban region area where you live. A peripheral residential area might therefore imply more cumbersome visiting trips and hence tend to decrease the number of such trips. Living far away from the closest urban railway station also makes it more inconvenient for people who do not have a car at their disposal to visit friends or relatives living beyond acceptable walking or biking distance. The somewhat surprising negative effect of local-area density on weekend visits may perhaps mirror a certain tendency to increased social contact among neighbours in small outer-area villages (where local area densities are low as the villages are often surrounded by farmland). It may, however, also mirror the higher supply of restaurants, cafés, cinemas, pubs etc. in the central areas and the averagely smaller dwellings in these areas, making it more attractive to meet friends or relatives at a public meeting place rather than at home (cf., among others, Hougen, 1998).

Living far away from the closest urban railway station tends to increase the number of trips carried out in order to *bring children to and from kindergarten/crèche or school* ($p = 0.023$). This probably reflects the higher need for children to be escorted by other family members to activities beyond walking or biking distances if the possibilities for going by public transport are poor. Moreover, when living far away from an urban railway station, several local facilities often located around stations will more often be situated beyond acceptable walking or biking distance. On weekdays, the number of such trips does not seem to be affected to any degree worth mentioning by urban structural characteristics.

The frequency of *errand or shopping* trips at the weekend tends to increase when living close to central Copenhagen ($p = 0.041$), while a high local area density contributes to reducing the frequency of such trips ($p = 0.033$). The first of these effects probably reflects the fact that a number of potential destinations for such trips, notably trips where (window) shopping and recreation are interwoven, are located in the inner-city area. The effort and cost of visiting the main shopping districts will be higher the further away from the city centre the residence is located. The opposite effect of high density in the local area of the residence may reflect a tendency among residents of dense areas, where a large number of shops are normally available close to the dwelling, to do (grocery) shopping on ordinary weekdays rather than concentrating the purchases to the weekend. On weekdays, we find a slight tendency for an increasing number of shopping trips, the further away from central Copenhagen the respondent lives ($p = 0.131$). This may reflect a tendency among peripheral residents to concentrate their shopping trips to the weekend to a higher extent than their inner-city counterparts do.

For *leisure trips* any influence of residential location on the trip frequency is limited to the weekend, and the effect is modest and somewhat uncertain. The number of leisure trips on Saturday and Sunday appears to be slightly increased the further away the respondents live from the closest urban railway station ($p = 0.091$). Possibly, this reflects a tendency among residents of peripheral parts of the region to make more frequent trips to forests, fields or other areas for outdoor recreation. A similar tendency was found in the mapping of activity frequencies (cf. Table 7.3), where residents of low-density areas tended to visit natural areas more often.

Some theorists have assumed that 'distance decay' will by and large also have its effects on the weekly number of days the *workplace* is visited, since information and communication technology has made it possible for an increasing part of the workforce to do some of their work from home. However, among our respondents, we hardly find any such tendency. Data from our main survey show that the number of days at the workplace is practically the same, regardless of the commuting distance. Controlling for variation in weekly working hours and a number of socio-economic variables, 20 kilometres increased commuting distance corresponds to working at

home instead of going to the regular workplace one day per eight weeks ($p = 0.084$). This very slight tendency is not matched by any corresponding tendency among outer-area workforce participants to less frequent attendance at the workplace. The weekly number of days at the workplace is unrelated to the distance between the residence and central Copenhagen ($p = 0.348$).

The absence of any tendency for less frequent journeys to work among outer-area residents is confirmed by a multivariate analysis of the relationship between residential location and the number of trips to workplace or place of education (based on the travel diary investigation). Our material shows a surprising, albeit quite modest tendency to more frequent trips to workplace or place of education the further away from central Copenhagen the residence is situated ($p = 0.098$). This effect is hard to explain, but at least it shows that there is no tendency among peripheral residents of Copenhagen Metropolitan Area to compensate for long commuting distances by working at home more often than their counterparts living in the central parts of the region.

Some debaters (among others Højer, 1998) have pointed at online shopping as a possible way for people living in peripheral areas to reduce their daily amount of travel. However, our data show that purchases via the internet do not – at least for the time being – contribute to any reduction of the difference in the amount of travel between respondents living centrally and on the periphery. On the contrary, the respondents most prone to making purchases via the internet are those who live in central parts of the metropolitan area, where the supply of stores in the proximity of the dwelling is the highest. Moreover, many of the purchases made online would arguably not in any case have implied physically visiting the store, but would instead have been based on ordering via post or telephone. Today, the commodities purchased online are often tickets (for flights and train journeys, as well as for films, theatre performances and concerts). This was also noticed in some of the interviews and verbal comments on the questionnaires. The higher propensity of computer-based purchases among inner-city residents may therefore reflect these residents' more frequent visits to films, theatre performances and concerts. As mentioned above, our material shows pronouncedly higher frequencies of visits to such events among residents of the inner districts, where distances to the facilities mentioned are short. The explanation might, however, also be sought in lifestyle characteristics. Imaginably, the effect of a central residential location on internet shopping may reflect the prevalence of certain 'urban-cosmopolitan' lifestyles also involving an extensive use of the internet (see also Chapter 10).

7.8 TIME CONSUMPTION FOR TRANSPORT

In sections 7.4 and 7.5, we noticed that differences between inner and outer parts of the metropolitan area in the availability of facilities translated into characteristic differences in average trip distances to the various facility categories, in particular workplaces and places of education. In spite of the considerably longer commuting distances, we do not find any clear relationships in the travel diary data between the location of the residence relative to central Copenhagen and the time consumption per trip. This applies to commuting as well as other trip purposes. Higher average travel speeds among outer-area residents, resulting from a high proportion of car travel and less congestion on suburban roads, counterbalance much of the effect of longer trips among these respondents. Time consumption for journeys to workplace or place of education are almost completely unrelated to the distance between the residence and central Copenhagen (bivariate correlation, Pearson's $r = 0.06$, $p = 0.27$).⁴⁰ Even more unrelated to residential location is time consumption on weekdays for visiting trips, leisure trips and official trips, with levels of significance varying from 0.78 to 0.99. Time consumption for errand/shopping trips and trips in order to bring children to/from school or kindergarten tends to increase somewhat when living in the peripheral parts of the region ($p = 0.049$ and 0.120 , respectively). At the weekend there is also a weak and quite uncertain correlation between a peripheral residence and lower time consumption for leisure trips ($p = 0.20$).

The total time consumption for transport depends not only on the time consumption per trip, but also on the number of trips. Altogether for all trip purposes, time consumption for transport on Monday–Tuesday is lower among respondents living in dense inner-city areas⁴¹. Controlling for the other investigated variables, respondents living less than 6 km away from the central Copenhagen area spend on average 98 minutes on their total transport activity during Monday and Tuesday, compared to 128 minutes, 132 minutes and 135 minutes, respectively, in the three outer distance belts ($p = 0.007$).⁴²

At the weekend the pattern is less clear. Controlling for non-urban-structural variables, the average time consumption for transport during Saturday and Sunday is 150 minutes among respondents living in inner suburbs (between 6 and 15 km from central Copenhagen), compared to 125 minutes in the inner distance belt and about 120 minutes in each of the two outer distance belts.

Our results illustrate the considerable difference in average travel speeds between inner area and outer-area respondents. Similar differences have been found in the Paris region (Fouchier, 1998) where outer-area respondents transport themselves considerably longer than the residents of the inner districts of Paris, but still spend slightly less time on travelling. These observations weaken the arguments put forth by certain commentators (e.g. Vilhelmson, 1990) who, referring to the so-called

'Zahavi's law of the constancy of travel time' (Schafer and Victor, 1997), question the possibility of influencing the amount of travel through a more concentrated urban development. Even if travel times among residents of central and peripheral areas were the same, this does not imply that travel distances are equal, since the modal split (higher proportions of walking and biking in inner areas) and the conditions for car travel are not the same. Moreover, our material also contradicts the hypothesis of a constant travel time independent of urban structural conditions. Apart from the considerable individual differences, we find a quite clear, urban structural-related difference between centre and periphery. Controlling for non-urban-structural variables, the weighted average weekly time consumption during the week as a whole is about 20 per cent lower among the respondents living less than 6 km from central Copenhagen than among the remaining respondents (with only small differences in the averages of the three outer distance belts).

7.9 CONCLUDING REMARKS

By investigating the relationships between residential location and facility availability, location of activities, trip distances, frequency of activity participation, trip frequencies, and time consumption for transport, this chapter has sought to contribute to a more detailed and nuanced understanding of the relationships between residential location and travel behaviour. Table 7.4 shows the main influences of residential location on availability of facilities, use of local facilities, trip distances, activity and trip frequencies, and travel time. The influences of residential location are especially strong on the availability of facilities and on trip distances. There are also influences of the location of the dwelling on the use of local facilities, activity participation, trip-making and travel time, but these influences are weaker and sometimes confined to certain activities, travel purposes or periods of the week.

The propensity for using local facilities is partly influenced by the *availability* of facilities close to the residence, and partly by the extent to which these facilities are exposed to *competition* from non-local opportunities. In general, the strong concentration of facilities in the inner and central parts of Copenhagen Metropolitan Area implies that average trip distances increase the more peripherally the residence is located. In particular, a peripheral residential location contributes to a substantial increase in average commuting distances.

The location of the residence in relation to the hierarchy of centres in the metropolitan area has some influence on the frequency of participation in different activities, with more visits to typical 'urban' facilities like cinemas, theaters and restaurants among inner-city dwellers, while residents of the outer suburbs go more often to forests and shores and spend more time on domestic repair and maintenance work.

Table 7.4 Main influences of residential location on availability of facilities, use of local facilities, trip distances, activity and trip frequencies, and travel time

<i>Dependent variable</i>	<i>Strength of influence from residential location</i>	<i>Nature of influence from residential location</i>
Availability of facilities	Very strong	Higher in central areas
Use of local facilities	Some	Lower in inner suburbs
Commuting distances	Very strong	Longer in peripheral areas
Length of non-work trips	Fairly strong	Longer in peripheral areas
Frequencies of activity participation	Moderate	Depending on types of activities
Trip frequency	Moderate	Higher on weekdays in peripheral areas
Travel time	Moderate	Shorter on weekdays in central areas

This reflects the differences between inner and outer parts of the metropolitan area in the availability of different types of facilities. For leisure activities we can thus observe a certain degree of 'distance decay'. Inner-city residents also tend to be in informal contact with friends and neighbours somewhat more often than suburbanites do. There is, however, no difference among outer and inner area workforce participants in the frequency of attendance at the workplace. The above differences in activity participation translate into corresponding differences in the frequencies of trips of different purposes. On weekdays, living far away from central Copenhagen contributes to a somewhat higher number of trips, possibly reflecting that residents living on the periphery have less opportunity of carrying out several errands during the same trip. At weekends, the differences between outer and inner areas in the frequencies of trips for different purposes largely outweigh each other.

In spite of higher average travel speeds among outer-area residents, time consumption for transport is higher in the peripheral than in the central part of Copenhagen Metropolitan Area. However, the difference in time consumption between suburbanites and inner-city dwellers is smaller than the corresponding difference in travelling distances.

CHAPTER 8

ARE THERE ADDITIONAL, INDIRECT EFFECTS OF RESIDENTIAL LOCATION ON TRAVEL?

8.1 INTRODUCTION

In the international research into urban structure and travel it has – to the extent that multivariate analyses have been carried out at all – been common to include car ownership among the control variables. In the multivariate statistical analyses in Chapters 6 and 7 car ownership was thus one of the control variables. However, in recent years several authors have called attention to the fact that car ownership is in itself influenced by urban structural conditions (Giuliano and Narayan, 2003; Fosli and Lian, 1999; Næss, 2003). Among other things, it may be argued from a time–geographical perspective that the location of the dwelling influences the residents' need for having private motor vehicles at their disposition. If you live far away from the destinations of the 'bounded trips' and are compelled to travel by foot, bike or public transport, these trips will consume a large proportion of the time budget. The time tied up in the necessary everyday travel may then easily supersede other, desired activities, for example being together with the children, participating in organized leisure activities, or managing full-time employment. By providing oneself with a car (or possibly a second car), higher travel speeds are obtained, and more time will be available for other everyday activities.

The inclusion of car ownership among the control variables may thus be considered a kind of 'over-control', as car ownership may be influenced by the distance from the dwelling to destinations for daily travel purposes and by the level of public transport services. The same can be said about some of our other control variables, notably transport attitudes. Arguably, those who live in an area where they feel strongly dependent on car travel in daily life will develop more positive attitudes towards the car. Conversely, inner-city residents who do not need to use the car in their daily life at all, but are exposed to traffic noise and emissions in their neighbourhoods, might develop more negative attitudes to private motoring and a higher awareness about urban environmental problems. Similar arguments could be advanced about certain other characteristics of the respondents partially susceptible to influence from the urban structural situation of the dwelling, among others possession of a driving licence: you want to drive a car, and in order to realize this wish you decide both to submit to the driving test and to buy a car.

Since car ownership is included in most multivariate studies on the topic, and because several authors have suggested that the relationships between urban

structure and travel may vanish or be reduced if attitudinal factors and driving licence holding are taken into regard, we still decided to include these 'grey zone' control variables in our main analyses. It should, however, be noted that this produces conservative estimates of the influences of urban structural variables. When controlling for the above-mentioned 'grey zone' control variables, we should therefore at the same time take the possible indirect effects of residential location via these variables into consideration. In particular, this makes a considerable difference in the analyses of the influence of urban structure on the amounts of travel by different modes.

On the other hand, a couple of other control variables may be influenced by residential location and thereby contribute to a certain exaggeration of the effects of the urban structural variables. This applies to the frequency of overnight stays away from home, which might imaginably be increased among residents of densely populated inner-city areas due to 'compensatory' leisure travel, and the weekly number of days at workplace or school, where 'distance decay' in the form of increased telecommuting could be imagined.

In this chapter an assessment will be made of the effects of the urban structural variables when taking both their direct effects and the effects via the above-mentioned 'grey zone' control variables into consideration. The total effects have been estimated by means of so-called path analyses including direct as well as indirect effects (Hellevik, 1989).

Below (section 8.2) we shall first take a look at the relationships between our urban structural variables and, respectively, car ownership and subjective opinions concerning car dependency, controlling for socio-economic and attitudinal differences between the respondents. Because the influence of residential location on car ownership is a contested issue in the research literature, these relationships will be dealt with in some length. Thus, material from the qualitative interviews, the main questionnaire survey as well as the travel diary investigation will be drawn on. The latter data also include analyses of any changes in car ownership among respondents who have moved from one residential address to a different location within Copenhagen Metropolitan Area.

Thereupon (section 8.3) follows a presentation of analyses where the indirect effects of residential location through car ownership as well as other 'grey zone' control variables has been calculated. In the subsequent section (8.4) the combination of direct and indirect effects into total causal effects will be illustrated. A summary section follows at the end of the Chapter (section 8.5).

8.2 RESIDENTIAL LOCATION INFLUENCES CAR OWNERSHIP AND CAR DEPENDENCY

EXAMPLES FROM THE QUALITATIVE INTERVIEWS

Our qualitative interviews show that the interviewees living in the peripheral parts of Copenhagen Metropolitan Area feel dependent on car travel to a considerably higher extent than the interviewees living in the central parts of the urban region. The interviews also show some examples of moving to a more peripheral dwelling resulting in the purchase of a car, or in consideration of purchasing one, either as the first car of the household or as an additional car. One interview household leading a carless 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:

We bought our car number two last year. One and a half year ago ... it was because we bought this house here last year. And then we thought it might be good to have a car number two, when we were going to live here out in the countryside. So we paid it before we bought the house.

(Male computer scientist, 30, living in the village of Uvelse)

Car purchase as a result of moving primarily applies to the interviewees living in Uvelse. Another household in this village was repeatedly deliberating whether to purchase a second car in order to reach daily activities, as the distances to these activities had become radically longer after they moved to Uvelse, and it would be very time-consuming to travel by public transport. In particular, the purchase of an additional car would be triggered if the husband was elected (which he expected he would be) as a local councillor in the coming-up election. In this case, the location of the residence would be a contributory cause for the car purchase, as it would not have been necessary to use a car to and from the local council meetings if the interviewee had instead lived in the municipal centre Slangerup (where the town hall is located). The bus connection between Uvelse and Slangerup is very poor with only one departure per hour in the evening, and no departures after 10 p.m.

Among the interviewees in the peripheral settlement of Stenløse, who all lived close to an urban railway station, there are no examples of car purchasing as a result of having moved to the area. Each of the four interview households in this area had one car, and they also had one car when they (many years ago) moved to Stenløse.

Four out of the nine interviewee households in the central part of the metropolitan area do not own any car. However, there are no examples of interviewees having got rid of their car as a result of moving from the outer suburbs to the inner-city districts.

Most interviewees in Uvelse consider themselves highly dependent on the car. The following quotation from the male computer scientist mentioned above is typical:

Well, I couldn't do without a car. Not out here. You really cannot.

(Male computer scientist, 30, living in the village of Uvelse)

This interviewee also states that he would immediately rent a car if both the household's cars were at the repair shop. Being asked the same question, another Uvelse household says that they would take a holiday during the weeks when the cars were at the repair shop:

If both [cars] were at the repair shop? It would be unthinkable, wouldn't it? ...

Then we would really have a problem. Then we would take a holiday or that kind of thing.'

(Female civil engineer, 38, living in the village of Uvelse)

This household as well as one of the other three interviewee households in Uvelse consider that they would have to reduce their working hours if they were to make do without a car or with only one car:

No, but then we would have to go and take the train, and the bus to the station, and then we would spend ... really, we wouldn't be able to be at work for more than five or six hours a day, because then we would have to go back home, you see, and pick up the children and that kind of things ... Then we would need to choose whether one of us had to work part-time in order to make things fit together. Indeed, we would have to work less, simply.

(Female civil engineer, 38, living in the village of Uvelse)

Indeed, it would almost, well, as I need to be at the workplace at seven o'clock, I actually don't think I could go to work ... Because then there is something about, I can take a bus to Frederikssund, and then another bus goes from Frederikssund to Jægerspris, but I don't think I could be there at seven o'clock ... I have checked it on the Internet several times. Eight o'clock is possible, but then there is half an hour waste of time ... Then I would spend almost one hour and a half on my trip to the workplace. One hour and a quarter, I guess we calculated it to be.

(Female graduate nurse, 34, living in the village of Uvelse)

Given their present employment situation, three out of the four Uvelse interviewee households state that it would be difficult to limit their car travel, even in the event of a pronounced rise in fuel prices. The following quotation is illustrative:

Indeed, we have talked about this thing, when petrol prices increase, well, until now we haven't been able to reduce our consumption. To be sure, we are simply

so dependent ... since we have chosen to live here, that even when the petrol price has been close to ten kroner, it has ... we do not at all think that we drive to activities we shouldn't drive to. We drive by far the largest part in connection with our work, and there we have no choice, have we? ... The petrol would really need to increase a lot before we start changing our habits.

(Female civil engineer, 38, living in the village of Uvelse)

They would also have to cut down on their 'non-bounded' trips (leisure activities, visiting friends). This also applies to a third Uvelse household where the wife was on maternity leave at the time of the interview. As long as the child was taken care of in the home, the opening hours of kindergartens, etc. did not put any constraints on the husband's time spent at the workplace, and making do without a car would therefore not necessitate any reductions in the household's working hours. However, it would be difficult for this couple to return to a situation with two full-time jobs if they did not have at least one car. Probably, a reduction from two cars to one car would also make it difficult to get to daily activities.

The workforce participants among the interviewees in Stenløse, where the urban railway line offers a good public transport service, would hardly need to reduce their working hours if they were to make do without a car. However, they would need to spend somewhat more time on both their 'bounded' and 'non-bounded' trips, which would in its turn probably compel a certain reduction in the number of out-of-home leisure activities.

As mentioned above, four out of the nine interview households living in the inner districts of Copenhagen did not have any car. One of these interviewees stated that they would perhaps have made more visiting trips if they had a car, but apart from this it does not appear likely that the activity patterns of these households would have been changed to any great extent if they had a car at their disposal. Conversely, the inner-city interview households who presently own a car would hardly need to change their everyday activity pattern significantly if they were no longer to have a car at their disposal. Their logistics would possibly be somewhat more cumbersome, especially in connection with visiting and leisure trips, but the interviewees would not be compelled to abstain from such trips:

Well, I would say it would not be impossible to continue, but ... if we were to abstain from driving, it would be a bit more troublesome to get around, in particular when we visiting friends

(Male civil engineer, 43, living in the inner city district of Frederiksberg)

These households also say that they would hardly rent a car if their car was stuck at the repair shop for a couple of weeks. The number of visiting trips and outings in natural areas would still probably be somewhat reduced.

The foregoing implies that the residents of Uvelse are quite *car dependent* in order to reach daily activities, and also with respect to the *necessary* and 'bounded' trips. Owing to the good train connection towards Copenhagen, the interviewees in Stenløse are not car dependent to the same extent as their Uvelse counterparts. The daily trips of the Stenløse residents working or studying in other parts of the metropolitan area than central Copenhagen or along the urban railway between Copenhagen and Frederikssund would, however, be quite inconvenient without a car. Stenløse residents working or studying outside the area covered by the urban railway passing through this settlement could therefore also be characterized as quite car dependent.

The nine interview households living in central parts of the metropolitan area are all quite *independent* of cars, especially for their 'bounded' trips, but to a high extent for 'non-bounded' activities as well. Even though five of these households have a car at their disposal, their activity patterns would not need to be changed substantially if they were to make do without a car.

RESIDENTIAL LOCATION AND CAR OWNERSHIP – EVIDENCE FROM THE STATISTICAL ANALYSES

The impression given by the qualitative interviews is confirmed when analyzing the variation in car ownership between inner-city and outer-area respondents of the main questionnaire survey. As several of the dependent variables discussed in the following section are dichotomous (i.e. variables with only two possible values), logistic regression analyses have been used instead of ordinary least square regressions for these variables.

The proportion of respondents with at least one car in the household increases sharply as the distance between the dwelling and central Copenhagen increases (Figure 8.1, right). The respondents' subjective opinions concerning dependence on private cars in their daily life point in the same direction (Figure 8.1, left). The further away the respondents live from central Copenhagen, the more often they consider themselves dependent on car travel in everyday life.

Controlling for socio-economic, attitudinal and other control variables, *the number of cars per adult household member* is higher in areas located far away from central Copenhagen and/or the closest second-order centre ($p = 0.000$ for both). 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, for example because a high car ownership enables households to widen their locational choices. However, in the latter case too, the implication is that residential location influences the need for a car – otherwise people would choose places of residence independently of their present (or expected future) access to cars.

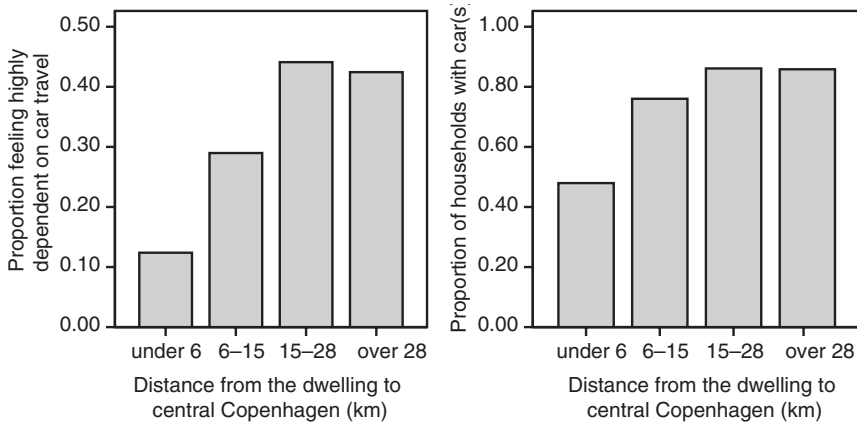


Figure 8.1 Proportions considering themselves as highly dependent on the private car in order to reach daily activities (to the left, $p = 0.000$), and proportions belonging to a household with a car (to the right, $p = 0.000$), among respondents living within different distance intervals from central Copenhagen $N = 1,897$ and $1,922$, respectively

Looking at factors influencing *whether or not the household has any car at all at its disposal*, we also find clear effects of the distances from the dwelling to central Copenhagen ($p = 0.000$) and to the closest second-order centre ($p = 0.001$). Among these effects, the influence of the location of the dwelling relative to central Copenhagen is the strongest and most certain. Looking finally at factors influencing the propensity of households with two or more adult household members to have *at least one car per adult household member*, we find that car ownership tends to be reduced with increasing local-area density ($p = 0.000$) and with reduced distances from the residence to the closest urban railway station ($p = 0.035$). In this case neither the distance from the dwelling to central Copenhagen nor to the closest second-order centre shows significant effects.

In all the above-mentioned analyses of factors influencing car ownership, transport attitudes and environmental attitudes were included among the control variables, and the attitudes to transportation issues especially showed relatively strong effects. However, there is a clear possibility here for two-way effects: maybe car ownership, with the habits it facilitates, influences attitudes to at least as high an extent as the purchasing of cars is influenced by pre-established transport attitudes. It might therefore be argued that the attitudinal variables should not be included in analyses of factors influencing car ownership (and vice versa). The path analyses presented in the next section are based on this reasoning.

Among the small sample of travel diary respondents who had moved to their present dwelling from a different address within Copenhagen Metropolitan Area during

the last five years, we find a tendency to increased car ownership due to (according to the respondents' own judgment) moving further away from central Copenhagen ($N = 38$, $p = 0.060$). With the low number of respondents and even lower number (11 households) who changed their car ownership after the move, there is considerable scope for coincidence. However, the significance level indicates that there is only 6 per cent likelihood that the relationship between the changes in car ownership and in the residence's distance from central Copenhagen could be a result of coincidence. Only four persons out of the 38 who moved say that they changed their car ownership entirely or partially due to the move. However, all these partially or entirely location-based changes are in line with what could be expected from theoretical considerations (increased car ownership only when moving outward). Surely, there is a considerable inertia in car ownership, in particular when it comes to parting with the car. Among the majority of those who have moved, including respondents having moved further away from as well as closer to the centre of Copenhagen, the number of cars per adult household member is the same since the move as before.

PERCEIVED CAR DEPENDENCY

Controlling for socio-economic and attitudinal variables, our material shows that the propensity for *not feeling at all dependent on car travel in everyday life* is influenced by quite a few variables, where a residential location close to central Copenhagen has one of the strongest and most conclusive effects ($p = 0.000$). Living near to the closest second-order centre ($p = 0.007$) and/or in a high-density local area ($p = 0.037$) also contribute to some increase in the likelihood of not feeling dependent on car travel.

In comparison, the likelihood of perceiving oneself as being highly dependent on car travel is influenced by a higher number of the investigated variables, and there is also a larger influence from factors and circumstances not included by the variables of the analysis. Among the urban structural variables, the location of the dwelling relative to central Copenhagen still has the strongest effect ($p = 0.008$), but this effect is weaker than in the analysis of factors influencing the propensity for not feeling at all dependent on a car. The likelihood of feeling highly dependent on car travel also increases when living far away from the closest second-order centre ($p = 0.036$) and/or in a low-density area ($p = 0.073$). We also find an effect of the distance from the dwelling to the closest urban railway station ($p = 0.068$). The latter may indicate that living far away from the closest urban railway station first and foremost contributes to an increase from a *moderate* to a *high* car dependency among some of the respondents who are already (due to other urban structural conditions or individual characteristics) dependent on car travel to some extent. Proximity to an urban railway station alone does not seem to make any contribution worth mentioning towards making people feel *independent* of cars in their daily life.

OUR DIFFERENT DATA SOURCES POINT IN THE SAME DIRECTION

The material from our questionnaire surveys shows that the examples seen in the qualitative interviews of perceived car dependency among peripheral residents are not isolated cases. Nor are the examples of households having purchased a car (or a second car) as a result of moving to a more peripheral residence exceptional.

Both among the respondents of the first survey and among the respondents of the travel diary survey we find a higher car ownership among outer-area respondents than among their counterparts living in inner, densely populated districts, even when controlling for socio-economic and attitudinal differences. Similarly, among the (admittedly few) travel diary respondents who have moved to a different residential address within Copenhagen Metropolitan Area during the last five years we find a tendency where some of those moving to a more peripheral residence provide themselves with a car (or an additional car) due to the move, while moving closer to central Copenhagen does not result in increased car ownership. Finally, we find a clear tendency that a peripheral residence increases the likelihood of considering oneself as being dependent on car travel in order to reach daily activities. Altogether, our qualitative and quantitative material provides a good basis for concluding that the respondents' car ownership is influenced by (among others) the location of their residence. Including car ownership as a control variable in analyses of relationships between residential location and travel must thus be said to be a kind of 'over control', as long as the socio-economic and other variables theoretically likely to influence car ownership have already been controlled for. If car ownership is included as a control variable in analyses of relationships between residential location and travel, the indirect effect of residential location on travel behaviour via car ownership must therefore also be taken into consideration.

8.3 INDIRECT EFFECTS OF RESIDENTIAL LOCATION

In order to investigate the indirect effects of the urban structural variables on travel behaviour, so-called path analyses have been conducted. First, the effects of the urban structural variables on each of the 'grey zone' control variables have been investigated by means of multivariate regression analyses, including the same control variables as previously, except for the 'grey zone' control variables. Next, the indirect effects have been calculated by multiplying the effects of the urban structural variables on each 'grey zone' control variable with the effects of the latter variables on the travel behaviour variables.

Thus excluding the other 'grey zone' control variables from the multivariate analysis, we find effects of all the four urban structural variables on *car ownership*, measured as the number of cars per adult household member. The effects of the

location of the dwelling relative to central Copenhagen and the closest second-order centre are still considerably stronger than the effects of the two remaining urban structural variables. Car ownership tends to increase, the further away the residence is located from central Copenhagen ($p = 0.000$), the closest second-order centre ($p = 0.000$) and/or the closest urban railway station ($p = 0.088$), and the lower is the local area density ($p = 0.131$).

According to our material, the respondents' *transport attitudes* tend to become less car-oriented the higher is the local area density ($p = 0.000$) and the closer to central Copenhagen the residence is located ($p = 0.092$). Both these effects are in line with our theoretical expectations. The effect of density probably partly reflects the lower car ownership rate in dense local areas (see the foregoing), as car ownership and regular car travel must be assumed to exert a certain influence on transport attitudes. However, the effect of density is considerably stronger on transport attitudes than on car ownership, so other aspects of high-density living must also play a role. One likely mechanism is the stronger exposure to congestion, noise and local air pollution experienced by residents of dense, inner-city environments. Such experience may partly contribute to a higher awareness of the negative environmental impact of car traffic. Congestion on the local roads may also stimulate the use of other modes of travel than the car, and thus give experience which, in its turn, influence transport attitudes. Finally, densely populated areas usually have better public transport services, and a number of potential trip destinations can be reached within walking or biking distance. Even though the questions about transport attitudes were formulated with the intention of avoiding answers that were influenced by, for example, the quality of public transport near the residence or the practical possibility of reaching daily destinations by foot or by bike, the opportunities and constraints given by the residential location may still have influenced the answers to some extent.

The respondents' attitudes to *environmental issues* appear to be influenced by the same two urban structural variables as their transport attitudes. Again, the effect of local area density is the stronger ($p = 0.000$), whereas the effect of the location of the residence relative to central Copenhagen is modest and somewhat uncertain ($p = 0.102$). These attitudes may partly be related to the transport attitudes, where exposure to noise, pollution and accidents in connection with car traffic in dense inner-city environments, combined with experience as pedestrians or bicyclists, contribute to developing a higher general environmental awareness, possibly reflected beyond transportation issues. Besides, inner-city residents are probably to a higher degree exposed to the activities of 'environmental grassroots' in the form of processions, information stands, demonstrations and exhibitions.

The respondents' possession of *driving licence for car* has been analyzed by means of logistic regression analysis, as the dependent variable in this case has

only two values (holds or does not hold a driving licence). According to our material, the frequency of driving licence holding is influenced by all four urban structural variables. The respondents tend to hold a driving licence more frequently if they live far away from central Copenhagen ($p = 0.001$), far away from the closest urban railway station ($p = 0.012$) and/or far away from the closest second-order centre ($p = 0.035$). In addition, living in a dense local area appears to increase the likelihood of holding a car driving licence ($p = 0.009$). While the first three of these effects probably reflect the lower need for car driving when living centrally, the effect of density is difficult to explain.

According to our material, the *number of days of appearance at workplace or place of education* is not influenced by any of our four urban structural variables.⁴³ A logistic regression analysis of factors influencing the propensity of having made four or more *overnight stays away from home* during the investigated week shows a tendency to less frequent overnight stays away from home, the further away from the closest second-order urban centre the residence is located. The effect is not very strong, but fairly certain ($p = 0.005$). A possible explanation might be a lower propensity among respondents living in peripheral areas for going on mini-holidays to tie in with Whitsun (included in the investigation period for some respondents). This would imply a sort of compensatory travel (cf. Chapter 10).

Table 8.1 provides an overview of the effects of the four urban structural variables on car ownership, transport attitudes, environmental attitudes, possession of driving licence, frequency of appearance at the workplace, and frequency of having stayed at least four nights away from home during the week of investigation. For the sake of comparison all effects – including the variables where logistic regression was used above in order to comply with the requirement of dichotomous variables – are shown by means of the standardized regression coefficients of ordinary least squares regressions. Because of the contraventions of the presuppositions of linear regression analyses occurring in the three analyses in the lower half of the table, the standardized regression coefficients of these effects have been bracketed.

Our material indicates that car ownership, transport attitudes, environmental attitudes, driving licence holding as well as the frequency of overnight stays away from home are influenced to a higher or lower extent by residential location. Controlling for socio-economic variables, we find significant effects of one or more of the urban structural variables on the above-mentioned characteristics of the respondents. It is therefore reasonable to conclude that urban structure influences travel behaviour indirectly through these variables. When controlling for car ownership and the attitudinal and other ‘grey zone’ control variables, we should therefore at the same time take such indirect effects into consideration.

8.4 COMBINING DIRECT AND INDIRECT EFFECTS

Based on the influences of the urban structural variables on the 'grey zone' control variables shown in Table 8.1, combined with the direct effects of the urban structural variables identified earlier (Chapter 6), Table 8.2 summarizes the main influences of urban structural characteristics on travel behaviour on weekdays. In line with the rules of path analysis the indirect effects emerge by multiplying the standardized regression coefficients of the two relationships making up the indirect effect by each other. Figure 8.2 shows the direct as well as the indirect effects of the four main urban structural variables (to the left) on the proportion of distance travelled by car. The strength of each effect has been indicated by the boldness of the arrows. The direct effects of residential location on the proportion of car travel are relatively modest. However, the indirect effects via car ownership and transport attitudes are strong, and when both direct and indirect effects are taken into consideration, we can conclude that residential location exerts quite a strong influence on the proportion of distance travelled by car.

In order to illustrate the direct and indirect effects of the urban structural variables among residents living centrally and on the periphery, Table 8.3 shows expected differences in travel distances and modal shares between respondents living in the residential areas closest to and furthest away from central Copenhagen. The respondents of the most central area, Vesterbro, live on average 1.7 km from the centre of Copenhagen, 1.1 km from the closest second-order urban centre and 0.2 km from the closest urban railway station, while the local area density is 169 persons per hectare. In the most peripheral area, Haslev, the corresponding figures are 62 km, 24 km, 24 km and 17 persons per hectare.

For the total travel distance, the indirect effects of the urban structural variables are moderate, compared to the direct effects. Thus, the expected difference between Haslev and Vesterbro in average travel distance over the weekdays is 154 km when both direct and indirect effects are taken into account, compared to 123 km with only direct effects included. When the travel activity is subdivided into different modes of transport, the indirect effects via car ownership, transport attitudes and driving licence are often as strong as, and in some cases stronger than, the direct effects. Thus, the expected proportion of distance travelled by car is 39 percentage points higher in Haslev than at Vesterbro when both direct and indirect effects are included, compared to only 14 percentage points with only the direct effects.

In most cases, the indirect effects amplify the direct effects of the urban structural variables. The inclusion of indirect effects also implies that local area density turns out to have considerable influences on transport variables where no direct effect was found. All these new effects are in line with what could be expected from theoretical considerations.

Table 8.1 Overview of the effects of the four urban structural variables on car ownership, transport attitudes, environmental attitudes, driving licence, driving licence, frequency of appearance at the workplace, and frequency of overnight stays of four or more nights away from home

	Car ownership	Transport attitudes (car-oriented = high value)	Environmental attitudes (environmentally oriented = high value)	Possession of driving licence for car	Frequency of appearance at workplace/school	Overnight stays away from home more than three nights (yes = 1, no = 0)
Location of the residence relative to central Copenhagen	0.121 (p = 0.000)	0.057 (p = 0.092)	-0.054 (p = 0.102)	[0.119] [p = 0.001]	[p > 0.15]	[p > 0.15]
Logarithm of the distance from the residence to the closest second-order urban centre	0.119 (p = 0.000)	(p > 0.15)	(p > 0.15)	[0.078] [p = 0.020]	[p > 0.15]	[-0.069] [p = 0.005]
Logarithm of the distance from the residence to the closest urban railway station	0.047 (p = 0.088)	(p > 0.15)	(p > 0.15)	[0.064] [p = 0.026]	[p > 0.15]	[p > 0.15]
Density of inhabitants and workplaces within the local area of the residence	-0.053 (p = 0.131)	-0.165 (p = 0.000)	0.199 (p = 0.000)	[0.108] [p = 0.003]	[p > 0.15]	[p > 0.15]

Standardized regression coefficients (Beta values) and levels of significance (p values)

Table 8.2 Direct and indirect effects of the four main urban structural variables on travel behaviour on weekdays

<i>Effects</i>	<i>Total travel distance</i>	<i>Travel distance by car</i>	<i>Travel distance by train</i>	<i>Travel distance by bus</i>	<i>Travel distance by non-motorized modes</i>	<i>Share of distance travelled by car</i>	<i>Share of distance travelled by public transport</i>	<i>Share of distance travelled by bike or by foot</i>
Distance between residence and central Copenhagen	0.145 0.024	0.114 0.043	0.119 -0.023	0 -0.030	-0.094 -0.026	0.069 0.077	0 -0.059	-0.085 -0.044
Distance between residence and closest second-order urban centre	0.055 0.011	0 0.028	0 -0.019	0.065 -0.027	0 -0.016	0.045 0.057	0 -0.046	-0.124 -0.026
Distance between residence and closest urban railway station	0.046 0.008	0.059 0.013	0 -0.006	0 -0.014	0 -0.004	0 0.026	0 -0.014	0.059 -0.012
Density of inhabitants and workplaces in the local area	0 -0.020	0 -0.045	0 0.028	0 0.001	0 0.044	0 -0.055	-0.101 0.015	0.075 0.050

Standardized regression coefficients

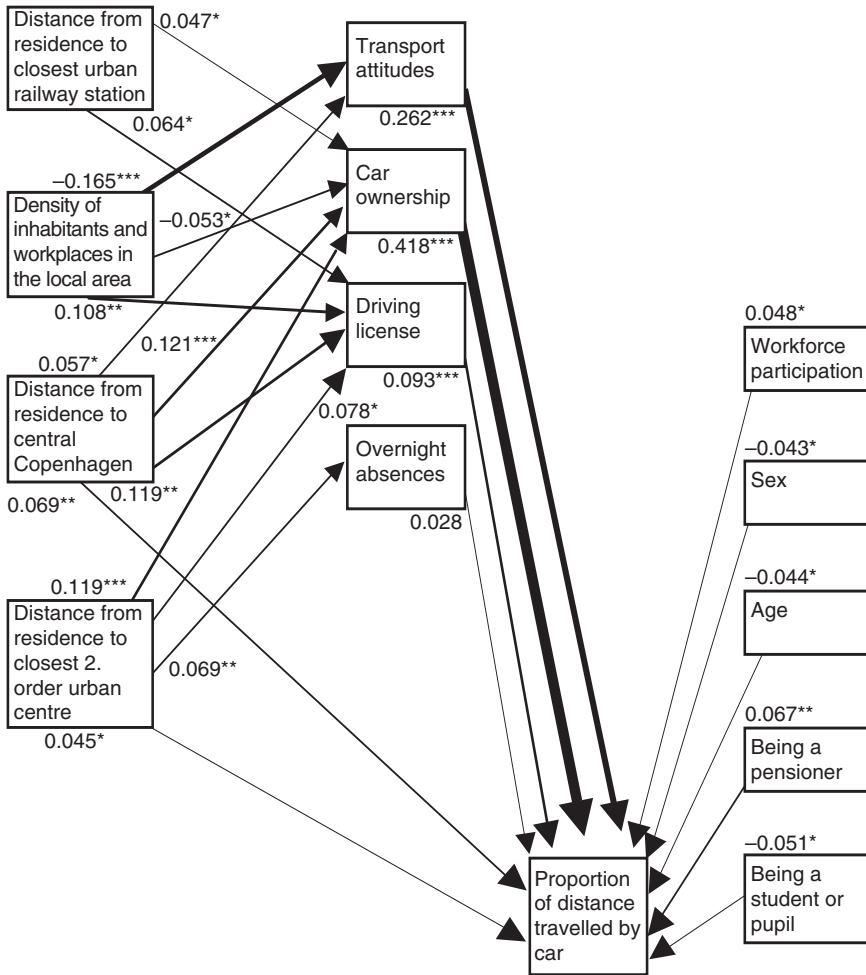


Figure 8.2 Simplified causal model of investigated variables affecting the proportion of distance travelled by car

The model applies to transport during weekdays from Monday to Friday. Both direct and indirect effects of the urban structural variables are shown. Only direct effects are shown for the remaining variables. The strengths of the effects are indicated by the boldness of the arrows, as well as by means of standardized regression coefficients. Levels of significance are indicated by means of asterisks: *** = $p < 0.0005$, ** = $p < 0.01$, * = $p < 0.10$.

Table 8.3 Expected differences in travel activity on weekdays between respondents from Haslev and Vesterbro for each of the eight investigated transport variables, based on multivariate regression analyses

	<i>Travel distance</i>					<i>Share of distance travelled</i>		
	<i>Total</i>	<i>By car</i>	<i>By train</i>	<i>By bus</i>	<i>By non-motorized modes</i>	<i>By car</i>	<i>By public transport</i>	<i>By bike or by foot</i>
Direct and indirect effects	154 km	144 km	6 km	0.5 km	-12 km	39 % points	-6 % points	-29 % points
Direct effects only	123 km	81 km	23 km	7 km	-6 km	14 % points	8 % points	-21 % points

The figures show the expected average value among respondents from Haslev minus the corresponding values among respondents from Vesterbro. N = 1,303–1,422.

In a few cases, the indirect effects work in the opposite direction to the direct effects. Notably, the indirect effects contribute considerably to counteracting a couple of surprising direct effects, where a high density was found to increase the proportion of distance travelled by car over the week as a whole and to decrease the distance travelled by non-motorized travel at the weekend. Similar, but weaker opposite indirect effects are found from local area density on the proportion of public transport, from the distance to the closest urban railway station on the proportion of walking/biking on weekdays and travel distances by bus over the week and by non-motorized transport at the weekend, and from the distance to central Copenhagen on the distance travelled by train on weekdays. Whereas a residential address far away from central Copenhagen or the closest urban railway station contributes, due to the longer distances to relevant facilities, to increasing travel distances by train and by walking/biking, respectively, the indirect effects via car ownership contribute to weaken these effects. Similarly, the somewhat counter-intuitive tendency for reduced proportion of public transport use among residents living in high-density local areas is weakened when the indirect effects via car ownership, transport attitudes and driving licence are also taken into consideration.

8.5 CONCLUDING REMARKS

Our quantitative material – both the information of the main survey about car ownership and perceived car dependency and the data of the travel diary investigation about changes in car ownership after having moved – support the conclusions of

the qualitative interviews about the role of residential location as a contributory factor influencing car ownership. Moreover, our analyses indicate that transport attitudes, environmental attitudes, possession of a driving licence, and the frequency of overnight stays away from home are also influenced by the urban structural situation of the dwelling. It is therefore reasonable to conclude that residential location influences travel behaviour indirectly through these variables. Analyses controlling for car ownership and the other 'grey zone' control variables without at the same time including the above-mentioned indirect effects will therefore underestimate the influences of residential location on travel behaviour.

Taking into account direct as well as indirect effects, our material indicates the following main influences of urban structural characteristics on travel behaviour:

The distance between the residence and central Copenhagen: Living far away from the city centre of Copenhagen contributes to

- a high total amount of travel (in particular on weekdays)
- a high amount of travel by car (on weekdays as well as at the weekend)
- a high amount of travel by train on weekdays
- a low amount of travel by foot or by bike (both on weekdays and at the weekend)
- a high proportion of distance travelled by car (both on weekdays and at the weekend)
- a low proportion of distance travelled by foot or by bike (on weekdays as well as at the weekend)
- a low proportion of distance travelled by public transport (in particular at the weekend).

The distance between the residence and the closest second-order urban centre: Living far away from the closest second-order urban centre contributes to

- somewhat increased amount of travel on weekdays
- a low amount of travel by foot or by bike at the weekend
- a certain increase in the distances travelled by car and by bus on weekdays
- a low proportion of distance travelled by foot or by bike (on weekdays as well as at the weekend)
- a high proportion of distance travelled by car (both on weekdays and at the weekend)
- a certain reduction of the proportion of distance travelled by public transport (in particular on weekdays).

The distance between the residence and the closest urban railway station:

Living far away from the closest urban railway station contributes to

- somewhat increased amount of travel on weekdays
- somewhat lower proportion of distance travelled by walking/biking on weekdays
- somewhat increased amount of travel by non-motorized modes at the week-end
- somewhat higher amount of travel by bus over the whole week.

The density of inhabitants and workplaces in the local area surrounding the dwelling: Living in a dense local area contributes to

- a high proportion of distance travelled by walking/biking, in particular on weekdays
- a low proportion of distance travelled by public transport (on weekdays as well as at the weekend)
- a somewhat lower proportion of distance travelled by car (both on weekdays and at the weekend)
- somewhat lower amount of travel by car on weekdays
- somewhat higher amount of travel by non-motorized modes on weekdays, and somewhat lower amount of travel by these modes at the weekend.

The indirect effects of the urban structural variables on the total travelling distance are modest, compared to the direct effects. However, looking at the distances travelled by different means of transport and the modal shares of each means of conveyance, the indirect effects of urban structure are considerable, and in some cases even stronger than the direct effects.

CHAPTER 9

DOES RESIDENTIAL LOCATION INFLUENCE DAILY-LIFE TRAVEL DIFFERENTLY AMONG DIFFERENT POPULATION GROUPS?

9.1 INTRODUCTION

This chapter presents the results of analyses where the sample of respondents has been divided into subgroups. The purpose of these analyses is to investigate whether the influences of urban structural characteristics on travel are different among different population groups. Previous studies, including Jørgensen (1992) and Næss and Jensen (2004), indicate that the amount of travel and the modal split are influenced by urban structural characteristics to a lesser extent among certain population groups than among the population as a whole. From theoretical considerations, influence on travel behaviour from the location of the residence relative to workplace concentrations could be expected to be different among workforce participants, compared to non-participants of the workforce. The distance from the dwelling to central Copenhagen (where there is a high concentration of office jobs) might also exert a different influence on travel behaviour among clerks than among employees of manufacturing industries. Differences in the influence of urban structure on travel might also possibly exist, depending on whether or not there are children in the household, and whether a household with children includes one or two adult persons.

Below, we shall first present analyses where the respondents have been divided into subgroups according to demographic characteristics (among others, gender and household type). Thereupon follow a number of analyses of different socio-economic groups, subdivided according to, among others, income, workforce participation, type of occupation, and car ownership. Moreover, analyses will be presented where the respondents have been subdivided according to their attitudes to environmental issues and transportation issues, respectively. Finally, we address the question of whether or not the residents of different areas have been 'self-selected' into certain combinations of residential locations and lifestyles, and the implications any such 'self-selection' might have for the relationships between residential location and travel. All analyses in this chapter are based on the main questionnaire survey, where the total number of respondents was 1,932. The numbers of respondents within the different subgroups analyzed are of course lower.

9.2 DIFFERENCES BETWEEN WOMEN AND MEN

Several previous studies (including Jørgensen, 1992) have shown that men often choose from job opportunities all over the metropolitan area, while women to a higher extent confine their choices of workplaces to those available locally. Such a geographic limitation appears to be especially common among working-class females. Given such a gender difference, women will to a higher extent than men find employment in the closest second-order centre or a local centre in the proximity of the dwelling (the latter often located in connection with the closest urban railway station). The location of the dwelling relative to the closest second-order centre and urban railway station could then be expected to influence commuting distances – and hence a large proportion of the total travel on weekdays – to a higher extent among females than among males.

The empirical data of the Copenhagen Metropolitan Area study support the above-mentioned assumptions about gender-based differences in the influences of residential location on travel. There is a clear tendency for a higher amount of travel on weekdays among peripheral residents than among inner-city dwellers not only among men, but also among women (see Figure 9.1). However, according to our material, this first and foremost reflects the fact that the average distances to second-order or local centres are longer in the outer than in the inner parts of the region (see below). The difference in travel distance between respondents living centrally and peripherally is considerably greater among men than among women. Whereas the

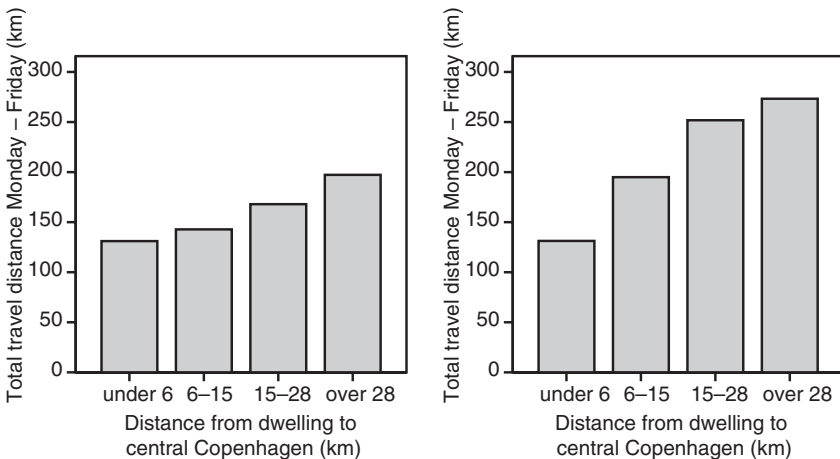


Figure 9.1 Average total travel distance Monday–Friday among female (to the left, $p = 0.000$) and male (to the right, $p = 0.000$) respondents living within different distance intervals from central Copenhagen
N = 933 women and 858 men

average travel distance during the five weekdays is about 130 km both among male and female respondents living in the inner of the four distance belts, the male respondents living in the two outer distance belts travel on average 80 km more than their female counterparts.

Among men, the location of the residence relative to central Copenhagen seems first and foremost to influence travelling distances. Among women, the distance from the dwelling to the city centre is mainly important to the modes of transport chosen. Among men, the distance from the residence to central Copenhagen is the only urban structural variable showing any effect on the amount of transportation on weekdays: the further away from the city centre the residence is located, the longer distances our male respondents tend to travel on weekdays. Among the women, we do not find any effect on the amount of transport on weekdays from the location of the dwelling relative to central Copenhagen. On the other hand, the distances from the dwelling to the closest second-order centre and the closest urban railway station, respectively, show clear, positive effects on travel distances.

The above-mentioned gender differences suggest that men to a higher extent than women orient themselves towards trip destinations in the inner parts of the metropolitan area. In particular, this applies to the concentration of workplaces, but to some extent also the centrally located service facilities. Among women, workplaces and other trip ends in local centres are preferred to a higher extent. The stronger influence on men's travelling distances from the location of the residence relative to central Copenhagen is probably not only due to a higher proportion of men than women working in the central area. The fact that the point of gravity of the remaining workplaces and other service facilities of the region is located close to central Copenhagen is probably also part of the explanation. If, as men tend to do more often than women, workplaces and service facilities are chosen from opportunities within the entire metropolitan area, the average distances from the dwelling to these destinations will increase, the further away the residence is located from the region's geographical point of gravity.

The gender differences in the influence of residential location on travel modes may reflect a prevalent tendency among many one-car households for regarding the husband as the spouse with the first right to use the car. In practice, this will result in higher car availability among men than among women, not registered by the car ownership variable. Such a pattern may cause men to travel by car more irrespectively of whether or not alternative means of transport could be used without too much inconvenience. Our material suggests that women to a higher extent than men choose walking or biking instead of driving by car, in particular if the residence is located in such a way that relevant destinations are found relatively close to the dwelling. As mentioned earlier, this is more likely to be the case with a central residential location.

9.3 DIFFERENT HOUSEHOLD TYPES

A subdivision of the respondents into groups with and without child(ren) under 18 years in the household shows no clear difference in the overall extent to which travel behaviour is influenced by residential location. However, the urban structural variables exerting the strongest effects differ somewhat between the two groups. Among both household types, living far away from central Copenhagen contributes to longer travelling distances and a lower share of walking and biking on weekdays. However, the proportion of car travel appears to be influenced by the location of the dwelling relative to central Copenhagen only among households without children living at home. In general, the location of the residence relative to the closest second-order centre and the closest urban railway station show somewhat stronger effects on travel behaviour among respondents with children in the household than among those belonging to a household without children. Possibly, this reflects the fact that the former group of respondents often bring children to and from school, daycare or leisure activities in the closest local centre or in the closest second-order urban centre. Long distance to these centre categories implies a higher need for transportation in connection with such errands, thus inducing a higher proportion of these trips to be carried out by car instead of non-motorized modes. Our data indicate that respondents without children in the household make fewer trips to destinations in the proximity of the closest urban railway station or second-order centre, compared to respondents belonging to a household with children.

Whereas a residence close to central Copenhagen contributes to a slight increase in the proportion of public transport use among childless households, an opposite effect is found among respondents with children in the household. Possibly, this difference reflects a tendency among households without children to use public transport more frequently for trips to leisure activities, provided that the standard of the public transport services in the proximity of the dwelling is good. Among households with children, the car may be preferred to a higher extent, regardless of the standard of the public transport services, as many people consider it too expensive and cumbersome to go by public transport when travelling with children on such trips. The latter respondents may find public transport more attractive if the residence is located peripherally, as each trip by public transport will then on average be longer, and walking distances and the inconvenience associated with getting the children on and off the bus or train will make up a smaller proportion of the journey time.

A subdivision of the respondents with children in the household into groups according to the age of the children suggests that the travel behaviour of respondents with preschool children is first and foremost influenced by the location of the residence relative to central Copenhagen. Among respondents with children aged

7–17 in the household, travel behaviour is also influenced by the distance to the closest urban railway station (longer distances travelled when living far away from the urban railway station) and the distance from the closest second-order centre (a higher share of car travel when living far away from the closest second-order centre). The higher influence of proximity to local centres on the travel behaviour of respondents with schoolchildren in the household than among parents of preschool children may reflect the fact that schoolchildren's leisure activities more often generate separate trips where parents follow the children to and from the locations where the activities take place (e.g. a school or sports hall in a local centre). In comparison, bringing preschool children to and from the kindergarten is more likely to be carried out in connection with the journey to work.

Maybe somewhat surprisingly, analyses of *single women without children in the household* and *single men without children living at home* do not show effects of the location of the residence relative to central Copenhagen on either travelling distances on weekdays or on the proportion of this transport carried out by car. However, several plausible reasons could be imagined. First, compared to couples, single people have a larger possibility of finding residence and workplace located with a short mutual distance, even if they live in a suburban area, because they do not need to take the commuting distance of any partner into consideration. Second, persons without children in the household usually do not routinely follow children to kindergarten, school or leisure activities, and 'non-bounded' trips may therefore make up a higher proportion of their travel. The predominance of 'non-bounded' trips will be further increased if the persons in question are pensioners, which is actually the case for a high proportion (36 per cent) of the single respondents without children in the household.

Single mothers have often been assumed to be a group possessing few mobility resources, therefore being more dependent than the population in general on the local job, service and leisure opportunities. Our analysis provides some support for this assumption, as the transportation carried out by this group appears to be influenced to a higher extent by the location of the residence relative to more local concentrations of facilities than by its location in the metropolitan-level urban structure. However, as the number of single mothers is low among our respondents, there is higher uncertainty about the relationships between urban structure and travel among this population group than in most of the other analyses. Among single mothers, living in a densely populated local area seems to contribute to increasing the proportion of car travel on weekdays as well as the travel distance at the weekend. The latter effect may indicate 'compensatory' travel among this group. A similar tendency is also found among mothers in general with children in the age group 7–17 years. A combination of a tight time schedule on weekdays and a lack of green areas in the local environment might perhaps create an increased need among

these groups of respondents for making trips to recreational areas with their children at the weekend. Among single men, no similar indication of compensatory travel can be found.

9.4 DIFFERENCES BETWEEN POPULATION GROUPS SUBDIVIDED ACCORDING TO WORKFORCE PARTICIPATION AND TYPES OF PROFESSION

DIFFERENCES BETWEEN WORKFORCE PARTICIPANTS AND NON-PARTICIPANTS OF THE WORKFORCE

There is a clear tendency that the location of the residence relative to central Copenhagen influences travelling distances on weekdays more strongly among workforce participants than among non-participants of the workforce (Figure 9.2). Among the latter group, only respondents from the inner of the four distance belts (less than 6 km from central Copenhagen) stand out with a lower amount of travel, whereas the average travelling distances are almost equal in the three outer distance belts. Among workforce participants, a clear tendency to increasing amount of travel with increasing distance between the dwelling and central Copenhagen can also be found in the three outer distance belts.

Controlling for non-urban structural variables, the location of the residence relative to central Copenhagen is the urban structural variable showing the strongest effect on the workforce participants' travelling distance on weekdays. In addition, the distance from the dwelling to the closest second-order centre exerts some influence. Among non-participants of the workforce, local-area density is the only urban structural variable with a significant effect on the amount of travel on weekdays, with shorter travelling distances the higher the density of the local area.

Among workforce participants, the distance travelled during the weekend does not appear to be influenced by any of the urban structural variables. However, among non-participants of the workforce, we find a tendency for longer travelling distances at the weekend, the further away from central Copenhagen the residence is located. Among both groups of respondents, living far away from the closest second-order centre as well as from central Copenhagen contributes to a higher proportion of car travel on weekdays. At the weekend, a peripheral residential location appears to increase the share of car travel more strongly among workforce participants than among non-participants of the workforce.

The stronger influence of the location of the residence relative to central Copenhagen among workforce participants than among non-participants of the workforce reflects the dependency of most workforce participants on job opportunities outside their local neighbourhood. As mentioned earlier, central Copenhagen has a

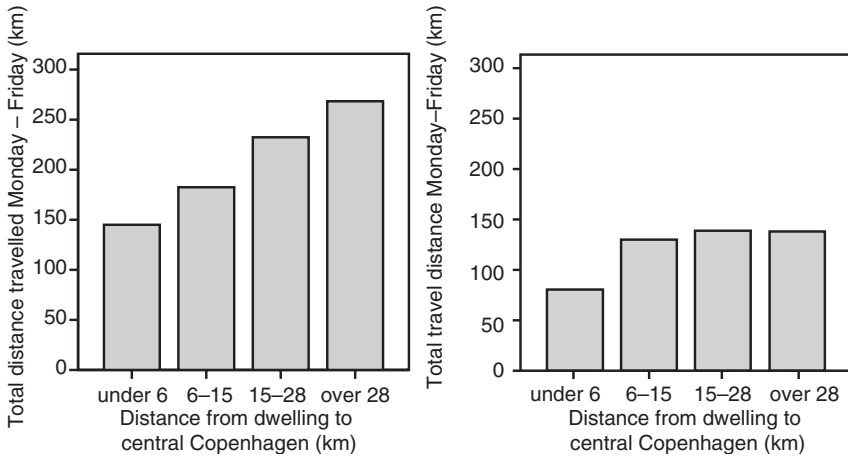


Figure 9.2 Average total travel distance Monday-Friday among respondents who are workforce participants (to the left, $p = 0.000$) and non-participants of the workforce (to the right, $p = 0.031$), living within different distance intervals from central Copenhagen $N = 1,340$ workforce participants and 450 non-participants of the workforce

high concentration of workplaces, and in addition the geographical point of gravity of the suburban workplaces is located in the central part of the metropolitan area. Among non-participants of the workforce, the distances to various types of service facilities and leisure activities will have more effect on the amount of travel. In our analysis, this can be seen in the effect of local area density, as dense local areas provide a basis for a broader supply of local service and leisure opportunities. Travelling distances to such destinations thus tend to be reduced if the residence is located in a dense local area.

The influence of the distance between the dwelling and central Copenhagen on the amount of travel at the weekend among non-participants of the workforce is a bit more difficult to explain. One imaginable reason is a possible stronger wish among non-participants of the workforce to visit the central area at the weekend for shopping or recreational purposes. As non-participants of the workforce are less prone than their employed counterparts to visit the city centre on weekdays, such trips in order to make use of central-city shopping facilities and experience the 'urban atmosphere' at the weekend seem fairly plausible.

SUBDIVISION INTO OCCUPATIONAL CATEGORIES

The influence of residential location on travel behaviour shows some interesting differences across occupational categories. Theoretically, such differences could partly be expected due to cultural differences associated with the types of knowledge emphasized during the education and the subsequent socialization into sharing certain common values when working within a profession. For example, Hartoft-Nielsen

(1997) has found that the modal split of the employees' journeys to work varies considerably between different businesses with similar education levels and locations in the urban structure, but dominated by different disciplinary fields. In addition, differences across trades in the typical location of workplaces may imply that residential location affects travel behaviour differently, depending on the category of occupation.

Several methods exist for classification of workforce participants into different occupational categories (see, among others, Hansen and Andersen, 2000). Many of these methods are based on some kind of division of society into classes or social groups (e.g. Wright, 1989; Hansen, 1984). Other classifications take differences between various disciplines or branches of trade as their point of departure (Statistics Denmark, 1996). However, the data material of our survey does not enable us to use the above-mentioned types of classifications. Instead, we have chosen to combine information given in the questionnaire survey about the length and type of education. Our classification is based on the assumption that workforce participants have a type of job corresponding to their education. This will obviously not always be true, but even when the job content differs from the educational background, the workforce participants' attitudes and lifestyles may still to some extent reflect the knowledge and values acquired during their education.

Based on previous studies (including Hartoft-Nielsen, 1997), persons with a technical or economical education might be expected to work more frequently than other workforce participants among colleagues seldom problematizing a high mobility and individual modes of travel. This is distinct from certain 'softer' trades where the employees typically are educated within the humanities or social sciences other than economics. Moreover, some previous investigations (Næss and Jensen, 2004; Jørgensen, 1992) suggest that travel is less influenced by urban structure among working-class people than among the population at large, possibly because a lower degree of professional specialization makes it possible to find employment more frequently within the local area, or at least within the local sector of the urban area.

Based on the available data and the above-mentioned considerations, the workforce participants among our respondents have been classified into the following four categories:

- Occupations normally requiring a high technical or economic education
- Other occupations normally requiring a high education
- Occupations where the workers typically have a short or medium-long education as a craftsman or industrial worker
- Other occupations where the workers typically have other short or medium-long educations

A simple comparison shows that average travel distances on weekdays within all four occupational groups are longer among respondents living in the outer

distance belts than among those respondents living close to central Copenhagen. However, some interesting differences are apparent. Among the two occupational groups with higher-level educations, the difference between central and peripheral residential locations in travel distance on weekdays is clearly larger among respondents with a technical or economic education than among the workforce participants with other types of high education. In the latter group, there is almost no difference between the three outer distance belts in average travelling distances (Figure 9.3). A similar difference can be seen between the two respondent groups working in occupations normally requiring a short or medium-long education (Figure 9.4). The amount of travel on weekdays varies to a lesser extent with the location of the dwelling relative to central Copenhagen among respondents working in 'blue collar' occupations than among the remaining workforce participants with a short or medium-long education. The latter group stands out with a particularly pronounced difference between the distance belts in average travelling distances.

Among respondents with occupations normally requiring a *high technical or economic education*, the location of the residence relative to central Copenhagen is the main urban structural characteristic influencing travel behaviour. The further away from the city centre of Copenhagen the dwelling is located, the longer distance the respondents tend to travel on weekdays, and the lower proportion of this distance they tend to cover by foot or by bike. In spite of a relatively low number of

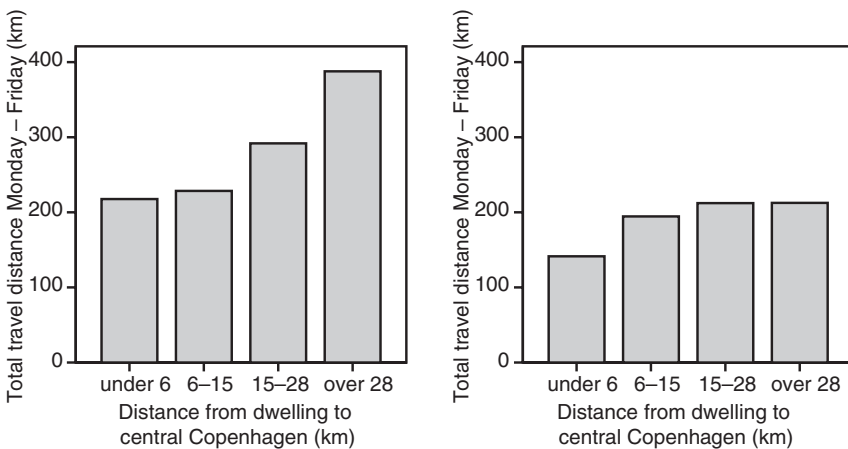


Figure 9.3 Average total travel distance Monday-Friday among workforce participants with different types of long education and living within different distance intervals from central Copenhagen: respondents working in positions requiring a long technical or economic education (to the left, $p = 0.000$) and respondents working in positions requiring other types of long education (to the right, $p = 0.000$)
 N = 166 and 393, respectively

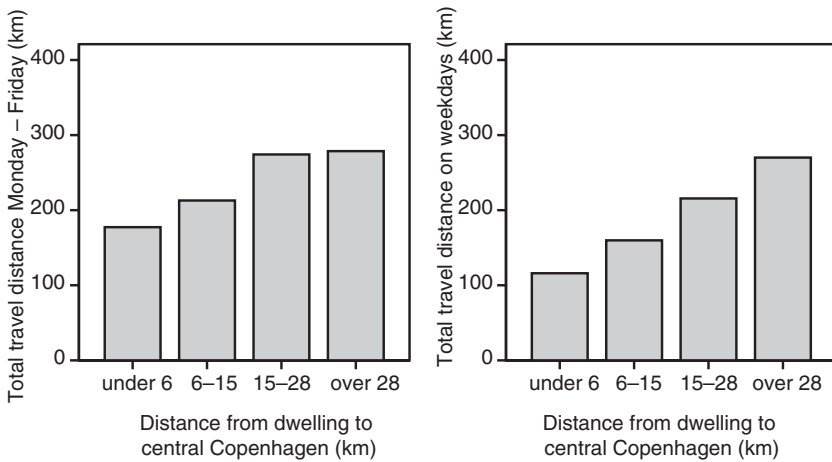


Figure 9.4 Average total travel distance Monday–Friday among workforce participants with different types of short or medium-long education and living within different distance intervals from central Copenhagen: respondents working in positions requiring a short or medium-long education as a tradesman or industrial worker (to the left, $p = 0.004$), and respondents working in positions requiring other short or medium-long education (to the right, $p = 0.000$)
 $N = 172$ and 479 , respectively.

respondents within this subgroup (129) these relationships have a high statistical certainty (significance levels 0.001 and 0.020, respectively).

The strong influence of the location of the residence relative to central Copenhagen on the travel behaviour of this group probably reflects the fact that a large proportion of the jobs requiring a technical or economic education are situated in inner-city Copenhagen and other central parts of the metropolitan area. This applies, for example, to numerous workplaces within bank, insurance and other financial enterprises, and technical consultancies. A number of employees in the national governmental administration also belong to this group of professionals. The closer to central Copenhagen the respondents within this occupational category live, the shorter on average will their journeys to work be, and the easier it will be to walk or bike to and from the workplace.

Among respondents with *other occupations requiring a higher education*, the location of the residence relative to central Copenhagen does not turn out with statistically significant effects either on the total distance travelled on weekdays or the shares of this transport carried out by different means of conveyance. This is in spite of the fact that the number of respondents is more than twice as high as in the former occupational group, which implies that a given level of significance can be

obtained at weaker correlations than among the workforce participants with a high technical or economic education. The daily travel among respondents with higher education within other disciplines than the technical and economic subjects seems to be oriented mainly towards local centres. The further away the respondents live from the closest second-order centre, the longer distances they tend to travel on weekdays, and the lower is their propensity for walking or biking to the daily destinations.

This impression is strengthened by an analysis of factors influencing commuting distances. Among the respondents with higher education within other disciplines than the technical and economic subjects, commuting distances tend to be reduced the closer the respondent lives to a second-order centre or urban railway station, and the higher is the local area density. However, the location of the residence relative to central Copenhagen shows no influence on their commuting distances. This lack of relationship stands in stark contrast to the situation among the respondents with higher technical or economic education, where the location of the residence relative to central Copenhagen was found to exert the strongest influence of all investigated variables on commuting distances.

A plausible explanation of the local orientation of respondents with higher education within non-technical/economic subjects is the fact that the workplaces of these respondents are typically found in schools, kindergartens, hospitals, nursing homes and town halls. These jobs are to a lesser extent than for the technical and economic subjects concentrated in the central part of the metropolitan area. Distinct from our remaining three occupational groups, whose dwellings are on average located 5–8 km further away from central Copenhagen than their workplaces, there is virtually no difference between the distance from central Copenhagen to the residences and to the workplaces of the respondents with higher educations in other disciplines than the technical and economic subjects. Inner-city Copenhagen thus exerts a considerably weaker attraction as a workplace concentration for this occupational group than among the remaining three groups.

The workforce participants with a *short or medium-long education as a craftsman or industrial worker* largely carry out manual labour as craftsmen, industrial workers, builders or other types of blue-collar workers. According to our material, travel distances on weekdays among this group are influenced by only one of the urban structural variables: the location of the residence relative to central Copenhagen. In line with the general pattern found among the total sample of respondents, the travelling distances on weekdays among this occupational group tends to increase the further away from central Copenhagen the residence is located. This reflects the fact that the residences of these respondents have on average a more decentralized location than their workplaces. Indeed, the workplaces of this occupational group are located at a higher average distance from the

city centre of Copenhagen (16.5 km) than the workplaces of any of the remaining three occupational groups. However, our blue-collar respondents is the occupational group most inclined to live in the peripheral parts of the region, with residences located at a considerably longer average distance from central Copenhagen (24 km) than their workplaces.

Compared to the two occupational groups with higher education, the proportions of weekday transport travelled by different modes of conveyance are influenced to a higher extent by urban structure among our blue-collar respondents. Possibly, the lower average income level among this group makes blue-collar respondents more prone to choose less expensive alternatives than the car for short trips.

Among the respondents with *short or medium education within subjects normally not included among the craft and industrial trades* we once again find a very clear relationship between the location of the residence relative to central Copenhagen and the total distance travelled on weekdays. The further away the respondents live from the city centre of Copenhagen, the longer distances they tend to travel on weekdays. This relationship reflects the fact that the commuting distances of this occupational group depend highly on whether the residence has a central or decentral location. On average, their dwellings are located considerably further away from central Copenhagen (22 km) than their workplaces (15 km). This occupational group includes a large proportion with education within accounting and other economically oriented office operations. The workplaces of these respondents are often found in the central parts of the metropolitan area.

At the same time our analyses show that a long distance from the residence to the closest urban railway station (which is often situated in a local centre) also contributes to a considerable increase in the total distance travelled at weekends. Besides, a high local area density contributes to increase the proportion of walking/bike travel. These effects indicate that these respondents, in spite of their strong orientation toward central Copenhagen, also visit a number of destinations within their local district. This occupational group also includes many employees within childcare and health and social work, for example, kindergarten assistants and licensed practical nurses. Their workplaces are to a high extent located in various local centres. In addition to the location of workplaces, frequent local trip destinations in connection with shopping, transporting children, etc. may also help explain the influence of local urban structural conditions on the travelling patterns among this occupational group. These tasks are to a high extent carried out by women, who make up a clear majority within this group of respondents.

9.5 DIFFERENCES BETWEEN POPULATION GROUPS SUBDIVIDED ACCORDING TO SOCIO-ECONOMIC CHARACTERISTICS

Figure 9.5 shows how average travelling distances on weekdays vary with the distance from the dwelling to central Copenhagen among respondents with a high (above the median value) and a low *income* (below or equal to the median value). In both income groups there is a tendency for a higher amount of travel in the outer distance belts. However, the differential in travel distance between the outermost and the innermost distance belt is considerably larger in the high-income group than in the low-income group.

Controlling for other urban structural variables than the location of the dwelling relative to central Copenhagen and the same non-urban structural variables as in Chapter 6, our material shows that the location of the residence relative to central Copenhagen exerts a stronger influence on weekday travel among respondents with a high income than among those with a low income. This applies both to the total distance travelled on weekdays and the proportion of this transport accounted for by different modes of travel. On the other hand, we find a clear tendency that the more local urban structural variables are of a higher importance to travel behaviour (notably the proportion of walking and biking on weekdays, travel distance at the weekend and the proportion of the latter travelled by car) among the low-income group than among the respondents with income above the median value.

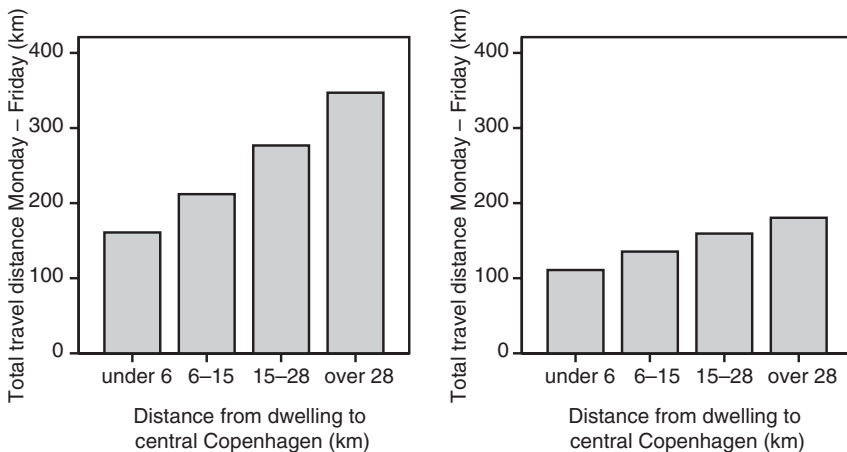


Figure 9.5 Average total travel distance Monday-Friday among respondents with income above (to the left, $p = 0.000$) or below/equal to the median (to the right, $p = 0.000$), living within different distance intervals from central Copenhagen
N = 1,670

The stronger influence of the distance to central Copenhagen among respondents with a high income probably reflects the fact that these respondents more often than their low-income counterparts have occupations where jobs are to a high extent concentrated in the central and inner areas of Copenhagen, such as highly specialized office jobs. Commuting distances, and hence also the likelihood of commuting by non-motorized modes, will then be influenced by the distance between the residence and the city centre of Copenhagen to a higher extent among the high-income group than among respondents with a low income.

Figure 9.6 shows how average travelling distances on weekdays vary with the distance belts from central Copenhagen within which the dwelling is located among respondents with and without a car in the household. The difference in the amount of travel between residents of peripheral and central parts of the region is considerably larger among those respondents having one or more cars at their disposal than among their car-less counterparts.

Controlling for non-urban-structural variables, the location of the residence relative to central Copenhagen is the only urban structural characteristic showing an effect on the total travel distance on weekdays among respondents without a car. Among respondents with a car in the household, the amount of travel on weekdays is influenced both by the distance from the dwelling to central Copenhagen and by the distance to the closest second-order centre (the latter effect, however, weaker). This difference between the groups of respondents may possibly reflect the fact that

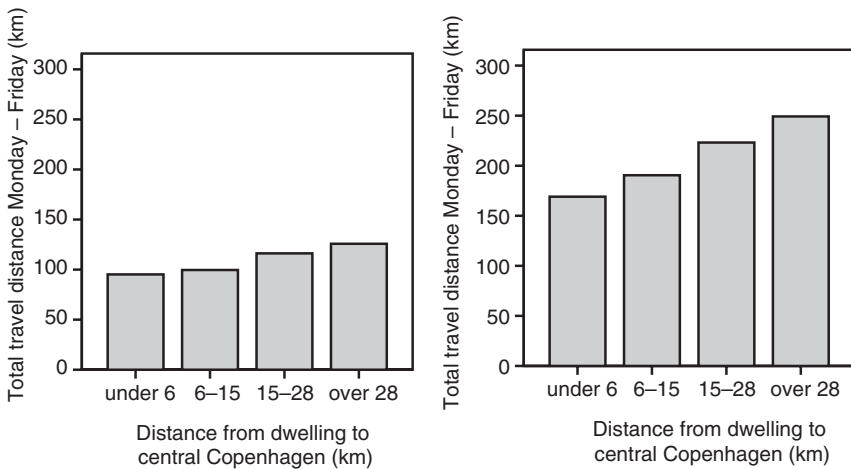


Figure 9.6 Average total travel distance Monday–Friday among respondents without (to the left, $p = 0.015$) and with a car in the household (to the right, $p = 0.000$), living within different distance intervals from central Copenhagen
 N = 438 and 1,353, respectively

the centralized structure of the public transport system makes it easier for most respondents without a car to reach central Copenhagen than any of the lower-order centres. The second-order centres in the outer parts of the region will probably exert a stronger attraction to respondents with a car, both because the latter are not dependent on the centralized layout of the public transport network and because there is usually less congestion and more ample parking opportunity in lower-order centres. The fact that the distance between the dwelling and central Copenhagen is also the urban structural variable exerting the strongest effect on travel distances among respondents with a car probably reflects the fact that the location of a high proportion of the destinations of 'bounded' trips (e.g. workplaces and places of education) among these respondents too are located in the central or inner parts of the metropolitan area.

According to our material, travel distances at the weekend are influenced by the location of the dwelling relative to central Copenhagen among respondents without a car in the household, but not among respondents having a car at their disposal. This probably reflects the higher freedom of car-owning households to spread their leisure and other weekend trips over a large geographical area, for example to recreational areas and shopping malls in the outer or peripheral parts of Copenhagen Metropolitan Area. Among those without a car, the public transport services will to a higher extent determine which destinations are considered relevant for the 'non-bounded' trips. Inner-city Copenhagen, with its rich supply of culture and entertainment facilities, may therefore exert a stronger attraction for the weekend trips among the car-less respondents.

9.6 DIFFERENCES BETWEEN HIGH-STATUS AND LOW-STATUS PARTS OF THE REGION

According to some authors (e.g. Dahl, 1997), there are distinctive sociological differences between the northern and the southern suburban areas of the region, with higher income and education levels in the North than in the South. In order to illuminate whether this gives rise to different relationships between residential location and travel among respondents from northern and southern suburbs, separate, multivariate analyses have been carried out among respondents living in one of the northern 'fingers'⁴⁴ and in the southernmost 'finger',⁴⁵ respectively. In general, however, the effects found among the respondents from the two corridors are very similar to the effects found among the sample as a whole. In particular, our material shows a high degree of consistency when we qualitatively take into consideration the more detail-level urban structural characteristics of the residential areas investigated in each of the two corridors.

To a certain extent we can nevertheless distinguish a few possible results of socio-cultural differences between the two 'fingers'. For example, gender has a stronger influence on the total travelling distances on weekdays as well as on the distances travelled by car among respondents of the southern corridor, where being male contributes to increased travel distances. In the northern corridor no such effect was found. Possibly, this difference reflects a higher degree of equality between the genders, regarding travel modes as well as choices of workplace locations, among the largely middle-class respondents of the northern corridor than among the respondents of the more working-class dominated southern corridor. Our material provides some support for this interpretation. Apart from this effect the separate analyses of the two corridors provides little information about differences between population groups in the way urban structure affects travel behaviour. Thus, the subdivision of our sample into subgroups according to gender, employment status, type of education, etc. appears to be more fruitful than the separate analysis of respondents living in different segments of the region. This reflects the fact that the socio-economic and cultural differences *within* each corridor are larger than the difference in averages across the corridors.

9.7 DIFFERENCES BETWEEN POPULATION GROUPS SUBDIVIDED ACCORDING TO ATTITUDINAL CHARACTERISTICS

Dividing the respondents into two approximately equally large groups according to their *attitudes to environmental issues* we find that the location of the residence relative to central Copenhagen has a stronger influence on weekday travel distances among those with the least positive attitudes to environmental protection. Within the other group, the amount of travel on weekdays is influenced by local area density and the distance from the dwelling to the nearest urban railway station to a higher extent than among their less environmentally oriented counterparts. These differences probably reflect a higher propensity among the more environmentally concerned respondents to use local facilities if such opportunities are available.

At the weekend, travel distances are influenced by the distance from the residence to the city centre of Copenhagen only among the more environmentally concerned respondents. Possibly, this reflects a higher propensity among these respondents for choosing weekend shopping and leisure facilities easily accessible by public transport (notably in inner-city Copenhagen) rather than suburban shopping malls, etc.

Among the group with the environmentally oriented attitudes, a high local area density contributes to public transport being to a high degree superseded by walking

and biking. Among the less environmentally concerned respondents there is only a weak negative effect of density on the proportion of public transport, and not at all on the share of non-motorized travel. Instead, the proportion of walking and biking is influenced considerably more by the location of the residence relative to central Copenhagen and to the closest second-order centre among the latter group of respondents. This may indicate that these respondents need stronger incentives in the form of short distances in order to choose the bike or go on foot than the more environmentally concerned respondents do. Somewhat surprisingly, the less environmentally oriented respondents use non-motorized modes to a lesser extent, the closer they live to an urban railway station. Maybe these respondents prefer the train rather than the bike, while the more environmentally oriented stick to a non-motorized lifestyle even in situations where it is easy to travel by public transport?

Analyses where the respondents have been divided into two approximately equally large groups according to their *transportation attitudes* generally show small differences in the effects of the urban structural variables on travel behaviour. Whereas the location of the residence relative to central Copenhagen exerts a stronger influence on the transportation activity of the less environmentally oriented respondents than among those more concerned about environmental issues (cf. above), the influence of this urban structural variable is slightly stronger among the respondent group with the most positive attitudes towards other modes of travel than the car. Although there is a clear correlation between positive attitudes to environmental protection in general and negative attitudes to car travel, these dimensions of attitudes do not fully overlap. Thus, the respondents with the least positive attitudes to car travel appear to be somewhat more oriented towards urban destinations than the more locally oriented respondents with the highest scores on the general environmental attitude variable.

Apart from this, the differences between the two transport attitudinal groups largely correspond to the difference found between the two groups with different environmental attitudes. For example, we find a tendency among the car-oriented respondents for an increasing share of walking and biking the further away the residence is located from an urban railway station. Yet, living close to a second-order centre and/or close to central Copenhagen has a stronger (and positive) influence on the proportion of non-motorized travel among this group. On the other hand, local area density only influences the proportion of walking and biking among the least car-oriented group of respondents (higher share of non-motorized travel the higher is the density). These effects are in accordance with the differences found between the environmentally concerned and the less environmentally oriented group.

9.8 ARE RESIDENTS 'SELF-SELECTED' INTO LOCATION/MOBILITY COMBINATIONS?

According to some authors (e.g. Kitamura *et al.*, 1997; Krizek, 2003.), the possibility that people choose their residence based on their preference for a particular travel mode precludes any firm conclusions about the influence of residential location on travel. In particular, American researchers working within a microeconomic tradition have considered this a source of error when comparing travel behaviour among residents living in different parts of an urban area. Our respondents' answers to questions about residential preferences may throw additional light on this issue. The respondents were asked to select three out of 17 characteristics as the most important ones if they were to move from their present residence to a new dwelling. Among those respondents living closer than 6 km to the city centre of Copenhagen, short distances to five 'urban' facility types⁴⁶ were mentioned by on average 18 per cent of the respondents, while seven 'suburban' qualities⁴⁷ were mentioned by 15 per cent on average. In the three other distance belts (6–15 km, 15–28 km, and more than 28 km from central Copenhagen, respectively), the 'suburban' qualities obtained slightly higher percentages than the 'urban' ones, notably in the outermost belt, where there was a preponderance of the 'suburban' qualities of 3 percentage points on average. Among the respondents from the inner of the four distance belts, a short distance to the workplace was in particular emphasized as a desired feature of the dwelling. In the three remaining distance belts, a private garden was the feature most often mentioned.

Thus, there are some variations in residential preferences reflecting the typical characteristics of residences in the areas where the respondents actually live. This indicates a certain degree of 'self-selection' (although the preferences may also be influenced by your experiences from living in a particular area, or be an artefact of post hoc rationalization). However, common preferences across residential locations or types of residences occur to a high extent. For example, among the residents of the two outer distance belts, where commuting distances are typically long, 17 per cent emphasize a short distance to the workplace as one of the most important characteristics of a possible new dwelling. Admittedly, this is a lower share than in the most central distance belt (30 per cent), but it still illustrates the fact that it will often be impossible in the actual residential choice to have all criteria fulfilled simultaneously. Similarly, as many as 25 per cent of the respondents living in the innermost distance belt consider that the next dwelling should have a private garden. This share is, not unexpectedly, lower than in the outermost distance belt (48 per cent), but still a clear indication of the fact that people are only to a limited extent 'self-selected' into their actual residential areas.

The residential choice of a household is a result of a trade-off between several wishes and concerns, not all of which can be fulfilled to the same extent by any specific dwelling. The wishes of the different family members may also vary. Not the least, the limited economical resources of the household confine the opportunities. Among our total sample of respondents, 28 per cent mentioned low price as one of the three most important criteria for residential choice, and among those living in apartment buildings this proportion was as high as 45 per cent. These circumstances contribute to weaken the line of argument, according to which the differences in travel behaviour found between residents of different parts of the city are caused not by urban structural conditions, but by the residents' predilection for a certain travel behaviour through 'self-selection' (cf., among others, Kitamura *et al.*, 1997; Bagley and Mokhtarian, 2002). The many constraints on the possibility of having all the different and often conflicting residential preferences fulfilled simultaneously imply that the proportion of the population actually 'self-selected' to live in a particular part of the city because of its facilitation of a certain form of mobility, is likely to be low.

Moreover, the fact that people to some extent 'self-select' into areas matching their transport attitudes and car ownership is in itself a demonstration of the importance of urban structure to travel behaviour. If there were no such influence, people who prefer to travel by non-motorized modes might as well settle in the peripheral part of the metropolitan area, far away from the concentration of workplaces and service facilities found in the central and inner-city.

It has been argued that managing travel behaviour through land-use policy is limited by the market of households who prefer to locate in areas with high neighbourhood accessibility (see, e.g., Krizek, 2003: 268). However, land-use planning may influence the supply of residential areas with different neighbourhood characteristics. Assuming that a given population will distribute themselves over the available residences in the region, construction of new suburban dwellings increases the number of people living in suburban areas, while growth in the number of inner-city dwellings increases the number of households living close to the city centre. Channeling residential development to transport-reducing locations may or may not suppress market demand. Suppressing some demands is an inherently normal consequence of public planning, the justification of which in market societies is precisely to produce a different result from that which would have occurred under unbridled market conditions (see, e.g., Klosterman, 1985). In the Copenhagen area, the very high prices of central and inner-area residences indicate that there is presently a suppressed demand for inner-city living. Constructing new residences in these areas would relieve this situation.

9.9 CONCLUDING REMARKS

Analyses where the respondents have been divided into subgroups according to socio-economic 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. There are also a few population groups among which urban structural conditions have a generally weaker influence on transport than among the other respondents.

Table 9.1 shows differences between various subgroups of the respondents regarding the influences of residential location on travel distances and the proportion of car travel. The table applies to travel on weekdays, and only direct effects are included. According to our material, the location of the residence influences the amount of transport more strongly among workforce participants than among non-participants of the workforce. Among the former, residential location makes a smaller difference among respondents who have either a long technical

Table 9.1 Differences in estimated travel distance on weekdays and proportion of car travel between residents living in the most peripheral and the most central of the investigated residential areas

	<i>Difference between residents of peripheral and central areas in:</i>	
	<i>Estimated travel distance on weekdays</i>	<i>Estimated proportion of distance on weekdays travelled by car (percentage points)</i>
All respondents (N = 1,414)	123 km	17%
Men (N = 679)	123 km	16%
Women (N = 734)	117 km	9%
Workforce participants (N = 1,085)	126 km	14%
Non-participants of the workforce (N = 328)	85 km	24%
Workforce participants with long technical or economic education (N = 139)	94 km	8%
Workforce participants with other types of long education (N = 311)	159 km	0%
Workforce participants with short or medium-long education as a tradesman or industrial worker (N = 137)	83 km	10%
Workforce participants with other short or medium-long education (N = 390)	179 km	12%

Results of multivariate analyses among selected subgroups of residents, controlling for demographic, socio-economic and attitudinal variables. (Direct effects only are included)

or economic education,⁴⁸ or a short or medium-long education as a tradesman or industrial worker. On the other hand, some of the groups whose travel distances are affected most by residential location are subject to only a weak influence regarding the proportion of car travel.⁴⁹

It is important to be aware that the figures in Table 9.1 refer to the *absolute* differences in travel distances and proportions of car travel, measured in kilometres and percentage points. The differences between the population groups in the *relative* influence of residential location on travel behaviour may be different. For example, the average proportion of car travel on weekdays is higher among men than among women, and the difference between men and women in the relative increase in the share of car travel resulting from a peripheral residential location is therefore smaller than the absolute figures might suggest.

Some interesting tendencies can be found when looking at variations in the strengths of the individual urban structural variables, for example the distance to central Copenhagen versus the distances to local centres. Table 9.2 shows an overview of the most important of these differences. The location of the residence relative to central Copenhagen appears to influence travelling distances in particular among those groups that may be characterized as socially privileged. Such a difference between the privileged and non-privileged exists both when the respondents are subdivided according to gender, workforce participation and income level, where the location of the residence relative to central Copenhagen influences the amount of transportation most strongly among men, workforce participants and persons with a high income. Among women, non-participants of the workforce and low-income groups, the amount of transportation is mainly influenced by more local urban structural conditions (the distances from the residence to the closest second-order urban centre, the closest urban railway station and the local area density). A similar, albeit less clear distinction can be seen when subdividing the respondents according to environmental attitudes, with a stronger influence from the local urban structure rather than the distance from the residence to central Copenhagen among persons attaching a high importance to environmental protection.

Urban structural conditions generally influence the amount of travel less among non-participants of the workforce than among those who are employed or in education. Within the former group, 'bounded' trips – which could be expected to be influenced by urban structure to a higher extent than 'non-bounded' trips (cf. Chapter 2) – account for a lower share of the amount of transportation. Among workforce participants and students, travel is strongly influenced by the distances from the dwelling to central Copenhagen and the closest second-order centre. This probably reflects the location of a large number of workplaces and places of education in Copenhagen's inner areas, and a university in one of the smaller towns of the

Table 9.2 Main differences between different population groups in the types of urban structural characteristics exerting the strongest influences on travel behaviour

<i>Subgroup</i>	<i>Urban structural characteristics exerting the strongest influences on travel behaviour</i>
Men	Distance to central Copenhagen
Women	Distances to local facilities
Singles without children	Overall weak effects; slight influence of distances to local facilities
Workforce participants	Distance to central Copenhagen
Non-participants of the workforce	Distances to local facilities
Workforce participants with long technical or economic education	Distance to central Copenhagen
Workforce participants with other types of long education	Distances to local facilities
Workforce participants with short or medium-long education as a tradesman or industrial worker	Distances to central Copenhagen
Workforce participants with other short or medium-long education	Distances to central Copenhagen as well as to local facilities
Low-income	Distances to local facilities
High-income	Distance to central Copenhagen
Without car in the household	Distance to central Copenhagen
With car in the household	Distances to central Copenhagen as well as to local facilities
High environmental awareness	Distances to local facilities
Low environmental awareness	Distance to central Copenhagen

conurbation (Roskilde). For persons who are neither workforce participants nor students/pupils, weekday transport is to a higher extent directed towards destinations available in a local centre, for example shops, cafés and post offices. Thus, among non-participants of the workforce, local area density is the only urban structural variable influencing the amount of transportation on weekdays.

Among single people without children in the household – males as well as females – travelling distances on weekdays are less influenced by urban structural conditions than among the respondents in general. 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. In addition, a considerable part of the single persons without children living at home are pensioners, with less frequent trips to the region's concentration of workplaces.

The location of the residence relative to central Copenhagen influences the amount of travel both on weekdays and at the weekend among respondents without a car in the household, whereas only the amount of weekday travel is influenced among those who have a car at the household's disposal. The latter difference may be due to a stronger influence from the centralized structure of the public transport network on the weekend destinations of car-less respondents, while persons with access to a car more often drive to destinations in the outer, minor towns or local centres. Moreover, by indirectly increasing the mobility resources of car-less persons through a better supply of public transport, a high local area density appears to contribute to increased weekend travel distances among respondents without a car in the household.

CHAPTER 10

ARE SHORT DAILY TRIPS COMPENSATED BY HIGHER LEISURE MOBILITY?

10.1 INTRODUCTION

In several previous chapters we have noticed that a high local-area density appears to contribute to an increased amount of transport at the weekend. Admittedly, residents of dense, inner-city local areas do not travel longer distances at the weekend than respondents living in low-density outer-area suburbs. However, when controlling for other urban structural characteristics, especially the location of the residence relative to central Copenhagen and the closest second-order urban centre, as well as for the non-urban-structural control variables, we find several examples of a positive correlation between a high local-area density and a high amount of travel at the weekend. Respondents living in dense local areas travel longer distances at the weekend than respondents living at the same distance from central Copenhagen and the closest second-order centre, but in a local area with a lower density. Our material thus suggests a certain compensatory leisure travel among our respondents living in dense urban environments.

In this chapter, the question of a possible compensatory travel behaviour will be elucidated more closely. The chapter summarizes the sporadic examples of increased leisure travel among residents of dense districts mentioned in the previous chapters, and supplements these examples by investigating other aspects of travel behaviour than the ones analyzed in the previous chapters. Which indication of compensatory travel can be found in our material? For which types of trips does compensatory travel occur? What is the causal status of urban structure in relation to the apparently compensatory travel behaviour? Which types of compensation exist? By which mechanisms does residential location cause compensatory travel behaviour? Besides looking more closely at the data from Copenhagen Metropolitan Area, results from a few other studies addressing the question of compensatory travel will be discussed.

Some authors (e. g. Kennedy, 1995; Berg, 1996 and Tillberg, 1998) have claimed that people living in high-density, inner-city areas, to a larger extent than their low-density counterparts, travel out of town in their leisure time in order to compensate for lack of access to a private garden and local-area greenery. Their reasoning has much in common with the so-called *escape hypothesis* in studies of leisure travel, according to which people who are dissatisfied with their dwelling and its surroundings will spend a large proportion of their leisure time elsewhere

(Kaiser, 1993). The hypothesis of the above-mentioned authors implies that residents of dense urban areas are so to speak 'forced' to make leisure trips 'out into the green countryside' in order to have their needs for outdoor life and contact with nature met. Among suburbanites, the need for such trips may be present to a lesser extent, as a large proportion of suburban residences have private gardens, and green areas and open fields make up a larger proportion of their surroundings. This hypothesis thus considers compensatory leisure trips as a 'phenomenon of deficit' arising because basic psychological needs for contact with nature (see, e.g. Grahn, 1993) cannot be met in dense urban areas.

Other theorists have considered compensatory travel rather as a 'surplus phenomenon'. According to this view, reduced consumption for daily travel purposes will, insofar as the total purchasing power remains constant, only result in a higher consumption of other goods and services. This hypothesis has in particular been put forth by Vilhelmson, (1990). With a given income level, this hypothesis implies that the 'sum of vices' in the form of environmental loads from the households' consumption pattern tends to be more or less constant, regardless of a transport-reducing or a more transport-requiring urban structural situation. The time saved when you do not need to travel long distances to the workplace and other daily activities, or on maintaining a single-family house with garden, may be 'harvested' in the form of leisure trips out of the city. Focusing on economical resources, compensatory leisure travel may result from money saved if the residential location makes it possible without too much inconvenience to abstain from car ownership, or to have only one car instead of two cars in the household. Lower housing costs when living in a small apartment may also enable inner-city dwellers to make more leisure trips, compared to owners of expensive single-family homes.

If compensatory mechanisms are wide-spread and result in long leisure trips, and in the absence of environmental policy regulations in order to reduce this transport, the positive environmental consequences of urban planning limiting the needs for daily transport will be reduced. Households living in moderate-size, low-cost dwellings and spending little money on daily travel might even consume more energy and natural resources and cause a higher environmental load than suburbanites through, for example, ownership of and visits to summer cabins, or flights to distant holiday resorts.

One of the few empirical studies investigating whether short daily trips are compensated through a high amount of leisure travel is Tillberg's (2001) investigation of travel behaviour among families with children living in different parts of the Gävle region in Sweden. Tillberg compared the trips made by residents living close to the centre of the region centre Gävle (68,000 inhabitants) with those made by similar families living in a small urban settlement (3,000 inhabitants) and a rural village in the same region. In line with findings in several other studies, the total travel

distance per adult person over the week was longest among the residents of the rural village and shortest among the inner-city residents of Gävle. The same applies to the distance travelled by car over the week. At the weekend the respondents of the inner-city area in Gävle travelled somewhat longer than those living in the small urban settlement, although not as long as the respondents from the rural village. However, looking specifically at *leisure trips by car at the weekend*, Tillberg found the longest average travel distances among the inner-city residents of Gävle and the shortest ones in the small urban settlement. Over the week, the distance travelled by car on leisure trips was practically the same in inner-city Gävle and the small urban settlement, whereas the inhabitants of the rural village travelled considerably longer. Tillberg's study (including her qualitative interviews) thus seems to support the hypothesis of compensatory travel to some extent.

Schlich and Axhausen (2002) have compared travel behaviour between residents of inner-city Zurich and two peripheral suburbs, one of which is situated close to major traffic routes. Controlling for socio-economic and demographic variables, they found more frequent trips to leisure activities away from home both among inner-city dwellers and the inhabitants of the traffic-exposed suburb, compared to the suburb not exposed to traffic nuisances. This may indicate compensatory trips, but the high frequency of out-of-home leisure activities among inner-city residents may also result from the broad supply of 'urban' leisure opportunities in the city centre. The overall distance travelled in connection with leisure activities was, however, found to be reduced when living in the inner-city.

Both in Tillberg's and in Schlich and Axhausen's study the numbers of respondents of the quantitative surveys were quite low (83 households and 71 individuals, respectively). Let us therefore see if any indications of compensatory travel can be found in the far more extensive empirical material of the Copenhagen Metropolitan Area study.

10.2 TRAVEL DISTANCES AT THE WEEKEND

The qualitative interviews of the Copenhagen Metropolitan Area study show some examples of more or less compensatory travel activity at weekends among interviewees living in dense urban environments. Several of these interviewees visited summer cottages and natural areas outside the metropolitan area quite often, whereas such trips were mentioned less often among the interviewees living in the outer suburbs. Some interviewees explicitly mentioned the less trafficked streets and more spacious outdoor areas when living in a single-family home as a reason for not going so frequently to natural areas but also pointed to the time tied up with gardening and house maintenance at the weekend:

When we lived in a flat, then we were much more out. Then we went to Klampenborg [an area with a park in a northern suburb] and to the water ... after we have got a [single-family] house, also because we spend so many weekends painting, but now we aren't so much out, because we haven't such a [need], the children can play out in the street and they have their playmates and they have grown bigger and we have the garden, haven't we. I felt it more when we lived in a flat that we went out often. We were almost out, that is, every weekend for some activity.

(Female teacher, 47, living in the inner district of Kartoffelrækkerne)

An interviewee living in one of the central areas gave the following answer to our question of whether she would have used her summer cottage less frequently, or maybe sold it, if she had lived in a single-family house:

there is some truth in it ... My sister lives enormously pleasantly. She lives like that with a view over the sea ... So you can just sit there in the garden and sniff. It is lovely; I can't do that in my own backyard.

(Female planner, 38, living in the inner-city district of Kartoffelrækkerne)

Apart from visiting summer cottages somewhat more frequently, the amount of travel carried out by inner-city interviewees when visiting natural areas is to some extent increased by the fact that the distance to the closest fairly large natural area is longer if you live in the central parts of the metropolitan area.

Thus, our qualitative interviews show that certain mechanisms of compensatory travel at the weekend exist among our interviewees. In order to assess the importance of these mechanisms to the total amount of travel, it is necessary to compare and summarize travel distances for different purposes as well as to include information about a larger number of individuals. Let us therefore turn to our quantitative survey data.

In general, transport at the weekends is much less influenced by urban structure than transport on weekdays. Compared to weekdays travel, trips during weekends and holidays are to a much lower extent a result of routine tasks and obligations. At the weekend too, living in the outer parts of the metropolitan area contributes to an increase in the amount of travel (cf. section 6.3), but the effect is weak. Controlling for non-urban-structural variables, residents living on the periphery of Copenhagen Metropolitan Area travel 14 per cent longer at the weekend than their inner-city counterparts ($p = 0.102$). The fact that a peripheral residential location contributes to increasing the distance travelled both on weekdays and at the weekend indicates that there is no general tendency to 'compensatory' weekend travel when living in the inner parts of the urban region. The above example from the qualitative interviews of a household reducing their number of trips to natural areas

after moving to a house with a garden is thus quite atypical. As mentioned in Chapter 7, the average number of trips to forests and natural areas is considerably higher among outer-area than among inner-city residents.

Nevertheless, more detailed analyses show that respondents living in dense local areas tend to travel somewhat longer at the weekend than respondents from less dense areas with a similar location relative to the centre structure of the metropolitan area, and with similar socio-economic and attitudinal characteristics. More specifically, the following indications of compensatory travel at the weekend can be found among respondents living in dense local areas, when controlling for the location of the residence relative to inner-city Copenhagen and lower-order centres, as well as for socio-economic and attitudinal variables:

- A longer distance travelled by car at the weekend (the main survey, $p = 0.054$) (cf. Figure 6.4). This effect may indicate compensatory travel, reflecting a more strongly felt need among residents of dense local areas to go to summer cottages and natural areas at the weekend. These destinations are often not very easily accessible by public transport. Moreover, trips to summer cottages often include considerable baggage, increasing the likelihood of opting for the car. It should, however, be noted that the effect of local area density on the distance travelled by car at the weekend is only present as long as control is made for the location of the dwelling relative to central Copenhagen.
- Slightly longer total travel distance on Saturday and Sunday (the travel diary investigation, $p = 0.162$). This effect has the opposite sign of the effect of local area density on the amount of travel on Monday and Tuesday, and indicates, albeit with considerable uncertainty, a tendency for compensatory travel at the weekend.
- A lower proportion of distance travelled by public transport at the weekend (the main survey, $p = 0.007$) (cf. Figure 6.9). This too may reflect compensatory travel among residents of dense local areas, for example in the form of trips to summer cottages. Such trips typically take place by car and may cause a considerable reduction in the share of public transport, both because of their length and because they replace other trips where public transport might have been a more relevant alternative. However, the negative effect of local area density on the share of public transport is also present on weekdays, and may partly be a result of the high number of destinations located within walking and cycling distance when living in a dense area.
- Fewer trips on foot at the weekend (the travel diary survey, $p = 0.018$). This effect too may hint at compensatory travel. If respondents of dense areas make more long leisure trips at the weekend, less time will be available for visiting local facilities, even if they are located within acceptable walking distance.

The travel diary investigation shows a tendency for fewer trips by car at the weekend, the higher the local area density. Seen in the light of the above-mentioned results this might appear surprising, but it is not incompatible with a general tendency for a higher amount of car travel at the weekend among respondents living in dense local areas. The compensatory car transport at the weekend that might be expected among these respondents would typically be a few, long trips (e.g. to and from a summer cottage). Distinct from that, the weekend transport among those respondents who do not take on a longer outing typically includes a number of shorter trips with different purposes, such as leisure activities, visits and errands.

More detailed analyses (based on the main survey, $N = 1,932$) indicate that the distance travelled on weekdays tends to be somewhat reduced if a green recreational area above 10 hectares exists within 1 km from the dwelling. This also holds true when controlling for the location of the residence relative to inner-city Copenhagen and the non-urban-structural variables mentioned in the introduction ($p = 0.028$). This appears to support Tillberg's (1998) and Kennedy's (1995) hypothesis saying that people living in parts of the city where there are few green areas will be 'forced' to travel to natural areas elsewhere. A similar relationship is present for the weekend transport as well, albeit weaker and more uncertain ($p = 0.204$). Availability of green areas close to the residence thus seems mainly to reduce the number of afternoon trips to more distant green areas. The destinations of weekend outings seem to a higher extent to be located further away (e.g. larger areas, since more time is usually available for the visit at the weekend), regardless of the existence of local green areas.

Analyses where the population of the main survey has been divided into sub-groups show that the tendency to increased weekend transport among residents of dense local areas is clearer among low-income persons and persons without a car in the household. A possible explanation may be that the increased mobility resulting from car ownership and more economic resources facilitates the choice of more distant recreational areas, even if such areas are available in the local area. Among less mobile groups, available local green areas will to a higher extent be used. Distant green areas will then mainly be chosen if no such areas exist in the local neighbourhood. The latter is more likely to be the situation in dense local areas. The tendency among respondents without a car for more weekend travel when living in a dense area may also be a result of the increased mobility resources for car-less persons provided by the high service level of public transport in high-density local areas.

An analysis of the *leisure trips* on Saturday and Sunday among our travel diary respondents shows that these trips are on average longer, the further away from central Copenhagen the respondents live ($p = 0.005$) (cf. Chapter 7). Admittedly, inner-city residents have poorer access to green recreational areas

than their outer-area counterparts. This is still of less importance to the total travel distance in connection with leisure trips than the broader supply of leisure and recreational opportunities in Copenhagen's central area.

10.3 TRIPS OUTSIDE THE ISLAND OF ZEALAND

Another indicator of the occurrence of long trips is the frequency of trips outside the island of Zealand (on which Copenhagen Metropolitan Area is located). In our first survey, the respondents were asked whether the destinations of any of the trips *during the week of investigation* were located outside Zealand. Among our respondents, 17 per cent had made such a trip. A multivariate logistic regression analysis was carried out, with occurrence of trips outside Zealand (yes or no) as the dependent variable. According to this analysis, one urban structural variable exerts a statistically significant effect on the likelihood of having visited areas outside Zealand during the week of investigation, namely the local area density. The higher the density of population and workplaces in the local area, the higher is the likelihood of having been outside Zealand ($p = 0.005$). This indicates compensatory travel among inner-city residents and supports the impression left by the qualitative interviews, where interviewees living in inner-city areas more often expressed a wish to go to summer cottages etc. than those living in suburban single family houses with gardens.

Our material does not say anything about the *length* of the respondents' trips outside Zealand. However, since these trips are all carried out during the week of investigation, they are already included in the account of the respondents' travel distances. The trips outside Zealand during the week of investigation are therefore far from sufficient to balance the clear tendency to a reduced amount of travel among the respondents of the inner and central parts of the metropolitan area. This also applies to the weekend, as a peripheral residential location, as already mentioned, contributes to somewhat longer travel distances on Saturday and Sunday than if the residence is located in the central parts of the urban area.

The occurrence of trips outside Zealand during the week of investigation is an indicator that may to some extent be vulnerable to seasonal variations. In fact, some of the respondents filled in the main survey questionnaire for a different week than was presupposed, and this alternative week included Whitsun. As this extended weekend is a popular period for outings to summer cottages etc., such trips may be somewhat over-represented in the main survey. In the travel diary survey, the respondents were instead asked about trips outside Zealand *during the past two months*. Distinct from the main survey, the travel diary respondents were asked about the *number* of trips outside Zealand during this period (and not only whether or not they

had made any such trips). The numbers were given in five different intervals (zero, 1 – 2, 3 – 4, 5 – 8 and more than 8).

A multivariate ordinal logistic regression⁵⁰ with the number of trips outside Zealand during the latest two months shows significant effects from none of the four urban structural variables (significance levels ranging from $p = 0.215$ to 0.830). However, running a binary logistic regression where the number of trips outside Zealand was transformed into a dichotomous variable with the value 0 if the number of trips was two or lower, and 1 if the respondent had made three or more trips outside Zealand yields results more similar to those based on the main survey. Among our respondents, 27 per cent had made at least three such trips.

This multivariate analysis shows a statistically significant ($p = 0.010$) tendency to a higher likelihood of having made three or more trips outside Zealand if the respondent lives close to central Copenhagen.⁵¹ This supports the hypothesis of compensatory travel. Although the urban structural variable showing effect in this case is different from the one found to influence the occurrence of trips outside Zealand during the week of investigation of the main survey (local area density), there is a considerable overlap between these two variables (Pearson's $r = -0.71$). In spite of the absence of formal multicollinearity problems (cf. section 6.2), the residential areas situated in high-density local areas are all located close to inner-city Copenhagen.

In addition to the previously mentioned 'surplus' (due to money saved from less daily travel) and 'escape' (due to urban stress and lack of green areas) reasons for compensatory leisure travel among inner-city dwellers, the easy access to Copenhagen's main railway stations enjoyed by these respondents may also facilitate more frequent trips outside Zealand. Such a relationship is theoretically imaginable, especially among persons who do not have a car at their disposal.

10.4 SUMMER COTTAGE ACCESS

If living in a central and dense urban environment contributes to a higher amount of travel during holidays and weekends, this may also manifest itself in – other things being equal – a higher frequency of summer cottage ownership among residents of dense inner-city areas. Once acquired, the summer cottage may in its turn stimulate the users to make more trips out of the city. Summer cottage access may therefore make up a link in a mechanism by which inner-city living contributes to compensatory leisure travel.

Our qualitative interviews showed some indications hinting at the existence of such a mechanism. A multivariate logistic regression analysis with summer cottage access as the dependent variable provides further evidence. Controlling for

socio-economic, attitudinal and other non-urban-structural differences between the respondents, having access to a summer cottage is more frequent among respondents living in a dense local area ($p = 0.000$). This effect is the strongest of all the effects of the independent variables. At the same time, the likelihood of having a summer cottage at one's disposal tends to increase when living far away from the closest second-order urban centre ($p = 0.000$). Although the significance level of this effect too indicates a very low degree of uncertainty, it is considerably weaker than the effect of local-area density. There is also a slight, but quite uncertain tendency to more frequent summer cottage ownership when living far away from the closest urban railway station ($p = 0.149$). The location of the residence relative to central Copenhagen shows no separate effect on summer cottage ownership.

The effect of local area density must be interpreted as clearly compensatory: if the local area is dense, fewer 'rural qualities' are available, and those residents who appreciate such qualities will therefore to a higher extent try to compensate for this deficit by purchasing a summer cottage. At the same time, the lower average housing costs when living in apartment buildings (except owner-occupied apartments close to central Copenhagen) may increase the residents' economic possibilities of purchasing a summer cottage. It is more difficult to explain why the propensity for having a summer cottage at one's disposal appears to increase when living far away from the closest second-order urban centre (and far from an urban railway station). A possible explanation might be that housing costs in such peripheral areas are lower, thus leaving more money available to be spent on a summer cottage. Reduced competition from more urban leisure activities (e.g. visits to cinemas, restaurants and concerts) when living peripherally might contribute in the same direction.

Above, the lower housing costs when living in apartment buildings were mentioned as a possible part of the explanation why residence in a dense local area appears to contribute to a higher propensity of summer cottage ownership. In order to investigate this more closely, an alternative multivariate analysis has been carried out, replacing the four urban structural variables with housing type (apartment building vs other types of residences) among the independent variables. This analysis indeed shows a significant relationship between summer cottage access and living in an apartment building ($p = 0.004$), but the effect is *negative*, not positive as might have been expected if the above-mentioned compensatory mechanism were important. A similar analysis has been made, where the housing type variable indicates whether or not the respondent lives in a detached single-family house. As mentioned above, the perceived need for a summer cottage could presumably be reduced if you live in a house with access to a private garden. However, no effect on summer cottage ownership from living in a detached single-family house was found. Finally, we also carried out an analysis where the availability of green recreational

areas in the proximity of the dwelling replaced the four urban structural variables. This variable too turned out to have no effect on summer cottage ownership.

Looked at together, our analyses suggest that the more frequent access to summer cottages among residents of dense local areas may not be a causal relationship. Neither a single-family house garden nor the availability of green recreational areas in the proximity of the dwelling shows any effect on the propensity for having a summer cottage at one's disposal. Lack of a private garden or green areas in the neighbourhood are therefore hardly the most important reasons for the increased frequency of summer cottage ownership among residents of dense local areas. The negative effect of living in an apartment building is surprising, given the control for income variations as well as a number of other socio-economic and attitudinal characteristics of the respondents. Apparently, summer cottage access is particularly high among respondents living in low-rise inner-city enclaves surrounded by more densely developed areas. If many of the residents of these old, low-density districts have large assets, for example because they have inherited their dwellings, their ability to purchase summer cottages would be higher than their income level would otherwise allow. Admittedly, this is a highly speculative explanation, but it fits with the data. Anyhow, further research will be required for a better understanding of the links between residential location, housing types and access to summer cottages.

10.5 HOLIDAY TRIPS AND FLIGHTS

Further indications of the occurrence of compensatory travel could perhaps be found by looking at possible relationships between residential location and holiday trips, in particular flights. Our main survey included questions asking whether the respondent had been on any holiday away from home at all during the past year, and the modes of transport on holiday trips. The travel diary investigation included questions about the number of flights during the past year, subdivided into private flights and official trips by aeroplane. Moreover, holiday trips were also a topic focused on in the qualitative interviews.

The data from our main survey show that the propensity for not making any holiday trip at all is somewhat higher among the respondents who live more than 28 km away from central Copenhagen (about 21 per cent, compared to 14–16 per cent among the respondents living in the three inner distance belts). A multivariate, logistic regression analysis shows that the occurrence of holiday trips correlates with residential location even when controlling for the same independent variables as in the previous analyses. Again, local area density is the urban structural variable showing a significant effect ($p = 0.003$). The higher the local-area density, the

higher is the likelihood that the respondent has been on holiday away from home during the past 12 months.

Moreover, our material shows a correlation between inner-city living and the likelihood of making holiday trips by aeroplane as the main means of transport. A multivariate ordinal logistic analysis indicates that respondents living in dense and central parts of the metropolitan area are more prone to fly to holiday resorts, even when control is made for a number of socio-economic and attitudinal characteristics of the respondents. Both the location of the residence relative to central Copenhagen ($p = 0.024$) and the local area density ($p = 0.039$) show significant effects. A multivariate ordinal logistic analysis of our travel diary data show similar tendencies. Controlled for the same non-urban-structural variables as above, the number of private flights during the past 12 months is slightly higher among residents living close to central Copenhagen and/or in a dense local area. Admittedly, none of these effects are statistically significant ($p = 0.19$ and 0.22 , respectively), which is not surprising, given the much lower number of respondents in this analysis ($N = 159$). However, removing the location of the residence relative to central Copenhagen from the regression model while including all the other independent variables, the effect of local area density becomes statistically significant ($p = 0.019$).

At first glance, these results appear to be clear indications of compensatory holiday flights among respondents whose residential location contributes to a low amount of daily and weekly travel. Yet, it is difficult to find a causal explanation of such compensatory air travel that fits with our data. The higher frequency of flights among residents of dense and central districts can hardly be a result of compensation for lack of green areas in the local neighbourhood. The number of flight-based holiday trips during the past 12 months is slightly *higher* among respondents who have access to a green recreational area above 10 hectares in the proximity of the dwelling, even when controlling for the non-urban-structural variables ($p = 0.017$ and 0.060 , for availability of such a green area within 1 km and 0.5 km from the dwelling, respectively). Neither does compensation for lack of a private garden seem to be a plausible explanation. Controlling for non-urban-structural variables, the number of holiday trips mainly by aeroplane is similar among residents of apartment buildings and other dwellings ($p = 0.660$). It also seems unlikely that the higher number of flights among inner-city residents is a result of lower housing costs enabling these residents to spend more money on air travel. Among our inner-city respondents, high average numbers of flights are in particular found in some residential areas known for their high housing prices.

It might instead be argued that money and time saved through a low amount of daily travel is utilized in the form of more extensive travel, in this case flights. If this were true, we would expect to find negative correlations between the number of

flights and the amount of daily or weekly travel. However, our material shows no such negative correlations. If the four urban structural variables of the multivariate analysis are replaced with the total amount of surface travel during the week of investigation, the latter variable shows no effect at all on the number of flight-based holiday trips during the past 12 months ($p = 0.922$). Similarly, among our travel diary respondents, the number of private flights during the past 12 months is unrelated to the weighted travel time as well as to the travel distance for surface transport during the week ($p = 0.579$ and 0.739 , respectively, controlling for non-urban-structural variables).

A surplus of money among inner-city residents due to reduced need for car ownership might perhaps increase these residents' opportunities for air travel. However, instead of a negative effect of car ownership on the number of flights when the urban structural variables are removed from the model, as would be expected if this hypothesis were true, car ownership is either unrelated to the likelihood of making flights (private flights in general, $p = 0.24$) or shows a positive effect (flight-based holiday trips, $p = 0.014$).

Thus, the statistical association between inner-city living and the number of flights is hardly causal. None of the participants of our qualitative interviews generally mentioned the location or quality of the dwelling as a reason for their holiday trips to distant destinations. Instead, exotic qualities of these destinations were often mentioned. This corresponds with the findings of Schlich and Axhausen (2002: 17–19), who concluded that the locations of destinations for holiday trips were chosen mainly from a wish to experience something new and different from one's daily life. Here, the urban–rural dimension was not important. Instead, variation at a larger geographical scale was sought for, such as the exotic, a better climate, foreign languages and cultures, or opportunities to carry out specific activities that cannot be carried out in the local region (e.g. skiing).

A possible, yet speculative, explanation of the higher frequency of flights among inner-city dwellers is instead that an 'urban' and cosmopolitan lifestyle, prevalent in particular among young students and academics, contributes both to an increased propensity for flights and a preference for inner-city living. Today, there is quite a widespread tendency among young people to make long-lasting trips to distant destinations. The television programme and travel guide *Lonely Planet* is a manifestation and probably also an accelerator of this phenomenon. This cosmopolitan lifestyle, probably more widespread among young academics and students than among young working-class people, seems to be associated with a prioritization of 'urban' activity opportunities like cinema, theatre, rock concerts, exhibitions, cafés and outdoor restaurants. This as distinct from seeking the rural and secluded life behind the privet hedges of single-family homes. If these assumptions of a tangled urban–cosmopolitan lifestyle among young people are correct, this

lifestyle will be a background factor contributing both to an increased propensity for flights and a preference for inner-city living. The lifestyle variables of the study (designed mainly to capture attitudes relevant to explain differences in transport at an urban and regional scale) are probably only to a limited extent able to capture differences along this lifestyle dimension.

In our qualitative interviews, this 'cosmopolitan lifestyle' could in particular be seen among some of the interviewees living in a previous working-class inner-city area now populated mainly by young academics and students. Some of these interviewees stated explicitly that the purpose of their flights was not to escape from the dense urban environment. Instead, the destinations were often other big cities.

Besides the above-mentioned urban and cosmopolitan lifestyle, apartment dwellers usually spend much less time than single-family house owners do on maintenance and improvement of their dwelling. An example of the latter mechanism was found in our interview with a household in a peripheral suburb:

And then we've also spent our vacation doing up our house. Last year it was the gutters, you know, and this year we dug up the entrance ... So the holiday is spent on that, you know ... Both money and holiday disappear. Sure, we take them from the same purse.

(Female assistant nurse, 54, living in the suburb of Stenløse)

This latter compensation mechanism must yet be considered uncertain, as the above-mentioned interview household appeared to 'take back the lost' in the form of longer holiday flights in intermediate years.

Even if real causal mechanisms did exist, encouraging residents of dense and central urban districts to make a higher number of flights, it would hardly be a good idea, seen in a greenhouse gas perspective, to locate a higher proportion of residential development to the outer suburbs in order to counteract such a tendency. If there is a social objective to reduce the amount of leisure flights, considerably more efficient measures could be used (e.g. increased taxes on such trips) than building low-density housing areas in order to counteract any 'compensatory' flights.

10.6 CONCLUDING REMARKS

Our quantitative material shows some indications of 'compensatory' travel behaviour in the form of more trips outside the local region among residents of dense local areas. Table 10.1 summarizes the results of our analyses of potential indicators of compensatory leisure travel among people living in areas where the need for travel in order to reach daily destinations is low. Residents of dense residential areas show patterns of weekend travel indicating compensatory travel to a certain extent.

Table 10.1 Overview of investigated potential indications of compensatory travel

<i>Potential indicator</i>	<i>Relationship with residential location</i>	<i>Is the relationship causal?</i>
Travel distance by car at the weekend	Somewhat longer in dense areas, but only when controlling for distance to city centre	Probably yes
Total distance travelled at the weekend	Slightly longer in dense areas, but only when controlling for distance to city centre	Probably yes
Public transport and walking trips at the weekend	Slightly lower in dense areas, but only when controlling for distance to city centre	Probably yes
Trips outside the island of Zealand	Higher frequency in dense and central areas	Probably yes
Summer cottage access	Higher frequency in dense areas	Uncertain, probably no
Flights	Higher frequency in dense and central areas	Hardly

They also make more frequent trips outside the island on which Copenhagen Metropolitan Area is situated. Moreover, they are more frequent owners of summer cottages, and make more flights. However, further analyses indicate that not all of these relationships are causal. Notably, the correlation between high-density living and a high number of flights is probably spurious.

Controlling for socio-economic, attitudinal and other control variables, a high density in the local area appears to contribute to more trips outside Zealand and somewhat longer travel distances at the weekend. The latter effect was, however, only present when comparing respondents living at the same distance from central Copenhagen. Our qualitative interviews show some examples of frequent trips to larger, continuous natural areas (including summer cabin areas) among residents of high-density inner-city blocks. Probably, this is compensation for lack of nature in the immediate surroundings of the dwelling as well as a result of less leisure time tied to gardening and house maintenance.

This mechanism is, however, only important among a limited share of the respondents. Our statistical material does not reveal any tendency to more frequent visits to forests and shores among inner-city dwellers. On the contrary, residential location close to the city centre appears to contribute to reducing the number of visits in natural areas (see Chapter 7). Thus, rather than compensatory trips, 'distance decay' (Maddison *et al.*, 1996) in the form of less frequent trips when the destination is far away is the most common mechanism. The lower overall frequency of

visits to natural areas among inner-city residents is, however, countered by a slightly stronger and oppositely directed tendency among these respondents to longer average distances to destinations for visits in natural areas. It should be noted that the resulting additional kilometres travelled in connection with visits to natural areas makes up a small proportion of the total transport. Even within the category of leisure trips, the longer travelling distances to natural areas among inner-city dwellers are outweighed by other leisure trip purposes where those living in the outer areas travel considerably longer. Longer total travelling distances for leisure purposes among suburbanites than among residents living close to the city centre have also been found in a study of the Zurich region (Schlich and Axhausen, 2002).

The above implies that the slight tendency for longer travel distances at the weekend when living in a dense local area is not caused by any compensatory higher frequency of outdoor recreation activities away from home, but instead by the longer distances to the locations visited.

Our study shows some of the same tendencies as Tillberg's (2001) study in the Swedish county of Gävleborg, where inner-city residents of the largest city of the region were found to travel somewhat longer than residents of smaller urban settlements for leisure purposes at the weekend, but still much shorter in total for all travel purposes than their more peripheral counterparts. However, in Copenhagen Metropolitan Area, the tendency to longer leisure trips at the weekend among residents of dense areas is only present when comparing residential locations at the same distance from the city centre. Without such a separation of the effects of density and centrality, the Copenhagen area data show somewhat longer travel distances for leisure purposes at the weekend among residents of low-density outer suburbs than among their counterparts living in high-density, inner-city areas.⁵²

A study in the little Danish town of Frederikshavn (population about 30,000) did not reveal any tendencies for compensatory travel (Næss and Jensen, 2004). Controlling for other potential factors of influence, there were no indications that living close to the centre of Frederikshavn contributed to more extensive car driving to non-local destinations or more frequent trips out of the county. This difference between Copenhagen Metropolitan Area and the small provincial town of Frederikshavn is most likely due to the fact that densities are relatively low even in the inner parts of Frederikshavn, with quite ample parks and open areas. Moreover, the largest forested green area in Frederikshavn is situated immediately south of the city, implying that residents of northern suburbs and villages have to travel longer in order to reach this area than those who live close to the centre.

Our material shows that the time and money saved from reduced travel for everyday purposes is only to a limited extent spent on extended leisure trips. In other words, the potential mobility resources (in the form of time or money) accumulated through inner-city living are mainly utilized for other purposes than travel.

Controlling for socio-economic and attitudinal variables, the frequency of *flights* is higher among respondents living close to the city centre of Copenhagen.⁵³ At first glance, this might seem to support the compensation hypothesis about longer and more frequent holiday trips among persons who save time and money by managing on a low amount of transportation in daily life (cf. Vilhelmson, 1990). However, there is hardly any correlation among our respondents between a high frequency of flights and short travel distance or travel time within the metropolitan area, which would be expected if the hypothesis were true. Neither does a high frequency of flights correlate with low housing prices. A possible, yet speculative, explanation of the higher frequency for flights among inner-city respondents is instead that an 'urban' and cosmopolitan lifestyle, prevalent in particular among young students and academics, contributes both to an increased propensity for flights and a preference for inner-city living.

For travel within 'weekend trip distance' from the residence, however, there is reason to conclude that living in the dense and central parts of Copenhagen has a certain compensatory effect in the form of more frequent, medium-long leisure trips. These trips imply a slight reduction of the transport-reducing effect of inner-city living, but are far from sufficient to change the overall tendency towards a lower amount of travel and a reduced car dependency when living in the central part of the metropolitan area. Such a residential location is also more robust in the event of possible future environmentally based limitations on automobility.

CHAPTER 11

CONCLUSIONS FROM THE COPENHAGEN METROPOLITAN AREA STUDY

11.1 INTRODUCTION

In this chapter we will try to draw together the threads from the previous chapters. First, the main empirical results from the qualitative and quantitative material of the Copenhagen Metropolitan Area study will be summarized. This summarizing will be structured around the five research questions formulated in Chapter 3.1.

Thereupon, the conclusions of the Copenhagen Metropolitan Area study will be compared to the results of other research studies. In this comparison, an attempt will be made to explain what might be the causes of any deviations between our findings in Copenhagen Metropolitan Area and the findings of other studies. The purpose of this is, among other things, to examine whether there is a basis for drawing more general conclusions about relationships between residential location and travel than the ones that can be drawn based solely on the Copenhagen Metropolitan Area study.

11.2 MAIN CONCLUSIONS OF THE STUDY

In Chapter 3, the following research questions were formulated for the investigation of residential location and travel in Copenhagen Metropolitan Area:

- Which relationships exist between the location of the residence within the urban structure and travel behaviour (amount of transport and modal split), when taking into consideration demographic, socio-economic as well as attitudinal factors?
- Does the location of the residence within the urban structure influence the range and frequency of activities in which people engage?
- On which rationales do people base their choices of activity locations and travel modes?
- Are the relationships between residential location and travel behaviour different among different subgroups of the population?
- Is the effect of a residential situation where the need for everyday transportation is low, offset by a tendency to compensate for this by making more frequent and long trips during holidays and weekends?

The Copenhagen Metropolitan Area study shows that residential location affects travel behaviour, even when taking into consideration socio-economic and attitudinal differences among the inhabitants as well. Although the specific influences of urban structure vary between population groups, the location of the residence in the urban structure of the Copenhagen Metropolitan Area affects travel behaviour within all our investigated subgroups. The main urban structural factors influencing travel behaviour among our respondents are:

- the location of the residence relative to central Copenhagen
- the distance from the residence to the closest second-order urban centre (sub-centre with a concentration of regionally oriented retail stores)
- the distance from the residence to the closest urban railway station
- the density of inhabitants and workplaces within the local area surrounding the dwelling.

On average for all our respondents, living in a dense area close to central Copenhagen contributes to less travel, a lower share of car driving and more trips by bike or on foot. Conversely, living in the peripheral parts of the metropolitan area contributes to a higher amount of transport and a lower share of travel by non-motorized modes.

The distance from the residence to central Copenhagen is the urban structural factor exerting the strongest influence on the respondents' travel. In particular, the length and travel mode of journeys to work are influenced by the location of the dwelling relative to central Copenhagen. For a number of 'non-bounded' travel purposes too, a central residential location contributes to a lower amount of transportation and a higher share of travel by walking and biking. The density in the local area and the distances from the residence to the closest second-order centre and urban railway station also influence travel to a relatively high extent. Usually, the effects of more detailed urban structural conditions are weaker than the effects of the above-mentioned four main urban structural variables. However, the concrete influences of the latter factors on travel behaviour work precisely through the accessibility of various types of detailed facilities, in particular workplaces, places of education and shopping opportunities, but also cultural and entertainment facilities and cafés/restaurants. For most of our respondents, the journey to work is the basic daily journey, to which other travel purposes, for example shopping, is sometimes linked.

Seen in isolation, green outdoor areas in the proximity of the dwelling appear to contribute to a slight reduction in the amount of travel, in particular on weekdays. However, trips to green areas make up a small proportion of the total number of trips, and the total amount of travel is therefore lower among inner-city respondents, in spite of the lower availability of local green areas in these districts than in the suburbs.

Our interviewees' *rationales* for location of activities, choice of transport modes and route choice make up important links in the mechanisms by which urban structures influence travel behaviour. The rationales are partially interwoven. Usually, the choice of an individual is not based on one single rationale, but on a combination of (and a trade-off between) several rationales. Most of the rationales identified either contribute actively to strengthen the relationships between residential location and travel, or are neutral as regards these relationships. A few of the rationales form the base of 'compensatory' mechanisms, which may contribute to weakening the relationships mentioned.

For most travel purposes, our respondents and interviewees emphasize the possibility of choosing among facilities 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. For leisure activities, the 'atmosphere' and the aesthetic qualities at the destination may also play a role, contributing to strengthening the attraction of Copenhagen's inner-city.

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 centre of the metropolitan area (inner-city Copenhagen), and to a lesser extent by the distance to lower-order centres. 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 centres may still be more important.

Many inner-city residents walk, cycle or go by public transport to their daily destinations even if they have got a car at their disposal, and this reduced car usage is only to a small extent, if at all, compensated through weekend driving. This illustrates the point made by Kaufmann (2002) that potentials for movement (*motility*, according to Kaufmann's vocabulary) are not automatically realized as actual movement (observable travel).

The location of the residence within the urban structure appears to exert a certain influence on car ownership. Our statistical analyses show that car ownership is higher in the peripheral than in the central areas, when also checking for a number of the socio-economic and attitudinal factors most likely to influence car ownership. It may of course be hard to tell whether this relationship is a result of car ownership being adapted to the need for transport experienced at a given residential location, or place of residence being chosen based on mobility resources already acquired through car ownership. However, the qualitative interviews show examples of households having moved from one of the inner districts of Copenhagen Metropolitan Area to one of the peripheral residential areas, and who therefore considered it necessary

to buy a car (or a second car) because it would otherwise be too inconvenient and time-consuming to reach daily activities. Regardless of whether the influence of residential location on car ownership or the influence of car ownership on residential location is the stronger, the relationship implies that residential location is of importance to the need for transportation – otherwise, people would choose places of residence independent of car ownership.

The relationship between residential location and travel is stronger among high-income groups and weaker among non-participants of the workforce, and single persons. The location of the dwelling within the urban structure seldom prevents the residents from participating in activities in which they are really interested, except among respondents with low mobility resources. Respondents living in the inner parts of Copenhagen still go more frequently to cinemas and restaurants and visit forests and other natural areas more seldom than outer-area residents do.

Our material shows certain indications of 'compensatory' travel behaviour in the form of a higher number of long trips (outside Copenhagen Metropolitan Area) among respondents living in dense local areas. More specifically, living in a dense local area appears to contribute to a higher number of trips outside the island of Zealand and somewhat longer travel distances at the weekend. (The latter relationship is only present when controlling for the location of the residence relative to the centre structure of the metropolitan area.) Probably, the above-mentioned relationships reflect both compensation for lack of nature in the immediate surroundings of the dwelling and the fact that residents of dense areas have less of their time consumed by gardening and maintenance of a single-family home. Due to the limited number of such trips, these 'compensatory' trips make up a small proportion of the total amount of travel.

Somewhat surprisingly, the frequency of flights is higher among respondents living close to central Copenhagen. However, this is hardly a causal influence of residential location. A possible, yet speculative explanation is that an 'urban' and cosmopolitan lifestyle, prevalent in particular among young students and academics, contributes both to an increased propensity for flights and a preference for inner-city living.

The above-mentioned compensatory effects, combined with the less clear influences of local area density on daily-life travelling patterns among the respondents of the main survey, might leave the impression that a high local area density contributes only weakly to reduce car traffic and emissions from transport. However, local area densities add up to the overall density of the city. The higher the population density of the city as a whole, the lower will be the average distance between the residences and the inner-city area. In this way, local area densities indirectly influence the urban structural variable that, according to our material, exerts the strongest influence on the respondents' travel behaviour, namely the location of the

residence relative to the city centre. This effect of the overall density of the city has been shown in several studies, for example Newman and Kenworthy (1989, 1999), Næss (1993a) and Næss *et al.* (1996). On the other hand, there is neither tradition nor demand for as dense housing in the peripheral as in the central parts of the urban region. The location of new residential development – on vacant areas close to central Copenhagen or as greenfield development in the outer-area municipalities – therefore to a high extent determines the relevant density levels.

As mentioned in Chapter 1, the need for construction of new dwellings in Copenhagen Metropolitan Areas has been assessed to 125,000 over the next 25 years (Nilas, 2003). Returning to the five different principles for urban development presented by the Copenhagen Region Development Council, densification within the central parts of the region is likely to bring about the lowest amount of travel, the lowest proportion of car travel and the highest share of travel by non-motorized modes. Among others, abandoned harbour areas and underutilized or derelict industrial areas make up an important potential for construction of new, centrally located buildings. The same applies to some of the inner-city surface parking areas, which might otherwise represent a capacity not compatible with the goal of reducing car traffic in the City of Copenhagen (The Municipality of Copenhagen, 1999). Realistically, though, not all residential development in the next decades can be located to Copenhagen's inner areas. The areas available for densification are after all limited, and residential development must also be balanced against the wish (from a transport energy point of view) to locate a high proportion of future office development close to inner-city Copenhagen (see, for example, Hartoft-Nielsen, 1997). Some of the future residential development must therefore take place outside the municipality of Copenhagen, even if a strategy aiming to limit the amount of transport and reduce car dependency is followed. Here, our results indicate that development along the parts of the urban 'fingers' relatively close to the inner-city (up to some 10–15 km) will be favourable, in particular on areas close to existing urban railway stations. Some of the residential construction should, however, also take place as densification close to the centres of five medium-sized towns located along the railway lines in the outer parts of the 'fingers'. These towns make up second-order urban centres, and their relatively high provision of workplaces and services is likely to compensate for their more peripheral location (approx. 30–50 km from central Copenhagen) compared to the parts of the 'fingers' situated between the 'inner joints' and the second-order centre towns themselves.

11.3 COMPARISON WITH OTHER INVESTIGATIONS

The results of our study are to a high extent consistent with the results of another relatively recent, but less thorough investigation of residential location and travel in Copenhagen Metropolitan Area (Hartoft-Nielsen, 2001). The latter study too showed a clear relationship between location of the residence relative to inner-city Copenhagen and the respondents' travel behaviour, both in terms of total travel distances and other aspects of travel. The length of journeys to work, especially, but also shopping and errand trip lengths were found to increase with increasing distances between the dwelling and central Copenhagen. For weekend travel and leisure trips, however, no such relationship was found. The respondents' total annual amount of travel varied from close to 20 km in the inner parts of Copenhagen to about 50 km in peripheral suburbs some 30 km away from the inner-city area. (These figures were, however, not controlled for the influence of non-urban-structural factors.) Besides, Hartoft-Nielsen found a 'town effect' where the residents of seven housing areas within or close to the five outer-region towns of Køge, Roskilde, Frederiksund, Hillerød and Helsingør had on average shorter travel distances than their counterparts living along the 'urban fingers' somewhat closer to inner-city Copenhagen (2001: 13–20). This effect corresponds to the effect of the distance from the residence to the closest second-order urban centre found in our study.

Our results are also well in accordance with the conclusions from studies of residential location and travel in Aalborg (Nielsen, 2002) and Frederikshavn (Næss and Jensen, 2004). In both the latter studies, a methodology similar to the Copenhagen Metropolitan Area study was used. The results also fit well with two similar investigations in Greater Oslo (Næss *et al.*, 1995; Røe, 1999). The results of investigations in the Århus area and some medium-sized Danish provincial towns follow the same pattern (Hartoft-Nielsen, 2001). As mentioned in section 2.7, a number of studies outside Scandinavia have also shown that residents of outer parts of the urban area travel considerably more by motorized modes of transport than their inner city counterparts. These studies include investigations in, among others, Paris (Mogridge, 1985; Fouchier, 1998), London (Mogridge, 1985), New York and Melbourne (Newman and Kenworthy, 1989), San Francisco (Schipper *et al.*, 1994), Dutch urban regions (Schwanen *et al.*, 2001) and English cities (Stead and Marshall, 2001). Our results thus seem to be of a high generality, indicating that the dominating mechanisms by which residential location influences urban travel will be present across city sizes within a broad context of Scandinavian and European cities.

In cities and urban regions where the population has a low access to fast modes of transportation a more decentralized urban structure might still be transport efficient (Brotchie, 1984; Owens, 1986). The influence of residential location relative to the inner city is also likely to be weaker in high-mobility cities without any clear

central business district, like Phoenix and Houston in the USA. Yet, even in such cities a central location is likely to generate less travel, as the point of gravity of the housing stock and the stock of workplaces in most cities is located relatively close to the city centre. The average distance to all the other addresses of the city will, even in a polycentric city, tend to be shorter from a central than from a peripheral location.

Admittedly, some previous studies have concluded that only weak relationships or no relationship at all exist between urban structural characteristics and the inhabitants' travel behaviour (see, e.g., Williams *et al.*, (2000), where some of these studies are referred). However, such conclusions are often based on model simulations where the results simply reflect that the in-built assumptions of the model do not capture the actual influence of the spatial urban structure on travel behaviour (cf., among others, Rickaby *et al.*, 1992; Dasgupta, 1994; Simmonds and Coombe, 2000). In other cases, the apparent absence of any relationship between urban structure and travel is the outcome of studies not including the variables (urban structural as well as travel behavioural) that could from theoretical considerations be expected to exert the strongest influence on each other. Finally, the myth of weak or no relationship between urban structure and travel is sometimes reproduced in literature reviews (e.g. Gordon, 1997; Frey, 1999) where the results from one or both of the two above-mentioned types of studies are communicated uncritically, seemingly without being aware of the conclusions of other, more credible studies where relationships between urban structural variables and travel behaviour have been found.

In some empirical studies, for example, respondents have been asked to indicate travel *time* instead of travel distance. However, travel time is not very well suited as an indicator of the amount of transport, as travel speeds vary considerably between different modes of travel and in many cases also with the time and place of travelling (among others due to congestion).⁵⁴ For example, an analysis of travelling distances and travel times among inhabitants in the Paris region showed considerably longer travelling distances among inhabitants living in the outer parts of the region than among residents of the inner, dense districts. At the same time, travel times were slightly longer among the inner city dwellers, mainly due to a higher proportion of travel being carried out by slow modes (Fouchier, 1998).⁵⁵ As mentioned in Chapter 7, the Copenhagen Metropolitan Area study too illustrates the fact that residential location is much more closely related to travel distance than to travel time. Still, the literature on urban structure and travel includes several examples where conclusions of non-existence of any relationship between urban form and the amount of transport have been drawn on the basis of analyses where travel time has been used as the dependent variable instead of travel distance (see, e.g., Gordon and Richardson, 1997; Snellen *et al.*, 1998).

In some other studies addressing the same research question, the daily *number of trips* per person has been used as an indicator of the amount of transport

(Kitamura *et al.*, 1997; Boarnet and Sarmiento, 1998). However, distinct from travel distances, there is less theoretical reason to believe that the daily number of trips will be lower among inner-city dwellers than among residents of outer suburbs. On the contrary, some authors have expected the number of trips to be somewhat higher among residents of the inner-city, where short distances from the dwelling to a broad range of facilities reduces the average inconvenience and cost per trip to these facilities (Crane, 1996). However, most studies of trip frequencies have concluded that the daily number of trips varies only modestly, if at all, between different types of neighbourhoods (Cervero, 2003). (In the Copenhagen area study, a higher trip frequency among outer-area residents was still found, cf. chapter 7.7.)

There are also several examples of studies focusing on urban structural factors that could hardly be expected to exert much influence on travel behaviour, whereupon general conclusions are drawn about weak or absent relationships between urban structure and transport. For example, based on an analysis of correlation between transport and population density within functional urban regions in England, Gordon (1997) claims that there is poor evidence for the assumption that urban structures influence travel behaviour. However, the population density within a functional urban region is an imprecise indicator for the relationships that could be expected to exist between urban structure and travel, as the geographical areas within which population density is measured at this scale usually include both large continuous non-built-up areas and urban land. Breheny (1995) draws a similar conclusion to Gordon based on a comparison of travel survey data in British cities of varying population sizes. However, the number of inhabitants is hardly a well suited indicator if the purpose is to test whether urban structure influences the amount of travel. For example, a study of 22 Nordic cities showed no relationship between energy use per capita for transport and the population size of the cities. Instead, energy use per capita was found to be influenced both by the population density within the urbanized area (measured as urban area per capita) and by the degree of centralized or decentralized location of residences within the urbanized area (Næss *et al.*, 1996).

Whereas Breheny and Gordon draw general conclusions about the absence of any relationship between urban structure and transport based on aggregate-level data at a high geographical level, other studies (in particular in the USA) compare urban districts with different density and street layout. Typically, the latter studies compare districts developed before and after the Second World War, and sometimes also areas constructed in the 1980s and 1990s according to so-called neotraditional urban design principles, but without including the location of the areas relative to the central structure of the urban region in the analyses (cf. Chapter 6). An example of studies belonging to this category is McNally and Kulkarni (1997).

Some of the debaters who claim that proximity or distance has lost its importance (e.g. Messelt and Kejsler, 2001; Skjeggedal *et al.*, 2003) seem to confuse the

importance of proximity to people's choices of *activities*, the importance of their choices of the *locations* in which the activities take place, and to the importance in terms of the *travelling* carried out in order to reach the chosen destinations. 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 neighbourhood of the residence, this does not mean that the location of urban functions has lost its importance for the amount of transport carried out in order to reach these destinations. On the contrary, the lower the extent to which 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.

Thus, the empirical studies concluding that urban structure has no influence worth mentioning on travel behaviour have usually investigated other aspects of travel (e.g. trip frequencies or travel time) and/or focused on other urban structural conditions than those which, according to our investigations, exert the strongest influences on travelling distances and modal split. Moreover, a common feature of many of the publications from the above-mentioned studies is an absence of theoretical discussion of the reasons why urban structure could be expected to influence travel, what characteristics of the urban structure could be expected to exert the strongest influence on travel behaviour, and what aspects of travel behaviour could be expected to be influenced by urban structure. Among empirical, multivariate investigations into the influences on travel from the location of residences within the urban area, the converging conclusion is that living close to the city centre does contribute to reducing travelling distances and the use of cars.

Table 11.1 summarizes the results of some of the latter studies, namely the studies conducted by myself and my colleagues in Copenhagen Metropolitan Area, Frederikshavn (Næss and Jensen, 2004) and Greater Oslo (Næss *et al.*, 1995), and Nielsen's (2002) study of residential location and travel in Aalborg.

Both in Copenhagen Metropolitan Area (population: 1.8 million), Greater Oslo (population: 0.9 million), Aalborg (population: 160,000) and in Frederikshavn (population: 35,000), travelling distances increase the further away from the centre of the urban region the residence is located. The table also shows that travel distances increase more quickly with increasing distance between the residence and the city centre, the smaller the city is. Controlling for non-urban-structural variables, the average weekly travel distance with motorized means of transport increases by about 60 km in Frederikshavn when the distance between the residence and the city centre is increased by 4 km. In Aalborg and Greater Oslo, an increase in this order of magnitude does not occur until the distance between the residence and the city centre

Table 11.1 Comparison of results from studies in different urban areas of relationships between residential location and weekly distance travelled by motorized modes of transport

<i>Urban area</i>	<i>Increase in expected weekly travelling distance (km) by motorized modes resulting from residential location at different distances from the city centre, compared to location in the inner city area (up to approx. 1.5 km from the defined centre)</i>				
<i>Distance from the residence to the city centre</i>	<i>4 km</i>	<i>8 km</i>	<i>12 km</i>	<i>20 km</i>	<i>40 km</i>
Copenhagen Metropolitan Area (the present study)	6	14	30	76	95
Greater Oslo (Næss <i>et al.</i> , 1995)	23	54	84	–	–
Aalborg ^a (Nielsen, 2002)	25	49	74	–	–
Frederikshavn (Næss & Jensen, 2004)	61	73	73	–	–

Control for socio-economic and attitudinal variables, except for the Oslo study, where attitudinal variables were not included. Car ownership is included as a control variable in all four urban areas. In all urban areas, urban structural variables other than the location of the residence relative to the main centre of the city have been excluded from the analysis.

a Based on information in Nielsen, 2002: 238, 260.

reaches about 9 km, and in Copenhagen Metropolitan Area at some 17 km from the city centre. Whereas weekly travelling distances in Copenhagen Metropolitan Area do not start levelling off until more than 30 km away from the centre, this point is already reached at a distance of 5 km from the centre in Frederikshavn. This reflects the fact that the continuous urban area in Frederikshavn reaches only some 3–4 km out from the city centre. Beyond that range, there is open countryside where the supply of service facilities and workplaces apart from agriculture is limited to the relatively modest number existing in the villages surrounding the town. In comparison, Copenhagen Metropolitan Area covers a much larger area, and along some of the urban railway lines the continuous urban area reaches 25–30 km out from central Copenhagen. In Greater Oslo the continuous urban area covers a somewhat smaller area, reaching 15–20 km westward, southward and eastward from the central area. In Aalborg, the continuous urban area reaches some 5–7 km outward from the inner-city area. Moreover, Copenhagen Metropolitan Area and Greater Oslo

both have a hierarchy of local centres in addition to the main centre of the region. In Aalborg, a secondary relief centre of considerable size exists (City South), whereas the inner-city area is the only location in Frederikshavn where any real concentration of centre facilities exists. In Frederikshavn, the accessibility to facilities therefore first and foremost depends on the location of the residence relative to the inner-city area. In larger cities, and in particular in metropolitan areas like Greater Oslo and Copenhagen Metropolitan Area, the accessibility to facilities is normally determined both by the distance to the main city centre and by the location of the dwelling relative to lower-order (sub-regional and local) centres.

The increase in motorized travel distance with increasing distance between the residence and the city centre is somewhat larger in Greater Oslo than what could be expected from a comparison with the three other urban areas. A possible reason for this is the fact that the relationship between residential location and travelling distances in the Oslo study was not controlled for differences in environmental and transport attitudes, as distinct from the investigations in the three Danish cities.

The respondents from the largest urban area (Copenhagen Metropolitan Area) have on average longer weekly motorized travelling distances than the respondents from the two smallest urban areas (Frederikshavn and Aalborg). The difference is about 60–70 km per week. This probably reflects the fact that Copenhagen Metropolitan Area to a high extent makes up a common housing, job and service market covering a substantial geographical area, whereas most of the inhabitants in Frederikshavn and Aalborg have their residences, workplaces and visited service facilities confined within a considerably smaller geographical area.

At the level of individual cities or metropolitan areas there is thus strong evidence that residential location close to the city centre contributes to reducing the amount of travel and energy use for transportation. However, it is more doubtful whether the advantages from centralization are also present when we turn from looking at single cities to larger regions (for instance a county or a province). Some professionals maintain that this will still be the case, from a line of argument that there will be a lot of criss-crossing transport between the different local communities in regions with a decentralized population pattern. However, several studies indicate that the amount of travel may be quite modest when people live sufficiently far away from large urban centres. A slight tendency for reduced travel distances could be observed among the respondents living in the most peripheral parts of Copenhagen Metropolitan Area (see Figure 6.1). In a study of three Danish provinces, Næss and Johannsen (2003) found that the amount of motorized travel tended to increase at a steady pace with increasing distance from the dwelling to the town centre of the closest one among the county's four to six largest towns, up to a distance of some 15 to 25 kilometres. Beyond that distance, travelling distances began to decline again,

reaching levels in the most peripheral locations only slightly above the levels found among the residents living closest to the centre of one of the county's main towns. A study of commuting distances in Finnish municipalities points in the same direction. Here, people living in rural and peripheral municipalities were usually found to have shorter commuting distances than those who live in the suburbs of the largest cities (Martamo, 1995). Similarly, an investigation of transport energy use in Swedish regions found that the energy use tended to increase the more the regional population was concentrated around the largest town of the region. Contrary to expectations, a high degree of urbanization, meaning that the proportion of the regional population living in rural areas and small settlements is small, tended to *increase* the use of energy for transport. On the other hand, a high population density within the cities contributed (as might be expected) to reduced energy use (Næss, 1993a).

The studies of travelling distances at regional or provincial level clearly point at 'distance decay' in the attractiveness of a large centre. Beyond the range of influence of the largest centres, most people are likely to orient themselves to smaller, more local centres, even if the job opportunities and selection of service facilities are narrower than in the big city. As mentioned in Chapter 2, this might form a basis for the development of more local lifestyles and activity patterns among people living in the peripheral parts of a region. On the other hand, with an increasingly mobile population, the range of influence of large centres will probably expand. If a residential development in peripheral rural areas and villages is to be compatible with modest average amounts of travel, the distances to the closest cities (and in particular major metropolitan centres) must therefore be sufficiently long.

CHAPTER 12

URBAN FORM AND TRAVEL BEHAVIOUR – A WIDER SUSTAINABILITY PERSPECTIVE

12.1 CRITERIA FOR SUSTAINABLE SPATIAL PLANNING

In the introduction to this book, national and international objectives of reducing the energy use and emissions from transportation were mentioned as an important part of the motivation for research into relationships between urban structure and travel. Since the report from the UN World Commission on Environment and Development (the Brundtland Commission) was published in 1987, the concept of *sustainable development* has become an important part of the vocabulary of politicians, administrators and planners. The present professional focus on the transport consequences of urban development is to a high extent originating from the concerns of sustainable development.

Throughout this book, the focus has been on the influences of different types of residential location on the possibility of obtaining a less car-dependent and less transport-demanding urban structure. Now the time has come to widen the perspective. How important is the possible contribution of urban planning as an instrument to reduce energy use and emissions from transportation? How compatible with other sustainability and environmental goals are those principles of residential location that may reduce car dependency and the need for travel? The conclusions of the Copenhagen Metropolitan Area study clearly point at densification rather than urban sprawl as the preferred urban developmental strategy in order to reduce transport-related environmental problems. Can such an overall 'compact city' strategy be combined with the environmental concerns emphasized by the proponents of the 'green city' model for urban sustainability?

As the saying goes, a pet child gets many names. Concerning the use of the concept of sustainable development, one might perhaps as well say, 'a pet name gets many children'. Today, a manifold range of strategies and projects are promoted with the claim that they are derived from the very concept of sustainable development. It has become politically impossible not to be a supporter of sustainable development, so there is a clear danger that the concept will be watered out.

The discourse about sustainable development based on the Brundtland Commission's report and the processes in the UN Committee on Environment and Development could be interpreted as a discourse in opposition to the dominating growth discourse in industrial countries.⁵⁶ A common technique of dominance a prevailing discourse can employ in order to retain its hegemony, is to try to manipulate

and change the object of the alternative discourse, among other things through de-radicalizing and redefinition (Van Dijk, 1996). The attempts to extend the concept of sustainable development to include a range of concerns not included in the concept as understood by the Brundtland Commission and the Rio de Janeiro conference could be taken as examples of such a strategy.

Distinct from such a 'broadened' concept, my discussion below is based on an interpretation of the term of sustainable development in line with the Brundtland Commission's report, the 1992 conference on Environment and Development in Rio de Janeiro, and the subsequent work of the UN Committee on Environment and Development. According to the Brundtland commission,

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

- the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given, and
- the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

(WCED, 1987: 43)

Understood this way, the concept combines ethical norms of welfare, distribution and democracy while recognizing that nature's ability to absorb human-made encroachments and pollution is limited. According to the Brundtland Commission a sustainable development is first and foremost about ensuring that everybody – both in poor and rich countries, and today as well as in future generations – can have their basic needs met. This must be obtained without jeopardizing the natural systems on which life on earth is dependent. Furthermore, the decision processes leading to such a result must be democratic and legitimate. Thus, the concept of sustainable development comprises a strong element of distributive ethics, focusing on the distribution of benefits and burdens over time (across generations) as well as spatially (within generations).

The content of sustainable development, as understood by the World Commission on Environment and Development, is far from 'business as usual'. The subject matter of the spatial planning – land use and development of buildings and infrastructure – causes a number of direct and indirect environmental impacts which, with current priorities, are clearly at odds with the requirements of sustainable development (see, for example, UN/ECE, 1998). The challenges raised by the imperative of sustainable development will be different for urban planning in poor developing countries than in the European Union and other wealthy regions of the

world. Whereas improvement of the residential and hygienic standard will be among the main tasks of a sustainable urban planning in the former countries, reducing the per capita expenditure of natural and environmental resources must be a central topic in the latter. On an overall and general scale, the requirement for a sustainable development of land use, building stock and technical infrastructure might perhaps be formulated as follows

In order for the development of land use, patterns of built-up land and infrastructure in an area to be characterized as sustainable, it must secure that the inhabitants of the area can have their vital needs met in a way that can be sustained in the future, and is not in conflict with sustainable development at a global level.

(OECD/CEMAT, 1994)

It is, of course, possible to operationalize such an overall goal in many different ways. However, in much of the literature on sustainable urban development and spatial planning in wealthy industrial countries (see, for example, OECD/CEMAT (1994); UN/ECE (1998); Næss *et al.* (1996)) the following five elements are emphasized:

- Reduction of the energy use and emissions per capita in the area (city, municipality, or region) down to a level compatible with the ecological and distributional criteria for sustainable development at a global level.
- A minimizing of the conversion of and encroachments on natural areas, ecosystems and soil resources for food production.
- A minimizing of the consumption of environmentally harmful construction materials.
- A replacement of open-ended flows, where natural resources are transformed into waste, with closed loops relying to a higher extent on local resources.
- A sound environment for the city's inhabitants, without pollution and noise damaging to the inhabitants' health, and with sufficient green areas to give opportunities for the population to experience and become emotionally related to nature.

A high *energy use* contributes to a range of serious environmental problems, both when the energy is extracted/produced, and when it is transported and used. A sustainable level of energy use and emissions in European countries must consider both a goal of reducing the global-level energy use and related emissions, and a goal of increasing the material standard of living in developing countries. For example, the United Nation Climate Panel has suggested that the global CO₂ emissions should be reduced by at least 60 per cent as soon as possible. Based on present technology, the amount of CO₂ emissions is proportional to the amount of fossil fuel

combustion. In practice, such a reduction would therefore imply that the annual consumption of fossil fuels be reduced by at least 60 per cent. Some of this reduction could be obtained by shifting to other energy sources than oil, coal and gas. However, it is hardly realistic to achieve all of the desirable reduction in emissions by concentrating on alternative sources of energy. In addition, renewable energy sources too are encumbered with environmental problems, both in relation to the sustainability goals of biodiversity and nature conservation, and in relation to other environmental concerns like outdoor recreation opportunities and the protection of landscape amenities.⁵⁷ Instead, the Brundtland Commission emphasizes the need for *both* a shift to renewable energy sources *and* a development in the direction of a 'low-energy future'. If at the same time an increase in the material standard of living is going to take place in developing countries, this will most likely imply substantial increases in the energy consumption of these countries. For such an increase to be possible within the frames of a total level of emissions that does not aggravate the greenhouse effect, industrial countries must reduce their emissions by considerably more than the 60 per cent suggested by the UN climate panel for the planet as a whole.⁵⁸

The need to protect *natural ecosystems* and *biological resources* is strongly underlined in the Brundtland Commission's report. In part, this is grounded on an assumption that these environmental resources constitute a 'life support system' necessary for the future health and survival of human beings. In addition, the Commission to some extent also points at moral obligations associated with the concept of nature's intrinsic value. Loss of habitats is a main cause of extinction of species, and habitat loss and fragmentation are increasingly the direct results of urban development (Beatley, 2000).

The goal of protecting *arable land* is based on the reasoning that meeting the needs for food for a future global population of 10 billion will limit the possibilities for Europe to import food from other parts of the world. According to the 1997 State of the World report (Brown *et al.*, 1997), the global population increases faster than food production. There is reason to believe that a sustainable and less polluting agricultural sector would depend on larger cultivated areas to maintain a given output of food products. Increased regional self-supply is also a strategy to limit the energy use and emissions associated with intercontinental transport of foodstuffs.

The *materials* used in buildings and infrastructure can to a greater or lesser degree imply negative environmental impacts. In a sustainability perspective, it is of particular importance to curb the consumption of building materials made from non-renewable or scarce, conditionally renewable natural resources; materials requiring a high energy use to be processed and/or transported to the construction site; and materials causing serious encroachments on ecosystems in the localities where they are extracted. By choosing plot ratios and dwelling types and by means of regulations

in local development plans on the use of materials, planners can influence the *amount* of materials needed, and to some extent also their *composition*.

'Open' *flows of substances* imply a continuous need for extraction of natural resources, and that steadily increasing amounts of waste have to be dealt with. Closing the cycles of substances has for a long time been recognized as a basic ecological principle (see Commoner, 1971). If the loops can be closed locally, the need to transport raw materials and waste will be reduced. Land use planning can influence the possibilities for local recycling schemes for, among others, water and foodstuffs.

The need for the urban environment to satisfy its inhabitants' basic material needs in terms of, among others, housing and hygiene, without causing health risks to its residents, is strongly underlined in the Brundtland Commission's Chapter 9 on the 'Urban challenge'. In addition to needs concerning physical survival and the satisfaction of a minimum level of material consumption, some authors have argued that some contact with nature must also be considered a basic human need. For instance, the philosopher Warwick Fox (1990) holds that we have a genetically inherited need for contact with nature, and that it is of importance to our psychical health to have this need met. Possibilities to experience nature have also been pointed out as a pedagogical means to create environmental awareness. The likelihood of rising generations to develop a more responsible attitude to nature than the one characterizing our generation will perhaps be higher if people from childhood onwards experience nature and get related to it not only intellectually, but also emotionally (see, among others, Næss, 1989). However, the Brundtland Commission does not focus on these aspects, which, according to some authors, make up a 'postmaterial' dimension of the concept of sustainability (Owens, 1994).

There may be some contradictions between the above five criteria. They reflect two different focal points in urban environmental policy: 'ecology within the city' and the 'city in ecology'. Traditional policies on urban environmental issues could largely be placed under the former of the two categories, with their focus on the importance of parks, green fields and non-polluted air and drinking water for the inhabitants' health and quality of life. Such local environmental concerns are of course still important. However, the recommendations of the Brundtland commission imply that the focus must also be expanded to encompass the city as a part of the larger natural ecosystem. What must be taken into consideration is not only the city's relationship to its nearest hinterland, but also its 'ecological footprints' in an international and global context.

Below, the consequences of a transport-reducing and less car-dependent urban development for each of the five criteria will be addressed.

12.2 ENERGY USE AND CO₂ EMISSIONS

Our analysis of relationships between residential location and energy use for transport is based on information given in the main questionnaire survey among residents of Copenhagen Metropolitan Area about their travel with different modes during the investigated week as a whole. The energy analyses do not include energy use in connection with, for example, flights to foreign destinations. As mentioned in Chapter 10, the increased frequency of flights among the respondents from some of the central investigated residential areas is hardly caused by the location of the residence within the urban structure.⁵⁹ The travel resulting from increased propensity of summer cottage ownership among respondents living in densely populated local areas is largely covered by the respondents' registration of travel at the weekend. Besides, as mentioned earlier, the investigation week of some of the respondents included the Whitsun weekend, which typically involves a higher number of trips to summer cottages, etc. than ordinary weekends. We therefore consider the data on the total travel during the investigated week as a reasonably good base for analyses of relationships between residential location and energy use for transport.

As we have already found that a central residential location contributes both to a lower amount of travel and a higher share of non-motorized transport, it is hardly any surprise that the respondents' energy use for transport and the resultant CO₂ emissions are closely related to the location of the residence relative to the hierarchy of centres in Copenhagen Metropolitan Area. In the analyses below of the influence of residential location on energy use and CO₂ emissions, energy use has been calculated from data on average energy use and emissions per person kilometre by car, bus and train. Using such averages of course implies that several nuances are lost. Ideally, factors such as engine size and weight of the car, driving style, the number of passengers in cars, buses and trains and the traffic situation along the route followed during each specific trip (e.g. degree of congestion, crossings, traffic lights, etc.) should all be taken into account. However, we do not think that we are committing any significant error by disregarding such factors.

If omission of these aspects of transport were causing any systematic under- or overestimation of the energy use and emissions of respondents in certain residential locations, ignoring the separate trips' deviations from the average values of the respective travel modes would of course be a serious source of error. However, the different circumstances that might contribute to a higher or lower energy use per kilometre with a given mode of travel, depending on the location of the residence, often tend to balance each other. For instance, a larger proportion of the car travel carried out by inner-city respondents may possibly take place under driving conditions characterized by congestion and many traffic lights. On the other hand, there is a higher propensity among our inner-city, car-owning residents to own small cars⁶⁰ – perhaps

because such cars are easier to manoeuvre and park in the narrow and crammed streets of the inner districts? As congestion is usually heavier in the direction towards inner-city Copenhagen in the morning and outwards in the afternoon, car-commuting respondents living on the periphery may experience congestion as much as car commuters living in the inner-city. For public means of transport, occupancy rates will usually be highest in the inner-city sections of the lines, due to the large passenger base provided by the high density of workplaces and residents. Accordingly, energy use per kilometre a passenger travels will be reduced. On the other hand, a high population and workplace density facilitates a more fine-meshed network of lines and more frequent departures, which will contribute to some extent to balance the tendency for higher occupancy rates in the inner districts of the city. For buses, there is also a considerably higher energy use and CO₂ emission per vehicle kilometre when driving in inner-city areas.

Looked at together, there hardly appears to be any strong and systematic tendency for variation in energy use and CO₂ emissions per passenger kilometre travelled by motorized means of transport that is dependent on the location of the residence within the metropolitan area. For each main category of motorized travel (car, bus and rail) we have therefore chosen to use the same per kilometre energy use and emission figures for all respondents.⁶¹ Based on information from the Ministry of Transport and Cowi (2000) and the Highways Directorate (2001, 2002) we have used energy use and emission coefficients per person kilometre by car, rail and bus in Copenhagen Metropolitan Area as set out in Table 12.1.

Based on the premises shown in Table 12.1 about the energy use and CO₂ emissions per person kilometre with different modes of travel, our respondents have on average used 143 kWh and emitted 30 kg CO₂ in connection with their travel during the week of investigation. The average energy use is 91 kWh among the respondents living closer to inner-city Copenhagen than 6 km, compared to 180 kWh among respondents living more than 28 km from the city centre. The corresponding CO₂ emission figures are 19 kg and 37 kg, respectively. In these calculations, as well as the analyses below, respondents with extreme travel distances during the week of investigation have been excluded (applies to 30 respondents with travelling distances exceeding 1,285 km).

Table 12.1 Calculation factors used in the analyses of the relationships between residential location and, respectively, energy use for transport and CO₂ emissions from transport

<i>Means of conveyance</i>	<i>Energy use per person kilometre (kWh)</i>	<i>CO₂ emissions per person kilometre (g)</i>
Car	0.64	133
Train	0.19	36
Bus	0.32	67

However, the above energy and emission figures have not been adjusted for the influence from other potential factors of influence correlating with residential location. A multivariate analysis including the same 23 independent variables as in sections 6.3 and 6.4 shows effects on energy use and CO₂ emissions⁶² from two urban structural variables, namely

- the location of the residence relative to inner-city Copenhagen (Beta = 0.101, p = 0.000), and
- the logarithmic distance from the residence to the closest urban railway station (Beta = 0.052, p = 0.034).

Controlling for the remaining independent variables, energy use for transport during the week increases the further away the residence is located from inner-city Copenhagen as well as from the closest urban railway station. Keeping the non-urban structural variables constant at mean values, the weekly energy use for transport is on average 122 kWh among respondents living in the most central of our four distance belts (less than 4 km from central Copenhagen), compared to 169 kWh among respondents living in the outer distance belt (more than 28 km from the city centre). The corresponding CO₂ emission figures are 25 kg and 35 kg, respectively. If we instead compare the *residential areas* with the highest and lowest energy use and emissions figures (controlled for non-urban-structural variables), the differences are larger, with an estimated energy use of 173 kWh and CO₂ emission of 36 kg in Osted (42 km away from central Copenhagen), compared to 112 kWh and 23 kg, respectively, at Vesterbro (1.7 km from the city centre).

The controlled differences in energy use and CO₂ emissions between the inner and the outer distance belt are a little bit above 38 per cent. The difference between the most favourable (from a wish to reduce CO₂ emissions) and least favourable among our residential areas is, as already mentioned, larger (55 per cent). The latter difference is also larger than the difference between the residential areas with the highest and lowest controlled travel distances over the week. This illustrates the fact that the respondents living in the peripheral areas have a higher propensity to use energy-demanding means of transport than their inner-area counterparts.

It should be noticed that all these differences must be considered *low* estimates of the influences of residential location on the energy use and CO₂ emissions from travel. Several of the characteristics of the respondents which, according to our analysis, exert the strongest influences on energy use and CO₂ emissions belong to the 'grey zone' variables that are themselves, to a higher or lesser extent, influenced by the location of the residence. As shown in Chapter 8, car ownership and transport attitudes, especially, but also environmental attitudes, driving licence holding and (to some degree) the frequency of overnight periods away from home are influenced by residential location. Apart from the latter control variable, the control for all

the variables mentioned contribute to weaken the calculated relationships between residential location and energy use as well as CO₂ emissions.

An alternative set of analyses has therefore been carried out where the above-mentioned six variables have been excluded as control variables. As one might expect, these analyses show stronger estimated effects of residential location. In this case, three urban structural variables show significant effects on energy use and CO₂ emissions:

- the location of the residence relative to inner-city Copenhagen ($p = 0.000$),
- the logarithmic distance from the residence to the closest urban railway station ($p = 0.013$), and
- the density of inhabitants and workplaces within the local area of the residence ($p = 0.017$).

In this case, the average, expected energy use in the inner of the four distance belts is 96 kWh, compared to 181 kWh in the outer distance belt, that is a difference of 89 per cent. The expected energy use per resident of the residential area with the lowest (Vesterbro) and highest (in this case Gilleleje) figures are now 188 kWh and 80 kWh, respectively, that is a difference of 135 per cent. The corresponding expected CO₂ emissions in the outer and inner distance belt are 38 kg and 20 kg, respectively, with an expected per capita CO₂ emission among Gilleleje residents of 39 kg, compared to 17 kg at Vesterbro.

Figure 12.1 shows the expected, average energy use for transport during the seven days of the week among respondents from each of the four distance belts, with and without controlling for the six above-mentioned 'grey zone control variables'. In both cases, the figures are controlled for the remaining control variables. Thus, in the diagram to the left, where the 'grey zone control variables' are included in the analysis, 19 socio-economic, attitudinal and other non-urban-structural variables have been controlled for. In the diagram to the right, control has been made for 13 non-urban-structural variables.

The difference in expected energy use between the most energy-demanding (Osted or Gilleleje) and the least energy demanding location (Vesterbro) is 61 kWh when the 'grey zone variables' are included in the statistical control and 108 kWh when only the remaining control variables are included in the analysis. Given that the week of investigation does not deviate significantly from an average week during the year,⁶³ this corresponds to annual differentials of 3,200 kWh and 5,600 kWh, respectively.

These figures could be considered as a lower and an upper estimate of the differential in energy use attributable to the difference between the most peripheral and the most central areas in their urban structural situation. Measured in CO₂ emissions, the corresponding differences are 680–1,180 kg.

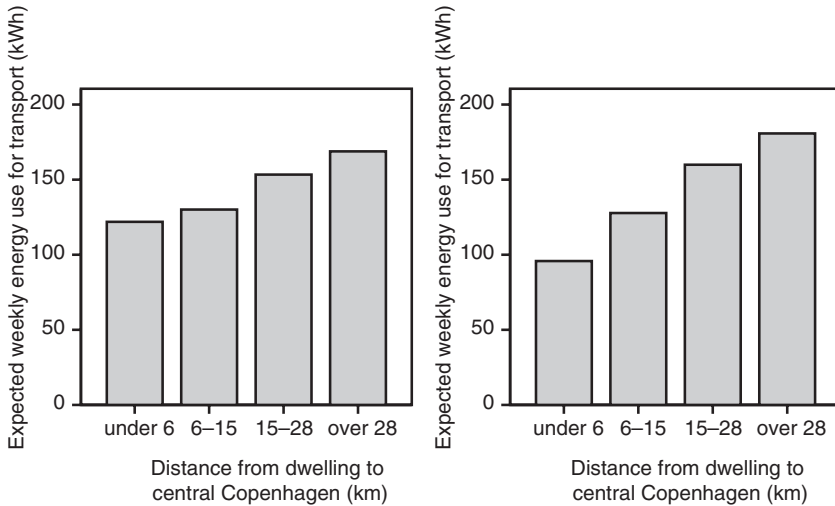


Figure 12.1 Average expected weekly energy use for transport among respondents living in different distance intervals from central Copenhagen. Multivariate control with (to the left, $p = 0.000$) and without (to the right, $p = 0.000$) 'grey zone control variables' included $N = 1,422$ and $1,624$, respectively. Apart from the six 'grey zone control variables' (car ownership, transport attitudes, environmental attitudes, driving's licence, frequency of appearance at the workplace, and frequency of overnight stays above 4 nights away from home) both analyses include control for 13 other, non-urban structural variables

12.3 TRANSPORT-REDUCING RESIDENTIAL LOCATION – IMPORTANT OR UNIMPORTANT FOR ENERGY USE AND CO₂ EMISSIONS?

Are the above-mentioned differences large or small, compared to Denmark's total energy use and CO₂ emissions? Figure 12.2 shows how energy use in Denmark in 2002 was distributed between different sectors. Out of a total of 645 petajoules (PJ), inland transportation accounted for 194 PJ, that is 30 per cent. Converted into kilowatts these figures imply a total energy use of 179 billion kWh, of which 54 billion for transportation. Energy use for transport has been steadily increasing for many years, yet with a reduction in 2001 and 2002 compared to 2000, when the highest figure was recorded. Out of the 54 billion kWh used for inland transportation, travel accounted for 37 billion and freight for 17 billion (The Danish Environmental Directorate, 2002).

With a population of close to 5.4 million, Denmark's energy use for inland transport is almost exactly 10,000 kWh per inhabitant. The location-conditioned differential between the most peripheral and the most central among our investigated residential areas thus makes up 32–56 per cent of the average Dane's total energy

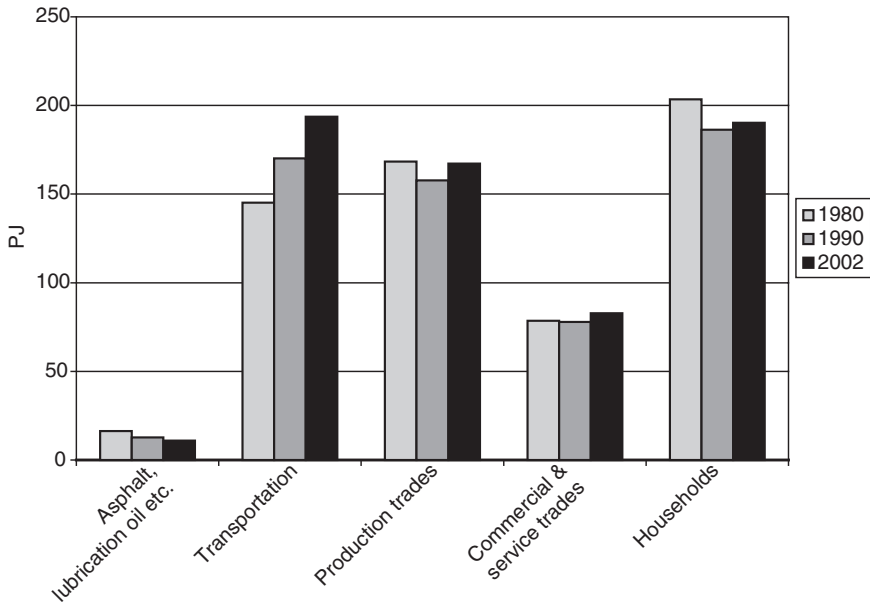


Figure 12.2 Domestic delivered energy use in Denmark, distributed between different purposes. The figures have been adjusted for climatic variations between the years, i.e. differences in the energy requirement for space heating and cooling resulting from variations from one year to another in the climatic conditions. (Source: Energistyrelsen, 2003)

use for transport (including freight). Limiting the comparison to the average energy use for *travel* (passenger transport), the differentials between the residential areas make up higher percentages. Thus, our material indicates that the difference in energy use attributable to the difference between the most central and the most peripheral investigation areas in their urban structural situation makes up 46–81 per cent of the energy used for inland travel by the average Dane. Compared to Denmark's total energy use (179 billion kWh) the per capita differential between the most peripheral and the most central locations of Copenhagen Metropolitan Area corresponds to 9.5–17 per cent.

According to the Danish Environmental Directorate (2003), Denmark's total inland CO₂ emissions amounted to 54.3 million tonnes. Per capita this equals to 10.100 kg. Based on this account, the location-dependent differential in CO₂ emissions between the most central and the most peripheral among our investigation areas corresponds to 7–12 per cent of the total CO₂ emissions per capita.⁶⁴

However, it is not realistic to locate all future residential development in Copenhagen Metropolitan Area either at Vesterbro or in Osted and Gilleleje. A more realistic illustration could be obtained from a comparison of a scenario where

all residential development during the next region plan period is located either to the inner of our four distance belts ('the bike hub') or to the two outer ('the car tyres'). According to a discussion paper for Region Plan 2005, prepared by The Copenhagen Region Development Council (2003), there will be a need to construct 80,000 new dwellings in Copenhagen Metropolitan Area during the period 2005–2017. Assuming an average occupancy rate of 2.15 persons per new dwelling, the new dwellings will be inhabited by 172,000 residents.

Below, two alternative estimates have been made of the consequences of the 'bike hub' and the 'car tyres' alternatives, respectively, for energy use and CO₂ emissions. The two alternative estimates are based on the estimated effects of residential location on travel with and without the 'grey zone variables' included among the control variables. The calculated differences between the location alternatives, measured in energy use and CO₂ emissions are, as above, compared to national figures.

According to our material, the difference between the 'car tyres' and the 'bike hub' alternatives in annual *energy use* for transport could be expected to be between 2,000 and 3,800 kWh per capita, depending on whether or not 'grey zone variables' are included among the control variables. This differential corresponds 29–55 per cent of the average Dane's energy use for inland *travel*, but only 6–11.5 per cent of the *total* per capita inland energy use in Denmark. Thus, if every Dane lived in urban structural situations similar to those characteristic of our two outer distance belts ('the car tyres'), their energy use for transport would cause the Danish inland energy use to be 6–11.5 per cent higher than if all Danes lived in urban structural situations similar to those characterizing our inner distance belt ('the bike hub'). In addition, their energy use for space heating and cooling would be higher, cf. below.

Altogether for the 80,000 planned new residences, the estimated difference between the two location alternatives is 340–660 million kWh annually. This difference corresponds to 2.8–5.3 per cent of the total energy use for transport among the 1.8 million inhabitants of Copenhagen Metropolitan Area. Thus, by pursuing a consistent densification policy (locating all new residences closer to the city centre of Copenhagen than 6 km), the energy use for travel among inhabitants of Copenhagen Metropolitan Area can only be reduced by some three to five per cent, compared to a very decentralized residential development (all the planned residential development of the Region Plan more than 15 km away from inner-city Copenhagen).

Measured in CO₂ *emissions*, locating the Region Plan's 80,000 new dwellings to the two outer distance belts could, according to our material, be expected to cause 410–790 kg higher CO₂ emissions per new resident than if the development is instead located to the inner distance belt. These differentials correspond to 26–51 per cent of the average Dane's CO₂ emissions from inland

travel. In total, there is a differential in the new residents' CO₂ emissions of 70,000–135,000 tonnes. Assuming that the inhabitants of Copenhagen Metropolitan Area on average do not deviate significantly from the rest of the Danish population in their CO₂ emissions, the calculated differences between the locational alternatives make up about 2.5–5 per cent of the total CO₂ emissions from the inland travel carried out by inhabitants of Copenhagen Metropolitan Area.

These examples show that urban planning reducing the need for transport and the dependency on cars cannot stand alone as an instrument for achieving an environmentally sustainable development within the transportation sector. In order to break the curve of traffic growth and obtain reductions in the environmental load from transport, several initiatives and instruments must be combined. It is not reasonable to expect that any single sector of society can provide the desired cutback in energy use. In order to make substantial reductions in the energy use and emissions from transport possible, more energy-efficient vehicles (Høyer and Heiberg, 1993), higher fuel taxes (Goodwin, 1992 and 1996; Bøgelund, 2003), road charging (Abraham and Maroney, 1994; Eggers *et al.*, 2003) and a transport-reducing spatial planning will probably be necessary. The latter includes both land use principles reducing the needs for transport while facilitating environmentally friendly modes of travel, and changes in the transport infrastructure, with strengthened public transport and improved networks of bike paths instead of road and parking capacity increases (Næss *et al.*, 2001; Mogridge, 1997).

In any event, the above examples illustrate that it is a long-term task to change the existing developmental pattern sufficiently to induce substantial effects on Denmark's energy use and emissions from transport. By the time horizon of the Region Plan in 2017, a vast majority of the present building stock will still be in use. However, precisely because it takes a long time to change the built environment it is important to avoid creating a future developmental pattern dependent – maybe to an even higher degree than today – on a continued supply of ample and cheap energy. Such a structure would be highly vulnerable to any future limitations on energy use, for example due to international quota or fees on CO₂ emissions. It would also lack robustness in the case of failing supplies, as could result from international conflicts and wars.

Moreover, residences are not the only type of development influencing the amount and modes of transport. A study of workplaces in Greater Oslo (Næss and Sandberg, 1996) showed that the difference between workplaces in the centre and on the urban fringe in energy use per employee for commuting trips was equally as high as the difference in energy use for travel between the most favourably and most unfavourably located among 30 investigated residential areas in Greater Oslo (Næss, Røe and Larsen, 1995; see also Hanssen, 1993). The difference is mainly

caused by the considerably lower proportion of car commuters among employees of inner-city workplaces. Similar results have been found in Copenhagen Metropolitan Area (Hartoft-Nielsen, 1997; Næss, 2006). The location of retail stores also plays an important role (Fosli and Lian, 1999).

Urban planning aiming to reduce the use of car and energy use for transport (as well as space heating, see below) will need to focus both on residences, workplaces and service facilities. In the most central parts of the cities it will probably be more favourable to locate new office workplaces and specialized service facilities rather than dwellings. Construction of high-density office buildings does not imply the same requirements for outdoor areas (playgrounds, etc.) as residential development. New dwellings could instead be accommodated on vacant lots adjacent to and around the Central Business District, for example on derelict and obsolete commercial or harbour areas. Converting central and inner-city parking lots might provide an additional supply of centrally located building sites without making encroachments on the green areas of the city. Seen in an environmental perspective, such a conversion is of particular interest, as it also reduces the accessibility to the inner-city by car. The latter may contribute to increasing the proportion of trips to the city centre by public transport, bike or on foot (Næss *et al.*, 2001), thus contributing to an additional decrease in car traffic.

As mentioned at the beginning of the chapter, the UN panel on climate change has recommended that CO₂ emissions for the planet as a whole be reduced by 50–70 per cent as fast as possible, with a subsequent further gradual reduction (IPCC, 1996, quoted from UNEP, 2000). According to the most recent UN population forecasts, the global population will reach 9 billion before 2050 (United Nations Population Division, 2001). Following the recommendations of the UN panel on climate change, this would imply a global per capita CO₂ emission of 7.5–12 per cent of the present CO₂ emission per inhabitant in Denmark.

The concept of 'ecological space' has been used to focus on the requirements of a sustainable development regarding the utilization, consumption and distribution of natural resources. Securing the access to natural resources for future generations, combined with an equality principle for the access to natural resources, would imply substantial changes compared to the present resource consumption (Danish Ministry of the Environment, 1999). Not the least, this is the case for energy use and greenhouse gas emissions. As can be seen above, concerns of ecological space might imply that the Danish CO₂ emissions should be reduced to about one tenth of the present level before the middle of this century. Such a perspective may appear to be far away from current political realities both in Denmark and internationally. However, the current modest political interest in the environmental problems associated with transport and its energy use does not make these problems disappear.

On the contrary, the most recent research into the global climate and updated estimates of future oil reserves indicate that these problems will become increasingly manifest in the next decades.

TRANSPORT INFRASTRUCTURE PLANNING MUST SUPPORT DENSIFICATION POLICIES

In some European countries, such as Sweden and Norway, urban sprawl slowed down in the 1980s and came to a halt in the early 1990s. Instead, a considerable densification has taken place. During the most recent years, population densities have increased in the largest cities in Sweden as well as in Norway (Statistics Sweden, 2002; Statistics Norway, 2004). In other EU countries, including Denmark, Spain and the UK, the spatial expansion of cities is continuing, in spite of an increased pace of inner-city regeneration and densification (UN/ECE, 1998; Damsgaard and Olesen 2000). In parallel with the stronger emphasis on densification, most European countries have continued to increase road and parking capacity. In all the Scandinavian countries, an intensified urban road development took place in the late 1980s and the 1990s (Strand, 2001; Tengström, 1999; Isaksson, 2001). In British transport policy, the last 10 years have seen a fundamental change in policy direction away from a reliance on building new road infrastructure (Owens, 1995; Vigar, 2001), although the actual impact of this 'new transport realism' remains to be seen (Richardson, 2001).

With the possible exception of Britain, the transport policy currently followed in many European cities seems to be a combination of investment in public transport in order to increase, or at least maintain, its market share, and road building in order to keep up with expected traffic growth. There is a risk that what is gained in reduced energy use and emissions through land use planning reducing the need for car travel in daily life will be outweighed by road development and parking area expansion making it easier to travel around in the city by car (see among others Mogridge, 1997; Engebretsen, 1996; Næss *et al.*, 2001). Apparently, there is a prevalent belief among policy-makers that increased road capacity in urban areas does not in itself cause any growth in car traffic worth mentioning.

Apart from rush hour periods, public transport in cities has difficulty in competing with the travel time of cars. In peak periods, cars lose time due to congestion (as distinct from public transport running on a separate lane) whereas the public transport's more frequent departures make the average waiting periods shorter. Thus, it is primarily for journeys to and from work that public transport is able to compete with cars. For such journeys, measures reducing travel time by car can make some public transport passengers change their means of transport. Conversely, an improvement in the competitiveness of the public transport regarding travel time can make some car travellers leave their cars at home. Theoretical considerations by, among others, Downs (1962), Thomson (1977) and Mogridge (1990) indicate that

increased road capacity in urban areas may turn out to be an inefficient or even counter-productive measure to reduce door-to-door travel times.

Several professionals have claimed, however, that a field of competition between car and public transport hardly exists (cf., among others, Bly *et al.* (1987), Klæboe (1994) and Solheim *et al.* (1994). According to these authors, increased road capacity in urban areas will lead to better-flowing traffic, but it would not influence, to a degree worth mentioning, the distribution between car travellers and public transport passengers. Such an assumption is also in-built in the transport analysis models most commonly used by traffic engineers (Cowi, 2004; Nielsen and Fosgerau, 2005). This belief neglects the simple economic theory of supply and demand, as well as more specific theories about the dynamics of traffic under congested conditions.

Recent investigations in the Oslo region, clearly show that a field of competition between car and public transport exists for journeys to work in the rush hours (Engebretsen, 1996; Næss *et al.*, 2001). The number of travellers sensitive to changes in travel time of the respective modes seems to be considerable. A number of factors influence the travellers' choice of conveyance, but the ratio of door-to-door travel times by car and public transport as well as the parking conditions at the workplace turn out to be important. Among male car-owning commuters holding a driving licence, living in the western suburbs of Oslo, working in the inner-city area and having easy parking facilities at the workplace, the probability of commuting by car was 40 per cent when car and public transport were equally fast. When the car was 20 per cent faster than public transport, the probability of going by car was 59 per cent. Increased road capacity leading in a short term to better-flowing traffic is therefore likely to change the modal split in favour of the least energy-efficient mode. In a longer term, congestion is likely to occur again (Mogridge, 1997). Similar results have been found in a recent study of travel times and modal choices in Copenhagen Metropolitan Area (Næss and Møller, 2004).

The findings of the above-mentioned studies, which are all very well in line with theoretical considerations, imply that the distribution of commuters between car, public transport and non-motorized modes is highly influenced by important elements of urban and traffic planning: road construction, investments in faster and more frequent public transport, allocation of existing road capacity to different modes of transport (e.g. bus or bike lanes vs lanes for ordinary car traffic), provision of parking capacity, and provision of bicycle paths. In urban areas with congestion on the road network, freer flowing traffic in the road network will induce a higher proportion of commuters to travel by car, whereas measures improving the door-to-door travel times of public transport or bike will have the opposite effect. These findings go to the heart of the present discussion about what to do to improve the traffic situation in European cities (OECD/ECMT, 1994).

Changes in travelling distances, notably for commuting, could also be expected, as the distances that can be travelled within a given time limit are increased. In the longer term, road capacity increases could also be expected to induce land-use changes by making it more attractive to build in areas made more accessible due to the higher speeds on the road network, for example areas previously located outside an acceptable commuting distance from an employment centre.

Conversely, faster public transport will reduce the proportion of car commuters, but the effects of such improvements will be offset if road capacity is simultaneously increased. In addition to the relative speeds of car and transit, the parking conditions at the workplace are of great importance to the choice of transport mode.

The traffic increase likely to occur as a result of road and parking capacity increases also represents a threat to local environmental qualities in the neighbourhoods of inner-city residents. A coordinated land use and transport planning requires not only the implementation of land use principles reducing car dependency and the need for transport, but also the use of the necessary transport policy measures to secure a good local environment for those who choose a residential location and type resulting in a low load on the global environment.

ENERGY USE IN BUILDINGS

Reduced needs for travel and a lower car dependency are not the only environmental benefits resulting from a more concentrated urban development. The housing types typically characterizing inner-city districts (apartment buildings and to some extent terrace houses and townhouses) require, other things being equal, considerably less energy for space heating than the detached single-family homes, which are the dominating housing type in the outer parts of the metropolitan area. In general, multi-family houses require less energy than single-family dwellings, because some of the surfaces delimiting the dwellings in multi-family houses are common partition walls and horizontal divisions with only a small loss of heat or none at all. As can be seen in Figure 12.3, the average energy requirement for space heating is almost twice as high per square metre in a detached one-storey single-family house as in an apartment, with two-storey terrace houses about mid-way between in their space heating requirement (Duun *et al.*, 1988, Asplan Viak, 1995). Besides, the floor area of a single-family home is usually larger than in apartments and terrace house dwellings. This implies a further increase in the differential in space heating requirement between dense and less densely developed residential areas.

These differences in the space heating requirements of different housing types suggest that location of residential development to the 'bike hub' instead of to the 'car tyres' will probably imply an equally high saving of energy for space heating

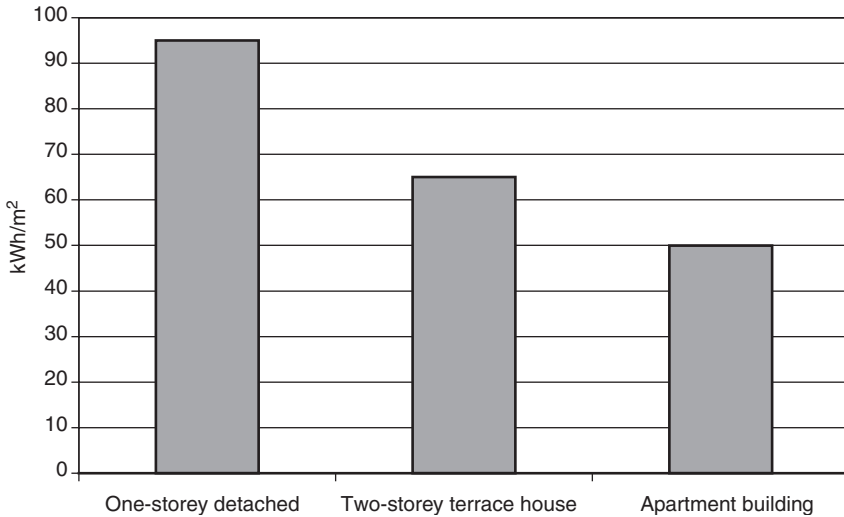


Figure 12.3 Variation in energy requirement for space heating (kWh) between different housing types, given a size of the dwelling of 120 m² floor area
The figure applies to climatic conditions as in Oslo. (Source: Duun *et al.*, 1988.)

as the energy saved through a reduced amount of public transport and lower car usage.⁶⁵

Table 12.2 shows the estimated total energy use for transport and space heating per resident when building 100 apartments within 'the bike hub' (less than 6 km from inner-city Copenhagen), compared to the construction of 100 single-family detached homes within the 'car tyres' (more than 15 km from inner-city Copenhagen). As can be seen in the table, the energy saved from choosing apartment buildings instead of single-family homes is slightly higher than that which is saved in transport energy from locating residential development in the inner distance belt instead of in the two outer ones. According to our material, a total of 6,700 kWh per resident can annually be saved for transport energy and space heating by constructing apartment buildings close to inner-city Copenhagen instead of building single-family homes in the outer parts of the region. This corresponds to 20 per cent of the total energy used annually by the average Dane. In these figures, the indirect effects of residential location on travel have been included (see Chapter 8). If these effects are omitted, the difference between the alternatives is 4,400 kWh, corresponding to 14 per cent of the annual energy use of the average Dane.

As can be seen above, land use and development strategies favourable to the reduction of energy use for transport are also well in accordance with some of the

Table 12.2 Expected total energy use per capita for surface transport and space heating resulting from the construction of a number of single-family houses evenly distributed within the 'car tyres' (more than 15 km away from central Copenhagen), compared to the construction of the same number of apartments evenly distributed within the 'bike hub' (less than 6 km away from central Copenhagen)

<i>Alternative</i>	<i>Annual energy use per person for surface transport (kWh)</i>	<i>Annual energy use per person for residential space heating (kWh)</i>	<i>Total annual energy use per person for surface transport and residential space heating (kWh)</i>	<i>Proportion of total annual energy use per person in Denmark^a (percent)</i>
Single-family houses in the 'car tyres' (more than 15 km from central Copenhagen)	9,410 (8,790)	4,750	14,160 (13,540)	42.5% (40.7%)
Apartments in the 'bike hub' (less than 6 km from central Copenhagen)	4,990 (6,340)	2,500	7,490 (8,840)	22.5% (26.6%)
Difference	4,420 (2,450)	2,250	6,670 (4,690)	20.0% (14.1%)

In both alternatives, the average floor area of the residences is assumed to be 120 square metres, and the average number of inhabitants to be 2.4 persons. The calculations of energy use for transport include the indirect effects of urban structural variables. Figures without indirect effects included are shown in parentheses.

a Measured as energy delivered to the supply system.

most important land use and developmental principles for energy saving in buildings. Although some conflicts also exist (in particular between the wish for a dense urban structure and the wish for optimal solar influx on each individual building), there is generally a higher degree of synergy than conflict between urban planning strategies aiming to save energy for transport and in buildings, respectively. Dense and concentrated urban structures are favourable both in order to minimize energy use for transport and to facilitate district heating. The most space-saving dwelling types (apartments and terrace houses) make it easier to obtain a high urban density and are therefore favourable seen from the perspective of transport energy conservation. At the same time, the energy requirement for space heating is clearly lower for these housing types than for single-family houses.

12.4 PROTECTION OF NATURAL AREAS AND SOIL FOR FOOD PRODUCTION

Apart from being favourable for energy conservation, a high developmental density and a prioritization of space-saving housing types are also favourable for the

protection of natural areas and soil for food production (Beatley, 2000; Zovanyi, 1998). A high population density for the city as a whole (i.e. a small amount of urban area per capita) implies that urban development has occupied a modest amount of previously unbuilt areas. This is favourable for the goal of minimizing the conversion and fragmentation of natural areas, ecosystems and productive soil. Moreover, with a given density within the neighbourhood or residential area, space-saving housing types increase the possibility of protecting intra-urban local natural qualities and utilizing favourable microclimatic conditions.

However, in some cases, the areas inside the urban demarcation may include areas rich in biodiversity of importance to the urban region as a whole, and in some cases even of national importance. Oslo, with its geological conditions and favourable climate, is a Scandinavian example of this. Cities have often developed precisely at those locations where the possibilities for agriculture and conditions for life in general were the best. Densification in areas of particularly high biological value is of course undesirable from a biodiversity perspective. Yet, for several reasons, the loss of biodiversity is often more serious when construction takes place in natural areas outside the city than inside. Because the site utilization is usually higher in central than in peripheral parts of an urban region, more undeveloped land is usually converted into built-up areas when development takes place as spatial expansion of the city than by densification (Fouchier, 1995). The diversity of species is also usually higher in large, continuous natural areas (Mörtberg, 1989). Therefore, conversion of one square kilometre of natural area outside the city into building sites is likely to imply a larger loss of biological life than construction on ten separate green areas within the city, totalling one square kilometre.

Even though considerations for biodiversity at a national and regional level most often speak in favour of densification rather than urban expansion into continuous natural areas, the green areas inside the city are important to the inhabitants' well-being and quality of life. This will be discussed below. Moreover, densification need not necessarily take place on the green areas within the urban area demarcation (see section 12.9).

12.5 CONSUMPTION OF CONSTRUCTION MATERIALS

The construction materials used in new buildings may to a higher or lesser extent lead to negative environmental consequences (see section 12.1). For the most common building materials in Scandinavia, the energy requirement in connection with their production (and, for imported construction materials, also transportation) probably represents the heaviest environmental load. Other construction materials (e.g. Scandinavian timber) may require little energy use both in production and transport,

but may still cause negative consequences regarding biodiversity and ecosystem encroachments in Scandinavian forests.

Single-family detached houses usually have a larger floor area than apartments and row houses. They also have a larger surface area of external walls and roofs per square metre floor area than more concentrated housing types. Moreover, the need for technical infrastructure (including roads, sewers, water pipes and electricity cables) are usually higher in single-family house areas. Altogether, these circumstances imply that the consumption of construction materials is usually higher for single-family residential development than for the development of apartment buildings or terrace houses.

On the other hand, the construction materials used are often more energy-demanding for large buildings than for smaller buildings. For example, a high consumption of steel and aluminum is more common in apartments and other high buildings than in buildings with few storeys. Much energy is required in order to produce these materials. Brick too is a relatively energy-demanding material compared for example to timber (Granum, 1989). In countries where wood is the dominant construction material for houses up to two or three storeys (e.g. Norway, Sweden and Finland), with brick predominantly used for larger buildings, more energy is often required for the production of the construction materials used in apartments than in single-family houses. To an even greater extent than brick, the production of glass requires a high amount of energy. The consumption of the latter material per square metre of floor area is probably at least as high in single-family houses as in more concentrated types of housing.

It should be noted that the energy required to produce the materials used in buildings is relatively low, compared to the energy used for heating, cooling and other uses in the building during its lifetime. According to Lahti (1995), the energy required to produce all the buildings of a city makes up only about 7 per cent of the amount of energy used for heating, cooling and other purposes in the buildings during an assumed lifetime of 50 years. According to Lahti, buildings account for five sixths of the total energy used to construct the physical structures of a city, whereas roads, railways, sewers and other kinds of technical infrastructure make up the remaining part.

12.6 CHALLENGES OF 'CLOSED LOOPS SOCIETY'

In Denmark, the Netherlands and partly in Sweden, the discourse on sustainable urban development has been influenced considerably by professionals and environmentalists advocating that ecological cycles of water and sewage should be closed within the separate neighbourhood or even at the individual site. Often,

they also hold that urban land use should facilitate higher local self-supporting in agricultural products within the city. These camps of professionals have advocated the 'green city' with ample open space as the sustainable urban model (Rådberg, 1995; Kennedy, 1995). In particular, the spatial consequences of establishing more ecologically favourable urban water infrastructure systems have been emphasized.

Indeed, it is important to integrate the choice of water infrastructure systems in the decision-making processes determining the strategic development of the urban structure. However, sustainable urban water and sewage systems are not incompatible with a transport-reducing, concentrated urban development. On the contrary, several of the sustainability criteria for sustainable urban water management tend to be better fulfilled in dense than in sprawling urban structures (Engström, 2005). Urban containment reduces the pressure for urban development over valuable groundwater resources. It also reduces the need for construction of numerous small and scattered water supply and sewage cleaning systems, which will be extremely costly if they are to comply with current EU environmental standards. Concentrated urban development also implies both a smaller size of the urban road network and reduced car traffic, and thus reduces both the polluted run-off from roads and the more diffuse and indirect contribution of urban traffic to rainwater pollution. Both the latter sources are among the most serious urban contributors to water pollution (Kärrman, 2005). Moreover, it should be noted that household water consumption per capita is usually considerably higher in single-family residential areas than in higher-density areas, notably because of garden irrigation (Newman and Kenworthy, 1989; Marling and Knudstrup, 1998). The use of fertilizers and pesticides in private gardens may also be quite high, often with far more intensive doses than in commercial agriculture or horticulture (Ramhøj, 1999).

A recent Swedish, 13 million Euro research programme on sustainable urban water management has shown that flows of substances can be managed in 'closed loops' both in dense and more spread-out urban structures. Alternative recycling schemes were tested in six different urban situations, varying from scattered rural dwellings to the dense inner-city of Gothenburg. In all areas, solutions satisfying the ecological, hygienic and economic criteria could be found. The preferable types of solutions varied between the areas, with the most decentralized and small-scale systems recommended in the rural situation (Malmquist, 2004; Engström, 2005).

In cities, the traditional solutions for water and sewage management have been centralized systems. In order to ensure closed loops, this model requires a well-functioning network of water pipes and sewers and one or several central treatment plants. However, centralized water and sewage systems have come under attack from environmentalists. Often, a considerable part of the pollutions from

sewage and storm water have not been intercepted by the treatment plants. Moreover, centralized sewer systems traditionally combine many different types of sewage in the same systems, both from households and small enterprises such as workshops and petrol stations. This implies that the systems are exposed to many types of pollution, including heavy metals and toxic chemicals. Removing all these different components is technically complicated and even sophisticated treatment plants are not able to fully cleanse the sludge. Because of the potential risk of these contaminants, the Swedish agricultural sector no longer accepts the use of sludge as a fertilizer on the fields.

The criticism against centralized water and sewage systems has paved the way for an increased interest in local solutions for water and sewage management. Through a number of urban ecological experiments and extensive research efforts, a considerable amount of information now exists about the merits of local water and sewage management systems – including those in dense built-up areas (Ebler and Ebler, 1995; Hahn, 1990). A key principle of these solutions is to utilize water of different quality for different purposes. Clean water is used as drinking water; locally cleaned 'grey' water for washing, and non-cleaned 'grey' water for toilet flushing. Instead of draining rainwater and melt water away through gutters, gratings and sewers (with the risk of overloading these systems in periods of high precipitation), as much as possible of the storm water is diverted back to areas in the neighbourhood not sealed by asphalt or buildings. The local sewage management models are based on composting toilets, septic tanks or infiltration systems on the individual site or within the neighbourhood. Some models also include systems for separation of urine and faeces.

Planners have often regarded a low density of buildings as a presupposition for local water and sewage management systems. Indeed, such solutions are somewhat more area-demanding than centralized systems. It has been estimated that on average about 2 per cent of the surface of a residential area must be set aside in order to take care of storm water by other means than pipelines (Malmquist, 2004). Such solutions are currently being tried out, among others, in the Swedish cities of Malmö (300,000 inhabitants) and Uppsala (140,000 inhabitants), typically in the form of ponds and ditches integrated into urban green areas. However, several conflicts may arise. For example, many urban residents consider such open-air water surfaces as barriers to recreational activities and a risk for children. Building fences around the ponds and ditches to protect children from drowning often has a negative impact on the aesthetic qualities of a park and reduces the space available for recreational activities. Infiltration of grey water in the street network or parking areas is an alternative solution, avoiding conflicts between grey water management and the recreational use of parks and other urban green areas. When appropriately designed, such solutions may add new aesthetic qualities.

It should be noticed that the local storm water solutions may create some new environmental problems. Due to run-off from roofs, roads, etc., storm water often includes considerable amounts of heavy metals. Solutions where storm water is collected in local ponds therefore run the risk of accumulating pollutants in the bottom of the ponds.

One should also be aware that the environmental friendliness of local water and sewage management solutions depends on the residents' motivation and knowledge of how to use them. Sometimes, such systems involve some cumbersome tasks for the inhabitants, or imply reduced comfort (e.g. attraction of flies to dry toilets). Although the pioneers who have hitherto tried out local water and sewage systems are probably more knowledgeable and motivated than the average citizen, problems have arisen with the functionality of these systems (Åberg, 2005). Doubt may arise about the environmental friendliness of local water and sewage systems if these systems were to replace the centralized systems at a city-wide scale, involving not only the motivated pioneers, but also population groups who may be indifferent or even hostile to such solutions. The above-mentioned Swedish research programme has pointed at several possibilities to improve the existing, professionally managed central systems for grey water management. When choosing the future grey water management system, these possibilities should be compared to the benefits and drawbacks of transferring the responsibility for identifying and carrying out the appropriate maintenance tasks to the individual users or to the more amateurish managers of smaller-scale systems.

Both in order to reduce polluted run-off from the city's hard surfaces and to make space for areas where storm water can be diverted to the local infiltration and delaying in order not to overload pipeline systems, it has been recommended that a low percentage of the urban area be sealed with hard surfaces. However, this does not necessarily mean that the city-level plot ratio needs to be low. In many cities, traffic area covers more area than buildings do, and run-off from asphalted areas often contains a higher number and amount of pollutants than run-off from the roofs of buildings (SwenSSon, 2005). Moreover, urban density depends not only on the proportion of the urban area covered by buildings, but also on the number of storeys (and the floor area per person, see section 12.10). In an urban sustainability perspective it would be a better idea to ensure sufficient un-sealed areas by reducing the size of the traffic areas than by decreasing the density of inhabitants and workplaces. Planting more trees on the sidewalks would also help to slow down storm water run-off.

The negative environmental consequences of storm water run-off from buildings depend heavily on the roof materials, with the most serious problems (heavy metals pollution) resulting from copper and zinc thatching. Choosing other roof materials, for example tiles or shingle, can reduce pollution from roof run-off considerably.

In very dense city districts where there is not enough space on the ground to allow for local storm water infiltration on non-sealed areas, 'green roofs', that is roof terraces covered (partly) by soil and vegetation, offer an opportunity. Such solutions have been implemented in some multi-storey houses in Swedish cities and have considerably less roof run-off than conventional buildings.

Systems for local infiltration of sewage are relatively space-demanding and require considerable maintenance work. Such systems could yet be compatible with dense types of housing if integrated into green areas in the proximity of the buildings. However, the question arises about the reasonableness of using the green outdoor areas of dense residential districts for this purpose at the cost of recreational purposes. One should also be aware that the sludge from local sewage systems does not necessarily contain less harmful substances than the manure distributed from centralized treatment plants. Today, human faeces and urine often contains remnants from medication (Ledin, 2005), and removing such substances from the sludge would require treatment in a centralized treatment plant.

Compared to local infiltration, the possibility for control against environmental toxics in the manure will probably be at least as high if the sludge is collected in local septic tanks and subsequently transported to farmland areas. In dense urban areas this is probably the most practical local scheme for ensuring that the sewage has a quality high enough to be used as fertilizer on agricultural areas.

Schemes for urine separation are, when implemented in dense urban situations, typically based on local collection only of urine (in septic tanks), and with faeces discharged into the ordinary sewer systems.

As mentioned above, many proponents of 'the green city' have emphasized the need to reduce the transportation distances of agricultural products. In this connection, some authors have mentioned the transportation of food across national borders and continents as an argument for urban agriculture (Girardet, 1995). Reducing excess international transport of foods is clearly an important sustainability issue, but both the 'compact city' and the 'green city' are compatible with an agricultural policy aiming to reduce long-distance foods transport. The question of import of agricultural products from distant countries is therefore hardly relevant to the discussion about the environmental sustainability of different urban developmental patterns in European cities. The transport that might be reduced through a higher degree of self-sufficiency with agricultural products is the transport of agricultural products, sludge and urine *between the city and its nearest surroundings*. The additional transportation energy required in 'compact cities' in order to bring food from the countryside to the city, and organic waste back to the farmland, is infinitesimal compared to the generally lower amounts of transport and car travel in dense and concentrated cities.

The above review shows that there need not be any conflict between a transport-reducing urban planning and the aim of closing cycles of substances.

Admittedly, urban models based on a high degree of self-sufficiency with, among others, agricultural products within the urban area will hardly be compatible with dense urban structures. However, it is difficult to see why sustainable cities should be based on self-sufficiency at such a local scale.

Some proponents of the green, low-density model for sustainable cities have argued that ample urban green areas have an important pedagogical effect on the inhabitants' knowledge about nature and motivation for environmental protection. Related to this argument is the idea that ecological closed loops solutions for, among others, food production and management of sewage and organic waste should be established within each neighbourhood in order to make the waste problem visible and increase the environmental awareness of the citizens (Knudsen, 1994).

As already mentioned, local closed loops solutions are possible both in dense and low-density urban environments. Meeting a high proportion of the inhabitants' needs for agricultural products within the urban area demarcation would, however, require a fragmented urban structure with large, open areas in-between the built-up areas. However, such a radical degree of self-sufficiency is hardly necessary for the urban population's acquirement of knowledge about the food production and manure circuits. Besides, the assumption that locally closed loops of substances induce a higher environmental awareness among the residents is poorly substantiated. In Copenhagen Metropolitan Area we find higher average levels of environmental awareness among inner-city residents, cf. Chapter 8. A similar finding has been made in Aalborg (Nielsen, 2002). Neither do investigations in Greater Oslo support the hypothesis that living in a house with a garden contributes to environmental awareness and a higher willingness to give priority to environmental concerns (Næss, 1999).

Regarding opportunities to experience nature, both dense and spread-out cities have their advantages and drawbacks (see below). Here, we would like to point to the fact that recreational areas should probably not be of a too cultivated character in order to be able to contribute to a higher awareness about nature and the environment. The American urban theorist Jane Jacobs holds that the establishment of cultivated parks and lawns reflects neither love for nature nor respect for nature, but

... a sentimental desire to toy, rather patronizingly, with some insipid, standardized, suburbanized shadow of nature – apparently in sheer disbelief that we and our cities, just by virtue of being, are a legitimate part of nature too, and involved in it in much deeper and inescapable ways than grass trimming, sunbathing, and contemplative uplift. And so, each day, several thousands more acres of our countryside are eaten by the bulldozers, covered by pavement, dotted with suburbanites who have killed the thing they thought they came to find.

(The Death and Life of Great American Cities, p. 458–459.)

12.7 A HEALTHY ENVIRONMENT

The need for a healthy urban environment is emphasized in the Brundtland Commission's report. Although the most urgent problems are in some of the cities in developing countries, pollution, traffic accidents and other health-damaging conditions are serious problems in European cities too.

Patterns of development requiring less energy use lead to lower overall emissions of polluting gases. A reduced amount of travel will in itself have a positive effect on the concentration of environmental nuisances from traffic (noise, local pollution etc.). On the other hand, dense and concentrated urban patterns of development most often imply that a higher proportion of the transport takes place within a limited area. Seen in isolation, this increases the concentration of pollution. It should be noted, however, that several of the components of urban air pollution stem from emissions blown with the wind over long distances. Thus, it has been estimated that most of the unwholesome particles in the air and ground-level ozone in Oslo originate from international and even intercontinental sources, notably agriculture and industry (Lövblad *et al.*, 2004). Moreover, as already mentioned, a concentrated urban development also facilitates a higher share of public and non-motorized transport. The latter has a positive effect not only on the global, but also on the local environment.

What is said above about noise and locally generated air pollution applies to a high extent to traffic accidents as well. On the one hand, a reduced overall amount of travel in dense cities contributes to reducing the number of accidents. On the other hand, the establishment of a fully differentiated road network is difficult in dense urban environments, for example the grid-pattern blocks found in the inner parts of many European cities. However, high traffic density appears to make road users act more carefully and be more watchful than under less congested conditions. Congested streets also result in lower speeds, and hence less likelihood of fatal or serious injuries when accidents occur. These circumstances tend to balance some of the increased risk of accidents resulting from the lack of separation between different groups of road users in dense and central urban districts.

Seen together, the traffic safety advantages of a high population density seem to outweigh the disadvantages. A comparison of the numbers of accidents in several Norwegian cities indicates that a high population density for the city as a whole contributes to a somewhat lower number of person injury accidents per 1000 inhabitants. However, the effect of population density is not very strong (Røe and Jones, 1997).

Even though a high population density for the city as a whole appears to reduce rather than increase the number of traffic accidents causing person injuries, the risk of accidents is still higher among inhabitants of central districts of the city

than among suburban residents. Regarding traffic accidents, local air pollution as well as noise, the location of developmental areas affects the issue of a fair distribution of burdens and benefits (see section 12.8).

As mentioned above, it is hardly relevant to use spatial planning as the only means to ensure an environmentally sustainable urban development. A host of other instruments will also be necessary if we want to achieve substantial results. These measures include economic and other types of restrictions on car traffic as well as a strengthened public transport service. In addition to contributing to lower energy use and emissions for the country as a whole, restrictions on urban motoring can give important local environmental improvements. Reduced opportunities for car driving in inner and central quarters can make these districts more attractive as residential areas and will contribute to a more just distribution of the negative environmental impacts of urban transport.

Most professionals within preventive health work agree that regular physical exercise contributes to better health. Our investigation in Copenhagen Metropolitan Area confirms the wide-spread assumption that a short distance from the dwelling to green recreational areas stimulates residents to do more frequent walking, jogging or cycling in these areas. Swedish investigations indicate that the proportion of residents making active use of green recreational areas is halved when the trip by foot or by bike to the area takes more than 8 or 10 minutes (Grahn, 1993). However, living far away from the closest green recreational area does not necessarily imply that the residents for this reason omit to do physical exercise. The exercise may instead take other forms, such as walking or jogging along streets and paths, or indoor training. The Copenhagen Metropolitan Area study indicates that the reduced frequency of walks and bike trips in natural area among inner-city residents is largely balanced by a higher frequency of other types of physical exercise (among others in sports centres, etc.). Moreover, the far more extensive use of non-motorized modes of travel among inner-city dwellers is in itself an important exercise activity. The possible negative health consequences resulting from longer distances in dense cities from the dwelling to larger recreational areas must therefore be compared to the positive health impacts of these residents' more frequent walks to and from public transport stops and higher number of trips by bike and by foot.

In this comparison, the increased pressure to convert natural areas into building sites resulting from a sprawling urban developmental pattern should also be taken into consideration. Although those who move into new dwellings on the fringes of forest or other natural areas obtain good outdoor recreation opportunities, such residential development implies a reduction of the city's recreational areas, to the disadvantage of the rest of the inhabitants.

12.8 SOCIAL DISTRIBUTION OF BENEFITS AND BURDENS

A location of residences reducing car dependency and the need for transport will make it easier to reach the various facilities of the city for those parts of the population who do not have access to a car or are unable to drive a car. Thirty-two per cent of all Danish households still do not have access to a car (Danish Transport Council, 2000), with higher percentages of car-less households in the largest cities. Regardless of the general growth in car ownership, some population groups are excluded from automobility. This applies, among others, to those who are too young to have a driving licence or are unable to drive a car because of age or disability. Moreover, a large proportion of one-car household members are practically unable to drive because the car is occupied by another household member. When distances between urban facilities are short, the inhabitants can be offered a high *accessibility* to the various facilities without being dependent on a high *mobility*. A transport-reducing and non-car-based urban planning thus contributes to *democratize accessibility*, compared to urban development where many urban facilities are difficult to reach for population groups who have few mobility resources at their disposal.

Although a high population density for the city as a whole seems to reduce the frequency of car accidents involving person injuries (cf. above), the risk of accidents is higher among inner-city residents than among residents living in the outskirts of the urban area (Røe and Jones, 1997). The reason for this is the higher concentration of traffic in the inner areas. Similar conditions exist for local pollution and noise. Regarding traffic accidents, noise and also local pollution, the location of developmental areas has its impacts on the distribution of burdens and benefits. If development takes place in the outer parts of the urban area, those who move into the new houses will benefit from a local neighbourhood more safe from traffic and less polluted than the urban average, while they themselves contribute to an increased overall amount of traffic, troubling residents living closer to the city centre with increased through traffic, pollution and risk of accidents. Correspondingly, people moving into infill development in the inner-city will on average create only a small amount of traffic and pollution while being themselves exposed to the nuisance from car traffic originating mainly in the outer parts of the urban area.

Outer-area greenfield development thus contributes to increased polarization by worsening the conditions among those residents who already experience the least satisfactory local traffic conditions, while providing a sheltered situation for the residents of the new dwellings on the periphery. In comparison, inner-area densification contributes to a higher degree of *equalization* of traffic-related environmental nuisances (besides reducing the overall amount of travel and its related pollution and injuries). In order to prevent inner-city residents from having to resign themselves to

lower-quality outdoor areas and a high environmental load from traffic, stronger measures to regulate urban motoring will be required than the ones seen so far in Danish cities.

Several investigations indicate that a concentrated and transport-reducing urban development implies lower economic costs for society than a spread-out and car-based land use (see section 13.4). For the individual comparing the prices of new dwellings in the inner city with suburban houses, in-fill residences may still appear to be expensive. Not the least is this evident in Copenhagen Metropolitan Area. Usually, the prices of building sites are highest in the central parts of an urban area, and this will influence selling prices and annual housing costs for infill residences in these areas. These additional costs for the developers and residents at the same time bring profit for the persons who sell the lots where urban densification takes place. Whether or not public authorities should intervene into this process, for example by taxing profits from sales of building sites and subsidizing housing costs for households moving into new inner-city residences, is a political question. Another point in case is the fact that high inner-city housing prices are partly caused by a lower supply of such dwellings than the demand. In other words, there is a shortage of urban, centrally located residences compared to the number of inhabitants who would prefer to live in such residences. Densification resulting in a higher number of dwellings in central and inner districts of the city would reduce this scarcity, which would in its turn – according to standard economic theory – reduce housing prices in these areas (Barlindhaug and Nordahl, 2005: 22).

12.9 CAN URBAN DENSIFICATION BE COMBINED WITH PROTECTION OF THE URBAN GREEN STRUCTURE?

In the introduction of the chapter, we mentioned the tension between the perspectives of 'ecology within the city' and the 'city in ecology' in urban environmental policies. In the discourse on sustainable urban development, these two perspectives are reflected in two competing models for sustainable cities: 'the green city' and 'the compact city' cf. chapter 1.5. As can be seen above, principles of a transport-reducing and energy-conscious spatial planning point rather unambiguously in the direction of relatively dense developmental patterns with a low proportion of detached single-family houses. The aim of protecting surrounding natural and agricultural areas from urban expansion points in the same direction. At the same time, some sustainability and environmental concerns speak against too dense urban structures, notably the wishes of some environmentalists for ecological recycling schemes for foodstuff and sewage in the local area, and the wish for ample green areas close to the residence.

Evaluated against the five criteria listed in section 12.1, concentrated and area-saving urban structures appear to be clearly preferable, compared to scattered and open patterns of urban development. However, many environmentalists fear that densification will result in loss of urban nature, playgrounds and green recreational areas close to the dwelling. This fear is not unfounded. Densification, as commonly practiced today, often leads to conflicts between developers and local environmental concerns (Saglie, 1998).

The question therefore arises: is it possible to combine the strengths of the compact as well as the green urban model, while avoiding their pitfalls? Several authors have tried to develop such alternatives, including Newman and Kenworthy (1999); Frey (1999) and Barton (2000). None of these authors believe that the city should be compact right through in the sense of a concentric 'core city' with no green wedges. Densities at neighbourhood and district level should, however, be high enough to facilitate local services and public transport as well as to reduce the need for new greenfield development. According to Frey (1999), district-level gross population densities of about 60 persons per hectare would provide a good basis for local provision centres within walking distances. In larger cities, the accessibility for inhabitants to green areas and the possibilities of 'symbiotic metabolism' between the city and the countryside speak against a too high degree of compactness at a metropolitan area level. Still, in order to limit travelling distances, residences should not be located too far away from the concentration of workplaces, administration centres, specialized service functions and cultural facilities usually found in the inner-city area.

Australians Newman and Kenworthy, renowned for their pioneer comparison (1989) of density and petrol consumption in a world-wide sample of 32 cities, have later (1999) modified their original compact city ideal towards a model incorporating values and objectives associated with the 'green city' model too. They envisage strategies for how to develop existing, sprawling and car-dependent large cities into more sustainable urban structures. Newman and Kenworthy recommend strengthening the central and inner-city by locating a considerable proportion of new office workplaces and residences to this part of the metropolitan area. Yet, the space available for new construction in the city centre is limited. Newman and Kenworthy therefore recommend developing a number of district and local-level centres around the stops of the main public transport lines (preferentially urban railway stations). Densification should therefore be channelled to these district and local centres, termed by Newman and Kenworthy 'urban villages', as well as to the city centre and the inner-city districts. Outside these priority densification areas Newman and Kenworthy recommend a gradual density *reduction*. By and large, this will make space for larger green areas and wedges facilitating urban agriculture and local 'closed loops' solutions for water and sewage.

The interdisciplinary research project 'Environmentally Sound Urban Development' (NAMIT), carried out in the years around 1990 by Norwegian Institute for Urban and Regional Research in cooperation with seven other research institutions, concluded that it is technically/physically possible to combine an overall densification strategy with protection and improvement of the urban green structure (Næss, 1993b). In this project, the possibilities for densification with the least possible reduction of local environmental qualities were investigated in three medium-sized and small Norwegian towns. The analyses showed that considerable areas exist where densification can take place without conflict with important green structure interests. The key lies in concentrating technical encroachments in order to save nature. This implies that densification ought primarily to take place in areas already dominated by buildings or other technical structures, leaving urban green areas intact as relatively untouched areas. For example, in many cities – in Scandinavia as well as other European countries – derelict or low-density industrial sites often exist close to the city centre. Landfills and superfluous harbour areas no longer filling any important function in the city's transport system are another example. Before old industrial sites and landfills can be built on, any toxic substances in the soil must be removed or sealed in a secure manner. Although this may be costly, such a 'recycling' of building sites is currently one of the main strategies for future urban development in many traditional industrial cities in Europe. Moreover, several non-utilized areas, for example along traffic arteries ('space left over after planning' – SLOAP), should be reconsidered as possible areas for densification with commercial or industrial buildings.

Reducing the number of inner-city parking places and narrowing down the width of main roads are, as mentioned above, effective means for reaching the goal of reducing traffic in inner-city areas. Moreover, many residential areas constructed during the 1950s and 1960s were developed with far wider access roads than would have been preferred today. In such areas, where motorists may easily be tempted to drive too fast, narrower roads may help slow down traffic. Reducing asphalt areas in these ways releases space which may be converted to other purposes (new construction or establishing of vegetation). Planting trees along the streets is an effective way of increasing the green image of the city. Such rows of trees occupy little space on the sidewalk and make up a kind of 'vertical green structure' of considerable value for urban biodiversity.

In addition to channelling densification to areas already characterized by technical encroachments, the NAMIT project recommended a relatively high site utilization, giving priority to apartment buildings and terrace houses rather than detached single-family houses (Næss, 1993b). Several possibilities for economizing on building sites might be employed, such as building on lids over major roads or railway shunt areas, and subterranean parking in residential areas. The need to limit

the consumption of building sites also applies to commercial and industrial areas. Such a limitation is, however, often opposed by companies wishing to reserve space for possible future expansion. However, instead of setting aside large expansion areas on each company's site, the municipality or a foundation might keep a certain amount of reserve areas in the same district as a common pool (Stabell, 1976). Such reserve areas might be let out on short term contracts for temporary purposes not requiring expensive buildings, for example warehousing.

12.10 IS ECO-EFFICIENCY AND REUSE SUFFICIENT?

In order to make urban development more in line with the requirements of sustainable development, it seems important to avoid further urban sprawl and further expansion of the road and parking capacity. Instead, most construction should take place within existing built-up boundaries, in particular in areas not far from the urban centre. Concentrated types of housing should be given priority, reducing the construction of detached single-family houses down to a minimum. Most of the densification should be channelled to areas already technically affected in order to save urban green areas. In addition, restrictions should be put on the use of cars, while improving public transport.

Building higher and more densely implies a *more efficient* use of the land, whereas the channelling of new buildings for example to derelict or abandoned industrial and dockland areas implies a *reuse* of urban areas, as opposed to taking into use adjacent natural and agricultural land as building sites. The question still remains whether reuse of urban areas and more effective utilization of building sites are sufficient to bring urban development in wealthy countries within the frames of what is ecologically sustainable, as long as the building stock continues to grow.

For a number of environmental aspects, the total environmental load of the building stock continues to increase as long as its size increases, even if the additional load *per new building* is reduced. New buildings imply – regardless of location and design – an increase in the building stock that has to be heated, lit and ventilated, resulting in increased energy use. New buildings also mean a need for building materials and land for building sites. Some of the environmental impacts of the building activity can be reduced by means of 'eco-efficiency' such as solar energy, heat pumps, better insulation materials, and so on. For other types of environmental impacts the prospects through new technical solutions are not so bright. This is especially true in terms of the consumption of land for building sites, with the conversion and encroachments into agricultural soil, natural areas, urban green structures, and valuable landscapes this consumption often implies.⁶⁶

Environmental problems might be divided into problems related to the flows of energy, nutrients and physical materials in a static situation ('ecological operational costs'), and problems caused by the dynamic changes of the landscape in terms of conversion of non-developed land into built-up areas and the use of construction materials ('ecological investment costs') (Næss *et al.*, 1998). Even if we can reduce the loss of ecologically valuable land categories by preferring concentration rather than urban sprawl, we will never completely avoid the 'ecological investment costs' resulting from the construction of buildings. In a similar way, the 'ecological operational costs' represented by space heating and ventilation can be reduced by choosing clever solutions, but the growth in the building stock inevitably pulls in the opposite direction, increasing the demand for energy.

Unless the new houses are built as a *replacement* for existing, more environmentally unfriendly buildings, new construction based on environmentally favourable solutions are seldom environmentally friendly in an *absolute* sense. If the new buildings come in addition to the already existing building stock, they will at best be ecologically favourable in a relative sense, that is compared to other, more environmentally conflicting solutions. The construction of buildings is basically an endeavor putting a load on the natural environment, even if the extent of negative environmental impacts may be significantly affected by the choice of solutions.

This leads us to the question whether it can be said to be at all consistent with sustainable development to increase the building stock considerably above present levels in wealthy countries such as, for instance, the countries of Northern Europe. During the period since the Second World War there has been a steady and significant growth in the floor area per inhabitant, in dwellings as well as in other types of buildings. Some of this increase is a result of the fact that the number of households and jobs has increased more rapidly than the general population growth. But this can only explain a small proportion of the growth in the building stock. Simultaneously with a decrease in the number of occupants per dwelling, the average size of dwellings has increased. Apart from agriculture, where the building stock (barns of different types, etc.) has decreased due to, among others, closing down and mergers of farms, the stock of non-residential buildings has also increased, both in absolute figures and measured as floor area per employee. This has happened in spite of the fact that a steadily increasing proportion of the workforce is employed within the service and office trades, where the number of square metres per employee has traditionally been lower than in manufacturing industries.

The Nordic countries belong to the nations where the size of the building stock, compared to the population size, is among the highest. Today, each Norwegian and Dane has on average more than 50 square metres of residential floor area at his/her disposal. This is twice as much as 30–35 years ago and about

70 per cent more than in contemporary, affluent Japan. Compared to poor developing countries the difference is much larger (UN/ECE, 1998). What would be the ecological consequences if poorer countries like China and India reached the North European consumption level in the housing sector? Can it be defended ethically to aim at a continual increase in Northern Europe resulting in a residential consumption level that we, for the sake of the planet's ecological carrying capacity, must hope will never be realized in the world's poor countries?

Population growth (which is modest in most European countries) and changes in the composition of households towards a higher number of small households imply that there will still be a need for a certain increase in the number of dwellings. Some population groups also live in substandard dwellings, even in the wealthy North European countries where the average standard is high. If a satisfaction of these needs is to be combined with a requirement for the nation as a whole to keep its consumption level within an 'ecological scope', it will be necessary to practice a principle of *selective standard improvement*. In a similar manner as the goal of raising the material standard of living in poor countries intensifies the need for industrial countries to reduce their CO₂ emissions, a national 'ceiling' for the total consumption of natural resources implies that increased floor space for those who already live in a spacious dwelling, comes in direct competition with the wish to build for those who are lacking a dwelling or live in a substandard residence. Previously, the residential standard for low-income groups has been substantially raised by a general elevation of the housing standard, for example as a result of moderate-price dwellings becoming vacant when people who can afford it move into new high-standard dwellings. As already mentioned, such a continuous, general increase in consumption is problematic in an environmental and natural resources perspective. If we intend to secure a certain minimum standard for everyone, resources must be allocated to raise the residential quality for the most poorly situated instead of increasing the standard further for the affluent groups.

CHAPTER 13

PLANNING FOR A SUSTAINABLE AND LESS CAR-DEPENDENT URBAN DEVELOPMENT

13.1 INTRODUCTION

In the previous chapter we concluded that an energy-saving, sustainable and environmentally friendly urban development would imply that:

- Most of construction takes place as densification within existing urban area demarcations.
- Few new detached single-family houses are built. Instead, priority is given to apartment buildings and terrace houses.
- Road and parking capacity is not being increased. Instead, restrictions on car driving in the city are effected while strengthening public transport.
- Most of the densification is channelled to areas already affected by technical encroachments, so that the urban green structure can be kept intact as much as possible.

Is such an urban development politically feasible? Do we want such cities, and how well would an urban development following these principles harmonize with economic driving forces in society? In this chapter, we shall go closer into these questions. First, however, we shall take a look at the likely consequences of such an urban development in terms of *quality of housing*, *households' organization of daily life and accessibility to activities*, and regarding *investment and running costs*.

13.2 IMPACTS OF A TRANSPORT-REDUCING URBAN DEVELOPMENT ON HOUSING QUALITY

The way the contemporary housing market functions in most cities, higher densities are usually accepted in inner-city neighbourhoods than in the outskirts of the urban area. Since different density levels are typically characterized by different housing types, a densification strategy will most likely result in a composition of housing types different from an alternative based on outward urban expansion.

Our assessment below will mainly be based on Scandinavian criteria of housing quality, as expressed through housing policy norms and recommendations and through evaluations carried out by Scandinavian housing researchers. As will be discussed below, these norms and criteria do not exist independently of the cultural

context in which they have emerged. To a high extent, the norms and recommendations of housing authorities and housing research in the Nordic countries are based on the architectural ideology of Functionalism, expressing a suburban housing ideal that may be directly contrary to inner-city, high-density housing. Nevertheless, these criteria will form the base of the evaluation below. In later sections of the chapter (13.3 and 13.5) we will return to the trade-off between this type of housing quality criteria and the value of 'urban qualities' in the proximity of the dwelling. To a high extent, the discussion is based on Guttu (1991) and Guttu and Martens (1998).

As a supplement to the below discussion based on normative housing policy and professional criteria, the compatibility of alternative urban developmental strategies with housing preferences among the population will be addressed in section 13.6. This discussion will mainly be based on the information given by the respondents and interviewees of the Copenhagen Metropolitan Area study of residential location and travel.

Even though Denmark belongs to the countries with the highest residential floor area per capita, there is reason to believe that most people still consider increased size of the residence as an important contribution to a higher housing standard. Spaciousness in the dwelling must therefore be included among the criteria when evaluating the consequences of different urban developmental strategies for housing quality. Another important criterion is the quality and size of private and common outdoor areas adjacent to the dwelling. Housing quality also includes the opportunities for the residents to pursue their preferred home activities undisturbed. This includes both the possibility of carrying out the desired activities within the dwelling, and any exposure to annoying noise, smell or view from neighbour dwellings. Moreover, housing quality is influenced by the dwelling's access to sunlight, the character of its surroundings, and whether a demand for 'life length standard' is met. The latter demand, which concerns the extent to which the residence is suitable for physically disabled persons, implies that the main floor and the main functions of the dwelling must be accessible for persons who are not able to use stairs. In practice (unless there is an internal lift) this will require that these functions are located on the entrance floor.

In addition to the above-mentioned factors, prices on the housing market clearly show that many people consider a high accessibility to various service and culture facilities as an important quality of the residence. As mentioned above, these aspects will not be dealt with here, but will be addressed in later sections of the chapter.

In practice, giving priority to apartments and terrace houses will imply a somewhat smaller average size of new dwellings than if the construction is dominated by single-family detached houses. The criterion of spaciousness is therefore fulfilled to a lesser extent than in the densification alternative. Single-family houses also have

the largest private outdoor areas. To some extent, common outdoor areas for terrace houses and apartments may compensate for this, but most people will still no doubt consider the standard of residential outdoor areas higher for single-family homes than for more concentrated types of housing.

The single-family house also obtains the highest score on the criterion of undisturbedness. In dense urban environments, especially apartment buildings, the likelihood of being sometimes exposed to unwanted sound, smell or view from neighbour dwellings is higher, and residents must also to a higher extent restrain their own activities in the dwelling for the sake of the neighbours.

In apartment buildings with a lift, both the demand for access without stairs and the demand that the main functions of the dwelling must be accessible on the same floor will usually be fulfilled. Row houses and apartments without a lift are usually able to fulfill only one of these two criteria. One-storey single-family houses may obtain a 'life length standard' if the site is flat and/or the location of the house on the site takes this demand into account. Single-family houses of two or more storeys could be compared to terrace houses regarding their suitability for physically disabled persons.

We may thus conclude that a developmental strategy giving priority to concentrated types of housing rather than detached single-family homes will result in a lower housing standard regarding dwelling sizes and availability of private outdoor areas. Dense housing types also offer less undisturbed conditions in relation to neighbours. Regarding sunshine and view, the differences are not so unambiguous, although single-family houses will usually shade each other to a lesser extent than terrace houses. Judged against the demand for a 'life length standard', low single-family houses and high apartment buildings achieve the highest score, whereas this demand is more difficult to meet in terrace houses and low apartment buildings (the latter because lifts are usually only installed if there are at least five or six floors).

By influencing the composition of dwelling types, densification thus contributes indirectly to a lower average size of dwellings and a lower degree of 'privacy', both implying a lower housing standard compared to outward urban expansion.

In addition, densification may influence the quality of housing independently of its influence on the composition of housing types. Maybe the most important of all direct influences is on the accessibility from new dwellings to service facilities and workplaces. As mentioned on several occasions throughout this book, centrally located residences have considerably better access to such facilities than residences on the periphery. Apart from this, some other direct influences also occur. The likelihood that new buildings will have sunlight or view obstructed by other buildings, or themselves block existing building from these qualities, is higher when the new houses are being inserted within existing built-up areas than for greenfield development. Moreover, for infill development within existing urban

areas the density of the separate residential area may be more likely to be pressed towards the upper limit of what is considered acceptable for the housing type in question. For example, when filling in new dwellings in single-family areas, the new subdivided plots are often smaller than is common for greenfield single-family house development. Similarly, new apartment estates on the periphery are usually developed at lower densities than infill construction of apartment buildings in inner-city districts. Thus, the availability of private as well as common outdoor areas adjacent to the residence will often be lower by densification than by greenfield development. The outdoor areas in connection with each housing type will probably also be less undisturbed in densification areas.

It is difficult to assess whether physically disabled persons will benefit from densification or outward urban expansion. The probability of constructing buildings high enough to be equipped with lifts is highest for inner-city development, but at the same time a densification alternative will probably result in a higher share of new dwellings in multi-floor houses without lift.

In summary, densification will usually give a lower standard of private and common outdoor areas than is usually achieved in greenfield development. Sunlight conditions and view will probably also be less favourable, and the average size of the dwellings somewhat lower. The share of residences suitable for physically disabled persons will hardly differ much from the situation in an alternative based on outward urban expansion.

13.3 CONSEQUENCES FOR EVERYDAY LIFE ORGANIZING AND ACCESSIBILITY TO FACILITIES

Everyday life may be defined as the activities and doings routinely carried out by people in order to maintain and develop their way of living (Grimsrud and Foss, 1991). The location of residences, workplaces, service and other facilities within an urban area may influence how simple or complicated and time-consuming it is for people to reach their daily activities. For several activities, the accessibility from the residence to facilities also influences the residents' frequency of participation (cf. Chapter 7).

As we have seen, inner-city residents travel considerably shorter for daily purposes than residents living on the urban periphery do. Residents living close to the city centre also carry out a higher proportion of their trips by bike or by foot. Since travel speeds are lower by foot (and outside the most congested areas also by bike) than by car and bus, some of the gain in travel time resulting from shorter distances travelled will be reduced. Lower levels of congestion on the outer-area roads also contribute to reducing the differences in travel time (although a net travel time saving among inner-area residents still exists, cf. Chapter 7).

However, the question might be asked if, for instance, a 15 minute trip by foot does not imply easier everyday life organizing than a 15 minute trip by car. Moreover, those who do not themselves have a car at their disposal and hold a driving licence will often depend on getting a lift with other persons in order to reach destinations usually accessed by car. The population segments often described as low-mobility groups may therefore have their activity options limited if distances to potential destinations are long. If not only the average travel time is short, but also the average trip distances, the various facilities may be reached in a simple way regardless of whether or not you have a car at your disposal.

In Chapter 2 we pointed at the fact that only part of the benefit from shorter distances to facilities is utilized in the form of shorter trips. The remaining part is utilized by opting between a wider range of facilities or by visiting the chosen facilities more frequently than if trip distances are long. Many people consider these increased opportunities for choice as an important benefit. A high accessibility not only to workplaces, but also to cinemas, theatres, concert halls, discotheques and other dancing facilities, restaurants, cafés and shops with special commodities is an 'urban quality' highly estimated by many city dwellers.

In most European cities the majority of such facilities are, as mentioned previously, located in the inner areas. An urban developmental strategy based on densification, especially in the central districts of the city, contributes to bring a higher share of the inhabitants in close proximity to these 'urban qualities'. A transport-reducing urban development thus appears to be favourable both in terms of easing people's daily routine activities (particularly the possibilities for low-mobility groups to reach their daily destinations) and in terms of providing a good and broad-ranging supply of job opportunities and service facilities.

As mentioned in Chapter 12, prioritization of transport-reducing urban planning principles must be combined with other instruments if substantial reductions in car traffic and its related environmental problems are to be achieved. Economic or administrative restrictions on urban motoring will contribute to reduce the mobility among population groups currently using their car for urban travel. Seen in isolation, this will make it more time-consuming for these groups to reach daily activities. To some extent such restrictions will also imply that people abstain from visiting some of the destinations to which they would otherwise have travelled. The impacts of a reduced mobility on time consumption and the opportunities to make use of various facilities will, however, not be the same in a dense and concentrated city as in a dispersed urban structure. The more car-based the pattern of development and location of facilities, the stronger will be the negative consequences of mobility restrictions in terms of increased time consumption and reduced accessibility. A transport-reducing pattern of development will be less vulnerable to any limitations on mobility. If future restrictions on the possibility for car driving in cities are

introduced, the present differences between dense and dispersed cities in terms of daily-life scheduling and accessibility to facilities will be increased.

13.4 INVESTMENT AND RUNNING COSTS

In decision-making about the location and design of new development, a high importance will usually be attached to the economic consequences of different urban developmental strategies. The attention will maybe be directed first and foremost towards the investments costs for new buildings and infrastructure. However, running costs may also vary considerably, depending on the developmental patterns chosen.

In many cases, investment and running costs reflect resource consumption relevant also in the discussion of an environmentally sustainable urban development. Not the least, this applies to transportation costs, expenses for heating and cooling of buildings, and some of the material costs for buildings and infrastructure. Because the prices of energy and raw materials only to a very limited degree reflect the environmental costs associated with the production and use of these commodities, the urban developmental alternatives involving the highest consumption of vulnerable/scarce natural resources and energy will not necessarily imply the highest monetary expenses. As a supplement to the previous discussions of consequences of alternative urban developmental strategies to environmental sustainability, it is therefore of interest to compare transport-reducing strategies to more dispersed developmental patterns in terms of monetary investment and running costs. The prospects for a transport-reducing urban development to be politically feasible will increase if such patterns of development are also found to be favourable from an economic point of view.

Although there is a clear association between different patterns of development and the dominant housing types, we will first discuss economic consequences of the composition of housing types separately, and then turn to the costs for infrastructure and public services. The assessments apply to costs for society, not for the individual resident, as the latter costs may be distorted through subsidies, taxation rules, etc.

COMPOSITION OF HOUSING TYPES

Above we have pointed to the fact that apartments and terrace house dwellings are usually built with a smaller floor area than detached single-family houses. Obviously, this contributes to decreasing the building costs for such residences. Moreover, apart from regional differences, for example between major urban regions and remote rural areas, costs of purchasing building sites and preparing them for development

are somewhat lower for concentrated housing types. At the same time, Norwegian investigations in the 1980s show that building costs per new dwelling vary little across housing types. If there is any difference at all, it is rather in the favour of single-family houses than apartments (Mønnesland, 1991). This reflects higher construction costs per square metre for apartments than for single-family houses, with terrace houses somewhere between. First, it is somewhat more expensive to build high-rise than low-rise buildings, among others due to a requirement for other building materials (cf. section 12.5). Second, because of differences in average dwelling sizes, the 'wet rooms' of the residence (bathroom, toilet and kitchen) usually make up a higher proportion of the total floor area of apartments and terrace house dwellings than in single-family homes. Such rooms, with their sanitary equipment, water heating units, sewers and pipes, are more expensive to build than the remaining rooms of a dwelling. This contributes to increasing the building costs per square metre in small dwellings compared to large residences. Finally, the higher building costs per square metre for apartments and terrace houses may partly reflect the fact that such residences are built first and foremost in the major urban regions, where housing prices and construction worker wages are generally higher than in rural areas due to a high market demand for new dwellings. For society as a whole, however, the latter additional costs per square metre cannot be considered as real cost but rather a matter of distribution between purchasers and sellers of residences.

Distinct from the construction costs, annual operational and maintenance costs are on average lower for concentrated types of residences than for detached single-family homes. Not the least, differences in energy requirement for space heating contribute to this.

DENSIFICATION VERSUS OUTWARD URBAN EXPANSION

A number of studies have focused on the infrastructure costs resulting from different urban developmental patterns (among others, Moen and Sigholt, 1970; Burchell and Listokin, 1982, Mønnesland, 1991; Jones, 1997). To a high extent, the conclusions are the same: both investment and operational costs in connection with roads, water pipes, sewers, electric cables and other technical infrastructure are higher for dispersed than for concentrated urban developmental alternatives, simply because the length of each category of installation is greater in sprawling urban structures. This applies both to the major transport arteries and pipeline systems connecting different parts of the city and to the corresponding local installations in each separate developmental area.

Moreover, when the city expands outwards, it will often be necessary to build new schools and other public services, at the same time as existing schools and services within the existing built-up area may have vacant capacity due to a reduction in the number of residents per dwelling.

Some commentators have claimed that the above-mentioned additional costs associated with a dispersed urban development are balanced through the need for a more complicated technical infrastructure in dense urban environments, including a higher density of traffic lights in the city centre areas. However, the need for such installations in the city centre area and the inner-city districts is almost completely independent of whether future development takes place as densification or outward urban expansion. A more valid argument is the fact that a high increase in density may increase the local population to a level exceeding the capacity of existing sewers and other infrastructure. If so, densification may necessitate the construction of new technical infrastructure and service installations. However, in many of the areas where densification is relevant, the population has decreased steadily due to changes in the household composition. In such areas, quite intensive densification can take place before the number of inhabitants exceeds the level when the existing buildings were new. Moreover, in many older urban districts it will anyway be necessary to upgrade and renew the existing infrastructure, for example due to leaking pipers and sewers. Exceeding the capacity of existing infrastructure will then not represent the same economic expense as it would otherwise have done. Finally, outward urban expansion too may overload the capacity of adjacent road, sewer and pipeline networks.

Concentrated urban developmental patterns also imply lower costs for maintenance and operation of infrastructure. This follows naturally from the fact that the amount of infrastructure to be operated and maintained is lower. These expenses include street lights, snowploughing, asphaltting and other road maintenance, and repair work on water pipes, sewers and cables. The expenses for certain types of public service (e.g. post delivery, home aid and waste collection) also appear to be lower, mainly because the distances between the served residences are shorter. In low-density areas, those who perform these tasks must spend a larger proportion of their working hours moving from one residence to another.

The total transportation costs will of course be highest in transport-demanding urban structures. As has been thoroughly demonstrated previously, dispersed and low-density structures are the least favourable in terms of transport cost minimizing.

WHO PAYS?

Seen together, transport-reducing urban developmental strategies also seem to bring about lower costs both for investment and operations than an area-expansive and scattered urban development. However, the above assessments are based on the total costs for society, irrespectively of who pays the bill. If the latter question is also taken into account, inner-city densification may appear costly. The prices of building lots are usually highest in these areas, and this will influence the selling prices and

annual mortgages for infill residences in such areas. These additional costs for developers and residents at the same time bring profit for those who sell the sites on which infill development takes place. Whether or not public authorities should intervene in this process, for example through taxation of profits from sales of inner-city plots and subsidizing residents moving into such areas, is a matter of political prioritization (cf. section 12.8). The same applies to the question of whether or not the prices of building sites prepared for development by the municipality should reflect the real costs of making these sites ready for construction or – as has been common in many Scandinavian municipalities – be sold at a price lower than these costs. In many municipalities common attachment fee levels for road, water, sewer and electricity have been customary, independent of the real costs of providing these kinds of infrastructure in the particular developmental area. This implies a subsidizing of the areas where the provision of such infrastructure is most expensive. It has also been common to operate with 'flat' tax levels for municipal services (e.g. road, water and sewage taxes, etc.), independent of the actual operational costs in the specific areas. This too implies a subsidizing of the most resource-demanding locations.

COST MINIMIZING IS NOT THE SAME AS ECONOMIC PROFITABILITY

The fact that a concentrated and dense urban development implies lower expenses for society than a more dispersed urban development does not necessarily mean that densification is the most economically profitable strategy. In order to assess this, it is necessary to consider what is gained in return for the costs. The lowest costs would no doubt occur if no increase at all in the building stock took place. Although this would possibly be environmentally favourable (cf. section 12.10), few citizens would probably consider such an alternative to be the economically most favourable for society. There hardly exists any unambiguous and commonly accepted answer to the question of how the benefits of a developmental alternative relates to the costs. Not the least, this is due to the problems of quantifying and valoring 'public goods' (including environmental qualities) and non-intended side effects of the developmental alternatives.

Low costs associated with a developmental strategy do not necessarily imply that such a pattern of development will be the most favourable one, seen from the perspective of economic growth. Alternatives requiring higher investment and operational costs may well be the ones contributing the most to 'make the wheels go round', thus making the largest contribution to economic growth. Regardless of whether or not an urban developmental strategy actually has such an effect on economic growth, it is likely to gain political support from influential players if it is *perceived* to satisfy the needs of the local business life.

13.5 HOUSING TYPES, URBAN LIFE AND DEMOGRAPHICS

In the preceding sections, transport-reducing urban developmental alternatives were shown to be to a high extent compatible with other long-term, ecology-oriented and global environmental concerns, as well as with thoughts of economic cost-minimizing. Such urban developmental patterns also appear to be fairly favourable to important concerns for local environment, health and quality of life, although the conclusion about benefits and drawbacks is a bit more nuanced here. Whereas concerns for more sustainable urban transport appear to support the same urban developmental strategies as most collective environmental concerns – and to a higher extent the larger collective in time and space included by these environmental interests – conflicts may arise in relation to the wish for the highest possible environmental quality in the most local and private sphere: the dwelling. In the Scandinavian countries, the environmental issues at stake at this scale may hardly be characterized as decisive for the residents' physical or psychological health, but rather to emerge from needs relatively high up in a hierarchy of needs.

The possibility of implementing a transport-reducing and environmentally sustainable urban development depends, among other things, on the extent to which collective and long-term environmental concerns are given priority in competition with private wishes for as high as possible material standard of living here and now. The single-family house and the car offer private pleasures but are at the same time the causes of collective worries.

From the above, one might perhaps assume that a transport-reducing and energy-saving urban development would only be possible if people act highly altruistically and are willing to give priority to long-term environmental concerns at the cost of their own well-being. This is, however, only part of the picture. As mentioned above, energy-saving urban developmental principles obtain a high score on criteria of facilitating easy organizing of daily life and ensuring high accessibility to a multitude of urban functions. With increasing work specialization, rising educational levels and reduced gender differences in workforce participation and social life in general, more and more people are likely to appreciate these qualities.

A wish for 'undisturbed' living probably makes up an important part of the motivation among people who prefer the detached single-family home as their ideal dwelling. As mentioned above, single-family residents are usually far better protected against noise from and visual exposure to neighbours, and they do not to the same extent as residents of concentrated housing types need to restrain their own activities for the sake of the neighbours. Single-family house areas are usually also socially more homogeneous than dense inner-city districts. Residents of single-family home areas are therefore usually not 'disturbed' in their local environment by

social groups perceived as alien or different. This 'undisturbedness' may at the same time give rise to ignorance and prejudice against people with a different social and cultural background.

Because we cannot live as 'undisturbed' in dense urban environments as in rural and low-density suburban areas, high-density living forces us to train our ability to show consideration and tolerance. Arguably, this is an important and valuable quality of urban social life. Learning to show consideration and to tolerate different fellow human beings is an important part of the process of becoming socialized into civilized humans.

Moreover, many people consider heterogeneity a stimulus, not a threat. Contact with people with a different lifestyle and way of thinking may increase our horizon. It may also be easier to maintain one's own individuality in dense urban environments than in more transparent, socially homogeneous areas where the pressure for conformity may be stronger. The dense city offers larger opportunities for *anonymity* (Simmel, 1903/1998). At the same time, the agglomeration of many people and facilities within a limited area provides the basis for a high number of coincidental and informal contacts. Many sociologists consider such informal and non-binding social contact as an important basis for the feeling of belonging to a neighbourhood. Such 'weak social ties' may of course also be established in single-family home areas, but the frequency and multitude of informal and coincidental contacts is likely to be higher in high-density districts. American investigations of the extent to which informal neighbourhood contact and the subjective feeling of community varies with the local-area urban structure seem to support this assumption (Freeman, 2001).

Our interviews among residents in Copenhagen Metropolitan Area provide some support to Putnam's (2000: 204–215) hypothesis saying that urban sprawl contributes to reducing people's participation in community activities. 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 café or go to a cinema together, among other things because of the atmosphere and the possibility of randomly meeting other friends and acquaintances (a finding also reported in other studies, including Hougen's (1998) study of urbanity and everyday life in Oslo). When living in the outer areas, contacts with friends typically occur in the form of pre-invited visits to 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 kilometres distance from the dwelling is much more common. Possible causes of this include:

- There are 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.
- Compared to single-family home areas, the layout of access roads and paths in more densely developed residential areas often implies an increased likelihood of meeting neighbours randomly:

Yes, there was [more contact between the neighbours] ... You know, we lived a little more densely. Here, I can drive directly down in the garage, and then sneak out of the car and sneak in without anyone noticing me. Over there, you park the car, and then you must walk to, along the paths to your house, mustn't you? So it is difficult to avoid meeting someone, really.

(Female assistant nurse, 54, living in the suburb of Stenløse)

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 neighbourhood.

13.6 RESIDENTIAL PREFERENCES AMONG OUR SURVEY RESPONDENTS

In the first of the two questionnaire surveys of the Copenhagen Metropolitan Area study, respondents were asked to indicate the residential qualities they considered to be of highest importance if they were to move to another residence. Among a total of 17 residential characteristics, the respondents were asked to tick the three qualities to which they would give the highest priority. Table 13.1. shows how the various characteristics are assessed among the total sample of respondents.

As can be seen in the table, a house with a private garden has a strong position as a residential ideal among our respondents. Thirty-nine per cent of the respondents have mentioned this among the three most important characteristics of their next residence. Many respondents (25–28 per cent) also mention low price, proximity to 'rural' recreational areas, proximity to relatives and friends, distance to major traffic arteries, proximity to shopping opportunities, and absence of social problems in the local neighbourhood. Short distance to the workplace and to train station is each mentioned by approximately one fifth of the respondents. On the other hand, few respondents express any wish to live at a distance from dense residential environments and social

Table 13.1 The importance attached by the respondents to 17 selected characteristics of a possible new dwelling

<i>Features of the dwelling</i>	<i>Proportion mentioning the feature among the three most important</i>
Private garden	39%
Low price	28%
Close to recreational areas in forests, at shores or in the countryside	28%
Close to relatives and friends	28%
Not situated close to major traffic artery	26%
Close to shopping facilities	26%
No social problems in the district/residential area	25%
Short distance to the workplace	21%
Good view	19%
Close to train station	19%
Short distance to school/kindergarten	15%
High architectural and aesthetical quality	10%
Situated in a district that the respondent is familiar with	9%
Close to bus stop	9%
Opportunities for 'do it yourself' activities (rebuilding, garden, etc.)	8%
Undisturbed and with any neighbours at a distance	7%
At a distance from multi-storey and social housing	5%

Proportions of respondents who have mentioned various characteristics as one of the three most important. N = 1,907–1,910

housing (only 5 per cent) or emphasize privacy and distance to neighbour as important qualities (7 per cent).

Preference for some of the above-mentioned qualities contributes to a demand for dwellings in suburban or rural surroundings, whereas other qualities concern accessibility to various facilities, most of which are most easily accessible in the dense and inner parts of the metropolitan area. In our material, the wishes for 'rural' qualities are first and foremost represented by the following qualities: house with private garden, good opportunities for 'do it yourself activities', undisturbed location, proximity to 'rural' recreational areas, good view, distance from apartment buildings and social housing, and distance from major traffic arteries. On the other hand, preference for the following qualities indicates (to a higher or lesser extent) a wish for urban living, with a high accessibility to facilities: short distance to work, short distance to train station, short distance to bus stop, short distance to school/kindergarten and short distance to shopping opportunities. The remaining five characteristics (low price, proximity to relatives and friends, high-quality architectural design, location in a quarter that the respondent knows well, and absence of social

problems) may be regarded as fairly 'neutral' in relation to the rurality–urbanity dimension. Admittedly, many of the existing hiring apartments in inner-city Copenhagen are cheaper than typical suburban dwellings. During recent years, however, housing prices have not been lower in the inner area than in the suburbs (see section 12.8).

When residential qualities are thus divided into 'rural' and 'urban' characteristics, the seven 'rural' characteristics are on average mentioned by about the same proportion of respondents (19 per cent) as the average for the five 'urban' qualities (18 per cent). A subdivision of the respondents according to age shows that young respondents (below 30 years of age) tend to prefer the 'urban' qualities (17 per cent) to a slightly higher degree than the 'rural' qualities (14 per cent), while there is an equally sized opposite majority within the age interval 30–59 years, where the rural qualities are emphasized by 20 per cent on average, compared to 17 per cent for proximity to facilities. In the age group above 60 years there is a slight preponderance of preferences for urban qualities (on average 20 per cent, compared to 19 per cent for the rural qualities). The above age differences are probably partly due to differences in the respondents' stages in life, where going to city centre meeting-places to meet friends, acquaintances and potential partners is considered more important among young people than among the middle-aged who more often live an established family life. On the other hand, fewer mobility resources among some of the members of the older group may imply that this group appreciates short distances to facilities to a higher extent than the middle-aged group.

However, the age differences in the importance attached to different residential qualities need not only reflect the fact that the respondents are in different phases of their lives. They may also result from cohort differences, that is that the dominant opinions and values among one age group (e.g. the youngest one) are different from those of other age groups and will remain so even when the members of the group grow older. Such differences may, for instance, be caused by the fact that different age groups have grown up in periods with different *zeitgeist* and have thus been exposed to different predominant attitudes and opinions in their formative years.

With increasing specializing in working life, rising educational level and a higher degree of gender equality, more and more people are likely to emphasize a high accessibility to a multitude of urban functions. Moreover, a new 'urban culture' seems to spread among young people who prefer proximity to cafés, cinemas, theatres and live music rather than the suburban idyll in the single-family home garden. So far, no documentation of the extent to which this tendency has gained foothold in Denmark is available, but several surveys in other Scandinavian countries show clear indications. Among couples aged 35–54 without any children living at home in the Norwegian cities of Oslo, Bergen and Trondheim, the proportion who preferred to live in an apartment building increased from 22 per cent in 1988 to 39 per cent in 1995. A similar, but even stronger tendency was found among single people

between 25 and 34 years. In this group, the proportion favouring apartment buildings increased from 17 per cent to 42 per cent in the same period. However, among young couples with children, the single-family house held a strong and stable position as the most popular type of residence, favoured by about 90 per cent both in 1988 and 1995 (Hansen, 1997). National surveys of values and attitudes among Norwegians may throw light on some of the background for the changing housing preferences among population groups other than the typical nuclear family. The proportion of Norwegians who preferred 'urban qualities' to a rural life was somewhat higher in 1995 than ten years earlier (Hellevik, 1995).

The above-mentioned changes in attitudes and preferences may be partially caused by the fact that a decreasing proportion of urban residents are newcomers from rural areas or have their roots in rural traditions through parents or grandparents living in the countryside. According to a Finnish study, urban residents without any family ties to the countryside consider the single-family home as the goal of their residential career to a lesser extent than first- or second-generation urbanites. Apart from demographic changes, the spreading of more urban lifestyles is probably also boosted by our increasing exposure to international impulses, notably through international media channels.

Residential preferences do not only vary with age, but also across household types. Among our respondents belonging to single-adult households – including households with as well as without children – there is a clear prevalence of preferences for 'urban' residential qualities to 'rural'. In particular, this tendency is apparent among single parents, who mention the 'urban' qualities on average almost twice as often as the 'rural' characteristics. Together, the two above-mentioned groups of singles make up 27 per cent of our respondents. On the other hand, we do not find any tendency among couples without children living at home to appreciate 'urban' qualities to a higher extent than 'rural' characteristics of the dwelling.

ARE THE INHABITANTS' RESIDENTIAL PREFERENCES COMPATIBLE WITH A TRANSPORT-REDUCING URBAN DEVELOPMENT?

Although housing preferences among the population will not necessarily determine the location and composition of residential development, they may nevertheless provide an indication of the *feasibility* of a transport-reducing urban development. In a purely market-based development, residential preferences would – in interaction with the supply provided by land-owners and developers – be decisive for the location and composition of residential development. However, in practically all countries, land use and urban development are subject to public planning and control, precisely in order to obtain a different (and for society better) result than would be the result of unbridled market forces. How extensive this planning is, and how

strong public direction of development is considered desirable, varies between countries and with the political fluctuations. For the time being, the political willingness to govern residential location in Copenhagen Metropolitan Area appears to be somewhat lower than ten years ago.

If residential preferences pull in the direction of outward urban expansion, public-sector planning aiming to reduce the amount of travel and car dependency will to a high extent need to struggle against market powers. The prospects of implementing such an urban developmental strategy will then be poorer, in particular in periods with a general political reluctance towards interventions into market mechanisms. However, our respondents' residential preferences also include some indications suggesting that a more concentrated urban development in Copenhagen Metropolitan Area will meet important segments of the demand on the housing market.

In most Danish cities, the need to increase the building stock beyond the present number of dwellings is not first and foremost caused by population growth, but by changes in the household composition (an increasing number of one- or two-person households). The number of single parents also increases. Moreover, some of the need for new construction is compensation for dwelling lost as a result of mergers. In particular, small dwellings are lost that way. In the light of the development of household composition this implies that large dwellings make up a lower proportion of the need for new residential construction than would otherwise have been the case.

According to our material, a strong prioritization of short distances to workplaces, schools and other facilities, combined with less interest in houses with a garden, is evident precisely among the household types currently increasing their share of the population, and who thereby contribute to a growing proportion of the demand on the housing market. Interestingly too, the proportion among the total number of respondents who have ticked 'private garden' as one of the three most important characteristics of any future new residence is lower (39 per cent) than the share of respondents already living in a single-family house (48 per cent).

Yet, the changes in the household composition do not necessarily imply that there will be a shift towards the construction of smaller dwellings. When new, large family dwellings are built, 'moving chains' are triggered which, in the other end of the chain, leave smaller dwellings vacant. Given the current prices on the housing market, the demand for new residences arises primarily among people who already have their own residence and wish to improve their housing standard, rather than among newly-established households who want to acquire their first independent dwelling. A more direct channelling of residential development in order to meet the demands among new population groups entering the housing market would imply that the necessary number of new dwellings could be produced with lower resource

consumption for the residential sector as a whole. Such a prioritization would probably also imply a larger proportion of concentrated development in the inner and central parts of the metropolitan area.

In any event, the current high housing prices in the inner parts of Copenhagen Metropolitan Area show that there is a high demand for centrally located dwellings. The increased interest for 'urban atmospheres' (Albertsen, 1999; Gehl and Gemzøe, 2001) and the 'Dionysian urban life' (Pløger, 2002) interact with the above-mentioned household composition changes in contributing to a revitalizing of inner-city living as a residential ideal. If these traits of development continue, a drop in residential prices in the peripheral parts of the metropolitan area could eventually be expected. This would in its turn reduce the motivation among developers for investments in residential development in these areas.

In this context it is also important to be aware that a pronounced reduction in the construction of detached single-family houses in Copenhagen Metropolitan Area would not imply that it would no longer be possible for those who wanted to buy such a dwelling. Even if no new single-family houses were built, a large number of existing single-family homes would still be available on the housing market. For example, in the Norwegian city of Trondheim, 92 new single-family houses were completed in 1996, whereas the number of single-family houses sold in Trondheim the same year was more than five times as high (484) (Norsk Eiendomsinformasjon, 1997; Adresseavisen, 1997). In Copenhagen Metropolitan Area too, a far higher number of residences is sold annually than the annual number of completed new dwellings. In the Municipality of Copenhagen, 5,645 detached single-family houses, terrace house units and owner-occupied apartments were sold in 2002, compared to a total of 667 newly constructed dwellings (including extensions and rebuilding) (Andersen, 2003).

13.7 PLANNING PROCESSES FOR A SUSTAINABLE DEVELOPMENT

In this last section of the book I shall focus on the implications of the challenges of sustainability for some of the topics of the contemporary debate on planning theory. Compared to the large number of books, articles and conference papers about the spatial and physical features of sustainable cities, the environmental and sustainability aspects have not been much in focus in the literature on procedural planning theory. Gradually, some contributions have come, but most of these deal with environmental issues only partially or indirectly. Most often, the authors discussing planning procedures and sustainability do not clarify what they consider to be the substantive content of a sustainable spatial planning. The detachment of planning

theories from the actual subject areas is a common trait of much of contemporary planning literature (Yiftachel and Huxley, 2000). In the case of sustainable development such a separation appears to be particularly inappropriate, as the recommendable procedures will most likely depend on the goals and policy issues dealt with.

In many cases, the authors seem to take for granted that the goals of sustainability are largely consistent with the prevailing lifestyles, consumption habits and perception of the environmental situation among the members of the local community. However, this will hardly be the case in affluent societies. Some of the most important challenges of a sustainable development in such countries concern the need to reduce environmentally harmful activities which, viewed in isolation, can make life for the individual citizen more convenient, more enjoyable, or more prestigious. These activities at the same time represent resource consumption and a degradation of the natural environment that threatens the possibilities of future generations and the world's poor to meet *their* needs.

NEITHER UNBRIDLED MARKET FORCES NOR INCREMENTALISM CAN DO THE JOB

There is little reason for hope that a sustainable urban development will emerge as a result of unbridled market forces. Classical economic theory recognizes that market processes alone are not able to counteract so-called externalities. Externalities are social costs not included in the profitability analyses of the agents of the market, but shifted on to other people or the environment. Pollution is an example of such costs. Neither are sole market processes able to ensure a socially acceptable distribution of burdens and benefits. Thus, both the two key elements of a sustainable development – to meet vital needs and ensure an equitable distribution in time and space, and the condition of environmental sustainability – depend on planning and management by public authorities (see, e. g., Klosterman, 1985).

In the Scandinavian and most other European countries, public authorities have quite wide legal and formal possibilities for controlling and directing the spatial distribution of residential, commercial and industrial development. The political willingness to make use of these legal instruments may vary, but at least in the Scandinavian countries, the actual urban development has to a high degree taken place in areas set aside for development in adopted land use plans (Saglie and Sandberg, 1996; Næss *et al.*, 1998). However, the need for intervention into market mechanisms in order to promote sustainability implies that the prospects for implementing a transport-reducing and sustainable urban development appear to be poorer in states that are weaker and have less potential for direction than the European countries. In states where market forces play a more dominant role, for

example the USA, there may be difficulties in realizing values and priorities that the population hold important when they act as *citizens*, insofar as these values and priorities are not also expressed through their role as *customers*.

A similar insufficiency with respect to the challenges of a sustainable development also applies to the incremental decision-making model (cf. Lindblom, 1959). According to the incremental model, alternatives for action are chosen in a way that deviates little from today's practice. If current practice is to consume non-renewable resources at a fast rate, none of the alternatives for actions considered will be able to change this negative development. Present development may also violate the interests of underprivileged groups in the present generation. By neglecting to examine alternatives differing much from the status quo, such alternatives lose the opportunity to become visualized and discussed. Furthermore, analyses of consequences are very limited in incremental planning, based on 'immediate' experiences with previous efforts, with little foundation in theory. Such 'non-analytical' evaluations of consequences are hardly very suited to illustrate where the aggregation of small steps will lead us. Incremental, 'one bite at a time' planning, using trial and error as a strategy, is fundamentally problematic regarding irreversible interferences with nature. An area is only protected as long as it is not being developed, while a realized development project physically prevents future conservation.

As action alternatives of incremental planning only represent small steps in relation to the present situation, it is possible to gain experiences quickly and implement these during evaluation of the next step. From an environmental point of view, this is favourable. Apart from this, incremental planning seems poorly suited to promote collective, instrumental goals, whether these address global or national environmental concerns, local environmental qualities, or a more just distribution among population groups.

PLANNING MUST BE GOAL-ORIENTED, BUT ...

There is little help in goal formulations about sustainability if the measures of the plans actually tend to move us further away from these goals. Thus, planning cannot disregard the goals. It has to be goal-oriented. The various means included in the plan must be efficient – or at least acceptable – judged from criteria of a sustainable development. Among the normative planning theories, the rational-comprehensive, synoptic model is the one with the strongest emphasis on finding efficient means in order to reach explicitly formulated goals.

However, the criticism of modernism's technology optimism and belief in progress has also affected the conception of rational and goal-oriented planning. This form of planning is rooted in the same technology-optimistic way of thinking

that has contributed to the environmental problems of today. With its strong emphasis on professional expertise it has also a tendency to neglect informal knowledge, for example the knowledge of lay people about local environmental qualities. Proponents of the goal-rational planning model are apt to have a high faith in technical-economic methods of analysis, for example cost-benefit analysis. In practice, such methods have often contributed to neglect of factors that cannot be quantified or expressed in monetary terms.

The rational-comprehensive planning model is based on a utilitarian tradition of social philosophy, where what counts is the total amount of utility, not the distribution between individuals or groups. This may easily lead to a pressure against the rights of minorities. Theoretically, a utilitarian calculus of utility and disadvantage might, for example, conclude that the gladiatorial combats in ancient Rome were ethically defensible, provided that the number of onlookers was high enough that the pain and death of the gladiators could be outweighed by the spectators' excitement and entertainment! In our contemporary liberal democracies such extreme outcomes would be prevented by legislation established to protect individuals and minorities against infringements in the name of 'the common good'. Still, the rationalist model of planning has an inherent tendency towards 'majority tyranny' that can result in the sacrifice of a small minority's vital interests in order to bring about marginal improvements for a large majority.

COMMUNICATIVE PLANNING

As a reaction to the technocratic elements of the synoptic planning model, alternative models putting more emphasis on citizen participation have been launched. The effects of the planning process on people's self-esteem, values, behaviour, capacity for growth and cooperative skills are often considered more important than the merely instrumental consequences of a plan. With their emphasis on giving the local population as high an influence as possible on their own situation, supporters of this form of planning are usually skeptical about top-down management, for example in the form of national-government directives to the municipalities. Much of the literature on communicative planning has also been characterized by a strong belief that dialogue can transform conflicts of interests into situations where both sides win, and that it is possible by means of decentralized and broad planning processes to arrive at mutual understanding and agreement. In particular, this is true about the strands known as 'collaborative planning' (Healey, 1992/1996, 1997) and 'planning as consensus-building' (Innes, 1996).

One of the most prominent representatives of this school of thought, Patsy Healey, goes far in the direction of putting brackets around the expert knowledge of planners as well as goals set by authorities outside the local community:

Knowledge is not preformulated but is specifically created anew in our communication through exchanging perceptions and understanding and through drawing on the stock of life experience and previously consolidated cultural and moral knowledge available to participants. We cannot, therefore, predefine a set of tasks that planning must address, since these must be specifically discovered, learnt about, and understood through intercommunicative processes.

(Healey, 1992/1996: 246)

Seen in relation to the challenges of a sustainable development, serious objections could be raised against this planning model. It is not at all certain – nor even probable – that an ecologically defensible and globally solidary land use or resource consumption will emerge spontaneously from the grassroots among the population in countries belonging to the world's most privileged nations. If a sustainable urban development were a matter of actions compatible with the dominating residential ideals and mobility preferences among the population, then bottom-up grassroots planning might perhaps have functioned in line with the goals of sustainability. However, a sustainable development is to a high extent a matter of *redistributing* consumption levels from us who live *here* and *now* to those who live *there* and *then*, that is, from present-day inhabitants in the most affluent nations to people in future generations and in poor countries. Municipalities that might wish to act in a globally solidary way, for example by reducing their carbon dioxide emissions, may see such efforts as useless as long as they cannot trust other municipalities to also do their part to reduce emissions. Similar to the way planning is necessary in order to solve common tasks *within* a municipality, higher-level coordination is necessary at regional, national or international scale in order to resolve the 'prisoner's dilemma' facing individual local communities in relation to global and national environmental problems. Such planning is also necessary to avoid the dispositions made by local authorities shifting problems on to other local communities (whether the latter are located in the neighbouring municipality or on the other side of the globe).

This does not mean that detailed control from above should replace local democracy in the municipalities. On the contrary, I consider vivid local planning processes as a precondition for developing the awareness about a sustainable development that is necessary if planning with such a target is ever going to become politically applicable. The Brundtland Commission emphasizes the need to support grassroots initiatives, empower citizen organizations and strengthen local democracy. However, it is hardly reasonable to interpret these recommendations as a call for radical decentralizing of the powers of decision from national authorities to the municipalities (or to the various local communities within each municipality). Local dispositions – not least concerning land use and development – often have

consequences far beyond the municipal borders. This implies that the local level should not have full sovereignty over such dispositions. Local planning should therefore take place within frames ensuring that consequences primarily manifesting themselves at other scale than the local are also taken into consideration.

Within the literature on communicative planning there has also been a tendency to downplay the role of scientific knowledge about the relationship between goals and means. Often, such knowledge is considered to be of a limited or doubtful validity, since each planning situation is in principle unique. Instead, a consensus-based criterion for knowledge and truth is taken as the point of departure. What is considered valid knowledge are those statements that, through debate and dialogue, have been agreed on as true. However, as a principle for diagnosing how the ecological situation is, or the consequences of various types of human activity for the natural environment, the consensus criterion for truth is hardly well suited. If the members of a local planning committee agree on the statement that car traffic does not represent any environmental problem, this conclusion will not for that reason be true!

Drawing the focus away from public goals and the efficiency of means is hardly conducive to a sustainable urban development. Even if the planning authority abstains from goal formulation, the various stakeholders are of course very well aware of what outcome they want. A weaker focus on goals in planning therefore implies that it is the *public* goals that are downplayed, not those of powerful interest groups. Likewise, reduced focus by the public authorities on expert knowledge does not imply that such knowledge is replaced in the planning process by the 'life-world' knowledge of ordinary people. Instead, the expertise will then be serving only those stakeholder groups who can pay for it. The banks have their experts advising how to act, and so have the property developers and the road construction segment. Thus, when planners draw their attention away from the relationship between means and ends, this tends to weaken the political influence on the outcome and increase the influence from the market and the strongest stakeholder groups. Rather than rejecting expert knowledge, planning for a sustainable development should make use of both expert and layman knowledge, and involve perspectives from natural, technological and social as well as human science.

Because of its strong belief that it is always possible to come to an agreement, communicative planning theory – especially in its collaborative and consensus-based versions – has been accused of naïvety about the power relations of the world (see, among others, Flyvbjerg, 1998; Tewdwr-Jones and Allmendinger, 1998). It is no *accident* that the present development implies a fast draining of natural resources, reduction of natural areas and high emissions of pollutants – some people have *wanted* it this way because these processes also yield profit and contribute to economic growth. For business life, continued growth in consumption levels, for example in the form of higher mobility and larger residences, provides a base for

increased sales, and hence for profit. A planning model that does not recognize the right of a majority to make decisions against the interests of a minority, is poorly suited to secure sustainability considerations in the face of actors with an economic interest in the present non-sustainable development. The need to make decisions across the interests of privileged groups is increased by the fact that retaining the national consumption level within an 'ecological scope' would most likely lead to sharpened conflicts between the social classes about the distribution of the limited resources available for consumption.

WHAT CAN URBAN PLANNERS DO TO PROMOTE SUSTAINABLE DEVELOPMENT?

As already mentioned, giving consistent priority to the concerns for a sustainable development would be very controversial, and there is not much political support today in any single European country for ambitious steps in this direction. If the individual countries were to be forced by external conditions to follow a more sustainable policy, for example as a result of future follow-up of the Kyoto agreement with more ambitious and obliging requirements for reduced greenhouse gas emissions, then the prospects for a more ambitious sustainability-oriented planning might be better. Still, planners can already today contribute to increasing the possibilities for promoting a sustainable development. This can be done by developing and communicating knowledge about what will be sustainable and environmentally friendly solutions, and by stimulating planning processes that can generate more debate about what values and interests we really want to promote.

The possibility for planners to act according to such a role is probably highest outside the public bureaucracy, for example in non-governmental organizations working for sustainability, or within the academic world. But there is scope for action also for planners working in governmental agencies at different levels or in private consultant companies. Even though the political context and historical background of the institutions in which planners work make up constraints on what is considered acceptable professional conduct, the ideas and skills of those working in these institutions matter.

First, planners have a responsibility to point to the likely consequences of different proposed solutions, seen in the light of criteria for a sustainable development. Even though it is not possible to analyze all types of consequences from the plan proposals, the alternatives should be evaluated against the goals considered most important. If, for example, planning is supposed to contribute to energy conservation and protection of biodiversity, then it is of course necessary that energy and biodiversity consequences of the alternatives be assessed.

Such information should be given to politicians as well as the population in general. Planners could also, from their own professional knowledge, try to formulate plan

alternatives compatible with a sustainable development to as high an extent as possible, and try to initiate a debate about these alternatives among politicians, different sectors of the administration as well as among the citizens. In many municipalities, planners could legitimate such behaviour by referring to official goals of sustainability adopted by the municipality's elected officials. In some cases, municipal planners could also argue that increased emphasis on sustainability is necessary in order to follow up national goals and to reduce the risk that higher-level environmental authorities overrule the municipal plans.

Realistically, though, planners who convey information to the public about unsustainable consequences of solutions preferred by powerful interest groups and politicians, may run the risk of being branded disloyal or even of being fired. In order to counteract the obvious danger that information about environmental and social consequences of planning alternatives is suppressed, legislation should be introduced, requiring local authorities to carry out impact analyses as well as subsequent monitoring of the consequences of their strategic-level plans against a set of sustainability indicators. In particular, such a requirement seems appropriate concerning the master plans for land use and construction of buildings and transport infrastructure. The results of such impact analyses and monitoring should be publicly available, thus ensuring a higher degree of transparency in the decision-making and implementation process. Compared to the present situation in many European countries, where goals of sustainable development seem to coexist peacefully with the implementation of unsustainable measures, such a reform might bring about a higher degree of accountability of planning and policies aiming at sustainable development (Flyvbjerg, 1994).

Even though I do not believe that dialogue can do away with fundamental conflicts of interests or values, dialogue surely can resolve pseudo-disagreement and also convey information that makes some participants of the debate change their mind. However, as argued above, dialogue cannot *replace* the decision mechanisms of representative democracy. Among proponents of communicative planning there has been a tendency to 'impose assumptions upon the process, such as participatory democracy "good", representative democracy "bad"' (Tewdwr-Jones and Allmendinger, 1998). Instead of such a polarization, I am of the opinion that *both* deliberation and voting have important functions in democratic decision-making processes. Deliberation and dialogue reach decisions by amalgamating arguments, while voting schemes lead to decisions by aggregating individual preferences. These two strategies could preferentially be combined in the same decision-making process (Sager, 2000). The subject matters of the plan can be discussed in various arenas (e.g. neighbourhood meetings, the press, meetings involving different sectors of the municipal administration, meetings between municipal and higher-level authorities, advisory councils made up of different stakeholder representatives, political

planning committees, and the municipal council). These discussions would help clarify the issues and interests at stake, and may sometimes identify solutions gaining broad support. During the process, voting in different political bodies, ranging in responsibility from preparatory (e.g. the planning committee) to final decision-making (e.g. the municipal council) can sort out the politically feasible alternatives of action. In some cases of special importance, a referendum among the inhabitants might also be organized.

In all the above-mentioned arenas of debate, John Forester's (1980) advice to planners about how to counteract 'distorted communication', that is communication violating the norms of comprehensibility, sincerity, legitimacy or truth, should be brought to mind. Counteracting 'distorted communication' of course requires that the planners are aware of their own way of communicating. In addition, planners have a responsibility to correct and counteract manipulating and incorrect communication carried out by other participants of the planning process. In particular, there is a challenge for planners to restrain the possibilities of the most powerful and influential players of the game to dominate and manipulate the other participants. Without serious efforts by the planners to contain the strong and empower the weak, participatory planning processes run the risk of bringing 'more power to the powerful' (Naustdalslid 1991; Hajer and Kesselring, 1999; Hillier, 2003), for example, those with vested interests in unsustainable ways of developing land use and mobility.

If a sustainable development of land use, building stock and infrastructure is ever going to be possible, a change in people's value priorities will probably be required. Without changed value priorities in the general public, politicians with a platform placing a sustainable development at the top of the agenda will not achieve a position of power. On the other hand, if most people do not prioritize nature and environment values more strongly than is done today, a government or a municipal council attempting to implement an ecologically defensible and globally solidary urban development will quickly lose its legitimacy. In a sustainability perspective, it is therefore highly desirable with planning processes that can contribute to a higher environmental awareness and responsibility.

SCENARIOS AND ALLIANCE-BUILDING

A problem in this context is that the long-term and global environmental and distributive issues often appear to ordinary people as far and abstract. Also the overall principles of the municipal master plan will often be considered diffuse and intangible. For planners, a great challenge lies in 'translating' and visualizing how our choices regarding housing types, location of development, transportation solutions and land use affect the possibilities of obtaining a sustainable development. The development of *scenarios* illustrating principally different strategies in these fields

might perhaps be a way to create more debate about what kind of urban development and land use planning we want. In Norway, the research project 'Environmentally Sound Urban Development' (NAMIT) illustrated the considerably different environmental consequences of a 'trend' versus an 'environmental' scenario in three urban areas (Næss, 1993b). The dissemination of results from this project has contributed to increasing the awareness of urban planners – and to some extent also politicians – about environmental consequences of land use and development (Naustdalslid and Reitan, 1994). By influencing the ideas of planners and decision-makers, the project was probably also one of the factors contributing to the less sprawling urban developmental patterns seen in Norway in the 1990s.

A working process where the scenarios are developed in interdisciplinary project groups might contribute to increased understanding of traits of development, scope for action and available options. This way, planning can to a higher extent become a learning process. In Sweden, such interdisciplinary activities have been tried out with some success, among others in the regional planning at county level (Guttu, 1993). The educational role of scenario-building is also documented in a current Nordic project where researchers as well as practitioners and politicians from the transportation sector are involved in the development and discussion of scenarios of sustainable mobility (Hansen *et al.*, 2000). If different sectors and interest groups are involved in such work, the process can perhaps also create a higher degree of consensus among the participants about important common interests to be secured through the planning. At the same time, such a process can reveal where fundamental antagonisms in interests or values exist. Thereby, the processes can contribute to increasing the participants' awareness about social realities.

It is hardly likely that the directors of enterprises based on unsustainable interference with the environment, for example oil companies, will bend to argumentation of negative consequences from the combustion of fossil fuels and join a consensus about heavy restrictions on the use of cars. Several studies have also illustrated the frequent success of corporate interests such as, for example, property brokers or the local chamber of commerce, in making coalitions with leading politicians and municipal administrators, effectively blocking environmental policies perceived to be unfavourable for the business climate (Flyvbjerg, 1994; Logan and Molotch, 1987/1996). In order to counterbalance the power of such alliances, urban planners who take the environmental and sustainability goals seriously should consider which alliances might be built to support these goals, and actively seek a dialogue with the relevant groups. Based on his study of the distorted implementation of a prize-awarded environmental project in the Danish city of Aalborg, Bent Flyvbjerg (1994: 393) draws the following conclusion: 'A municipal administration and its technicians, as well as an urban government and its politicians, may need influential alliance-partners and skills in strategic and tactic thinking, if their projects are ever going to succeed.'

Hence, rather than the ideal of consensus-building across all stakeholder groups, as advocated by proponents of the collaborative planning model (Innes, 1996; Healey, 1997), *alliance-building* appears to be a more viable strategy in a world of fundamental conflicts. As illustrated above, alliance-building is already an important feature of planning processes. Today, this strategy is mainly used by agents pursuing growth goals at the expense of environmental and equity considerations (a fact also realized by Healey (1997: 162, 235–237) in her discussion of 'entrepreneurial consensus'). However, instead of relying on the wishful thinking that the participants in such coalitions will change their priorities if a more inclusionary planning process can be established, efforts should be made to foster alliance-building around the goals of a sustainable development. In my opinion, aiming to achieve consensus among *all* stakeholders is futile. What could be hoped for, is some consensus among those groups who do not have vested interests in the most environmentally harmful enterprises and sectors. *Within* groups who share some basic common values and interests, dialogue and deliberation can play an important role in creating consensus, and make those groups more powerful against their antagonists. Open and well-informed planning processes might then perhaps contribute to the emergence of common strategies for ecological sustainability and social justice, supported by a sufficient number of people to make a difference, and robust enough to withstand the pressure from those actors who harvest profit from the present non-sustainable development.

APPENDIX

THE INDEPENDENT VARIABLES INCLUDED IN MOST OF THE MULTIVARIATE ANALYSES OF THE MAIN SURVEY

<i>Independent variable</i>	<i>Assumed effects on travel behaviour</i>	<i>Arguments for including the variable in the analysis</i>
Location of the residence relative to central Copenhagen (non-linear transformation of the distance along the road network) ¹	Longer travel distances in total, by car and by public transport, and shorter by non-motorized modes among outer-area residents. Higher proportion travelled by car and lower proportion by walk/bike. Yet reduced effects at long distances from the city centre, and maybe somewhat lower amount of travel in the very most peripheral areas.	Urban structural variable of primary interest in this investigation. Not a control variable.
Logarithm of the distance from the residence to the closest second-order urban centre ²	Longer travel distances in total, by car and by public transport, and shorter by non-motorized modes among those living far from a second-order centre. Higher proportion travelled by car and lower proportion by walk/bike.	Urban structural variable of primary interest in this investigation. Not a control variable.
Logarithm of the distance from the residence to the closest urban railway station	Longer travel distances in total and by car, and shorter by public transport among those living far from an urban railway station. Higher proportion travelled by car. Maybe also more travel by non-motorized modes (in order to reach the station and the local service facilities located close to it).	Urban structural variable of primary interest in this investigation. Not a control variable.

<i>Continued</i> <i>Independent variable</i>	<i>Assumed effects on travel behaviour</i>	<i>Arguments for including the variable in the analysis</i>
Density of inhabitants and workplaces within the local area of the residence ³	Shorter travel distances on weekdays in total as well as by car among those living in high-density areas. Longer distances by walk/bike and higher proportions of these modes, lower proportion of car travel. Maybe a higher, compensatory amount of travel by motorized modes at the weekend. Ambiguous expectations regarding public transport on weekdays.	Urban structural variable of primary interest in this investigation. Not a control variable.
Sex (female = 1, male = 0)	Shorter travel distances in total and by car among women than among men. Higher proportions of public transport and walk/bike.	The proportions of men and women among respondents vary somewhat between the areas. Besides, enables comparison of urban structural and demographic variables, and across population groups.
Age (deviation from being 'middle-age', logarithmically measured)	Shorter travel distances in total and by car, and lower proportion of car travel among young and old people.	Age distribution varies between the residential areas, among others with a higher proportion of young people in the inner-city. Besides, enables comparison of urban structural and demographic variables.
Number of household members below 7 years of age	Shorter travel distances in total and by public transport, a higher proportion travelled by car and a lower proportion by public transport if there are small children in the household. Ambiguous expectations regarding travel by walk/bike.	Number of children varies between the areas, among others with fewer children in the inner-city and large local variations in outer areas. Besides, enables comparison of urban structural and demographic variables, and across population groups.

Continued <i>Independent variable</i>	<i>Assumed effects on travel behaviour</i>	<i>Arguments for including the variable in the analysis</i>
Number of household members aged 7–17	Shorter travel distances by public transport, a higher proportion travelled by car and a lower proportion by public transport if there are schoolchildren in the household. Maybe also a lower proportion of walk/bike. Ambiguous expectations regarding the total travel distance.	Same as for the previous variable.
Workforce participation (yes = 1, no = 0)	Longer travel distances in total, by car and by public transport among workforce participants. Ambiguous expectations regarding the modal split and the distance travelled by walk/bike.	The proportion of workforce participants varies between the areas. Besides, enables comparison of urban structural and demographic variables, and across population groups.
Student/pupil (yes = 1, no = 0)	Shorter travel distances by car and longer by public transport and walk/bike among students/pupils, with corresponding effects on the modal split. Ambiguous expectations regarding the total travel distance.	The proportion of students/pupils varies between the areas, with considerably higher shares in the inner-city. Besides, enables comparison of urban structural and demographic variables, and across population groups.
Pensioner (yes = 1, no = 0)	Somewhat shorter total travel distance. Ambiguous expectations regarding the modal split and the distances travelled by the various modes.	The proportion of pensioners varies between the areas. Besides, enables comparison of urban structural and demographic variables, and across population groups.
Personal annual income (1000 DKK)	Longer travel distances in total and by car, and a higher proportion travelled by car, when income is high. Lower proportions of public and non-motorized transport.	Income levels vary considerably between the areas. Besides, enables comparison of urban structural and demographic variables, and across population groups.

Continued <i>Independent variable</i>	<i>Assumed effects on travel behaviour</i>	<i>Arguments for including the variable in the analysis</i>
Whether the respondent holds a driving licence (yes = 1, no = 0)	Longer travel distances in total and by car, and a higher proportion travelled by car among those who hold a driving licence. Shorter distance travelled by public transport and a lower proportion of this mode. Maybe somewhat more walk/bike travel, as these modes, alike with the car, are individual providing some of the same flexibility.	The proportion holding a driving licence varies between the areas. Arguably though, the part of this variation which is not due to factors already included as variables in the analysis may to a high extent be a result of urban structural conditions, and should therefore perhaps not be controlled for.
Car ownership (measured as number of cars per adult household member)	Longer travel distances in total and by car, and a higher proportion travelled by car when car ownership is high. Shorter distance travelled by public transport and walk/bike, and lower proportions of these modes.	Car ownership varies considerably between the areas. Arguably though, the part of this variation which is not due to factors already included as variables in the analysis may to a high extent be a result of urban structural conditions, and should therefore perhaps not be controlled for.
Whether the respondent has a higher education within technical or economic subjects ⁴ (yes = 1, no = 0)	Longer travel distances in total, by car and by public transport among those with a long technical or economic education, maybe also a lower proportion of walk/bike.	The dominating levels and types of education vary between the areas. Besides, enables comparison of urban structural and demographic variables, and across population groups.
Whether the respondent has a short or medium-long education as a tradesman or industrial worker ⁵ (yes = 1, no = 0)	Longer travel distances in total and by car, and shorter by public transport and walk/bike among those with a short or medium 'blue-collar' education. Also a higher proportion of car travel and lower proportions of public transport and non-motorized modes.	Same as for the previous variable.

Continued <i>Independent variable</i>	<i>Assumed effects on travel behaviour</i>	<i>Arguments for including the variable in the analysis</i>
Index for attitudes to transport issues (high value = car-oriented attitudes)	Longer travel distances in total and by car, and shorter by public transport and walk/bike among those with car-oriented attitudes. Also a higher proportion of car travel and lower proportions of public transport and non-motorized modes.	Transport attitudes vary between the areas. Arguably though, the part of this variation which is not due to factors already included as variables in the analysis may to a high extent be a result of urban structural conditions, and should therefore perhaps not be controlled for. Enables anyway a comparison across population groups.
Index for attitudes to environmental issues (high value = environmentally oriented attitudes)	Shorter travel distances in total and by car, and longer by non-motorized modes among those with environmentally oriented attitudes. Also a lower proportion of car travel and a higher proportion of walk/bike.	Same as for the previous variable.
Regular transport of children to school or kindergarten (yes = 1, no = 0)	Longer travel distance by car, a higher proportion travelled by car and a lower proportion by public transport among those who transport children regularly. Maybe also somewhat longer total travel distance. Ambiguous expectations regarding the distance by walk/bike and the proportion of such travel.	The proportions with such responsibilities vary between the areas, maybe in a way different from the variation in the number of children in the households.

<i>Continued Independent variable</i>	<i>Assumed effects on travel behaviour</i>	<i>Arguments for including the variable in the analysis</i>
Number of days at the workplace or school during the investigated week	Longer total travel distances the higher the number of days at workplace/school. Maybe also higher shares of public transport and walk/bike (due to the advantages of these modes in the rush hours, compared to car).	To the extent that the frequency of appearance varies due to commuting distances (e. g. because of more telework among outer area residents), this is perhaps a factor which should not be controlled for. This variable is only included in the analyses of travel on weekdays and for the week as a whole.
Overnight stays away from home more than three nights during the investigated week (yes = 1, no = 0)	Longer travel distances in total, by car and by public transport, and a lower proportion of walk/bike among those who have many overnight stays away from home.	A sort of 'noise' which it might be desirable to eliminate in the estimation of the effects of the other variables. (Yet interesting – in other analyses – to see whether the frequency of overnight stays away from home varies with residential location in a 'compensatory' way).
Official trips during the investigated week (yes = 1, no = 0)	Longer travel distances in total, by car and by public transport, and a lower proportion of walk/bike among those who have carried out official trips.	A sort of 'noise' which it might be desirable to eliminate in the estimation of the effects of the other variables.
Has moved to the present dwelling less than five years ago (yes = 1, no = 0)	Longer total travel distance for all modes (in particular at weekends) among those who have moved. Also more travel by car and public transport, and less by non-motorized modes.	The proportion who has moved is likely to vary between the areas (some areas are more characterized by turnover than other areas).

NOTES

- 1 Based on theoretical considerations as well as preliminary analyses of the empirical data, the location of the residence relative to central Copenhagen was measured by means of a variable constructed by transforming the linear distance along the road network by means of a non-linear function. This function was composed of a hyperbolic tangential function and a quadratic function.
- 2 Distances to the closest second order centre and the closest urban railway station were measured logarithmically, from an assumption that the influence of a one-kilometre increase in the distance within the relevant distance intervals (with averages of 6.5 and 4.4 km, respectively) would be stronger if the distance is short at the outset than if it is already long.
- 3 Local area density was calculated as the sum of inhabitants and workplaces per hectare within a circle of 2 square kilometres (i. e. with a radius of 800 m) around the centroid of the residential area from which the respondents were recruited.
- 4 The workforce participants of our sample were divided into different educational categories from an assumption that the dominating values within the various trades might affect the respondents attitudes to travel (cf. the norm of car-preparedness at the workplaces of some of the interviewees). Cultural differences might also originate from the types of knowledge acquired during their education. Besides, the geographical distribution of workplaces might differ between different professions and trades. Our actual subdivision into four groups according to the length and type of education was partly based on such theoretical considerations, partly on previous empirical studies (Stangeby, 1989; Hartoft-Nielsen, 1997), and partly on exploratory, preliminary analyses of our data. Belonging to two of our four original trade groups turned out to correlate very weakly with the transport variables. Thus, only two educational variables were included in the main analyses, namely long technical or economic education, and short or medium-long education as a tradesman or industrial worker.
- 5 See the previous note.

NOTES

- 1 A detailed Danish-language account of this study is available in Næss and Jensen (2005).
- 2 Construction in order to replace dwellings lost as a result of demolition, fire, changed utilization, merging etc. comes in addition. This is estimated to amount to somewhat above 10,000 residences per year, increasing to about 15,000 dwellings annually after 2020. The report emphasizes the high uncertainty incident to these figures (Madsen, 2000: 11).
- 3 Hovedstadens Udviklingsråd (HUR).
- 4 In order to avoid confusion with the structures of the agency-structure relationship discussed earlier, we have used the notion of 'causal powers and conditions' in Figure 2.2 instead of Sayer's term 'structure', since the latter also includes the powers, abilities and liabilities of individual persons.
- 5 Pløger introduces the term of 'Dionysian urban life' in order to conceptualize 'the enjoyment, 'intoxication', the delight in the practice of flâneurism, the expropriation of space by the eye, hedonism and above all individuality'.
- 6 Critics have claimed that central place theory is based on positivist principles assuming the existence of an identifiable order in the material world; that humans are rational, utility-maximizing decision-makers; and that economic activity takes place within a context of free competition and search for equilibrium (Brown, 1995). Actual locations of cities also deviate considerably from those predicted by central place theory (a fact emphasized by Christaller himself, who acknowledged the existence of a number of locational factors in addition to the ones included in his model: cities are seldom located on mountain tops, even if the distance to other centres, seen in isolation, might indicate such a location). However, the fact that humans are not *entirely* rational utility-maximizing decision-makers does not imply that they do *not at all* use instrumental rationality. According to Sayer (1992), central place theory makes up an important contribution to understanding the mechanisms influencing the location of centre functions. The strength of the theory thus lies in its contribution to explanation, while its ability to predict actual location patterns within a given area is limited.
- 7 The figure does not show conditions influencing the travel modes used, which make up another important aspect of the study. Travel modes could be expected to be influenced indirectly by the factors shown in Figure 2.4 through their influence on travelling distances, and directly by individual resources and motives, transport infrastructure and social environments.
- 8 This presupposes that the residents choose more or less the shortest routes. This is discussed further in section 5.5.
- 9 This touches on the so-called self-selection problem addressed by several authors, in particular in the American debate on relationships between land use and travel. This will be discussed in particular in section 9.8.

- 10 Admittedly, some American studies include regional accessibility among the urban structural variables (e.g. Handy, 1993; Kitamura *et al.*, 1997 and Krizek, 2003). However, in these studies regional accessibility is usually calculated by measuring travel times by motor vehicle to workplaces or retail employment within a given area, transformed by means of a gravity function. This measure fails to account for the higher accessibility to city centre facilities among residents living close to public transport stops or in the inner parts of the city. In Krizek's analyses (2003), the accessibility measure was based only on the availability of retail employment within given travel times, and the effects of the urban form variables on travel were controlled for changes in commuting distances. Although this may be reasonable if the aim of the study is solely to trace the impact on non-work travel from changing residential location, it precludes estimating the influence of residential location on the total daily or weekly travel. As will be shown later in this book, the length and travel mode of journeys to work among our respondents are more than any other travel purpose influenced by the location of the residence. Regrettably, Krizek's article does not address the influence of residential location on commuting distances.
- 11 In addition, one municipality in the county of West Zealand (Haslev) is included in our case study area.
- 12 The selected residential areas were demarcated so that each included approximately 200 households registered in the internet-based address directory Kraks Kort. The questionnaires were sent to all households within the demarcated areas.
- 13 Basically, social science studies aiming to throw light on relationships between outcomes and possible causes, as distinct from measuring the extension of a phenomenon at a given point of time, must be considered a form of case studies. Judgements of the extent to which the relationships found in such studies can be generalized, must be based on the analytic generalization logic of case study research, not on the statistic generalizations of the 'context-independent' sciences. The fact that some time always passes between the collection of data and the publishing of the results of a study is in itself a reason for this: even with perfect statistical representativeness during the phase of data collection, the world has already become different at the time of publishing.
- 14 A similar qualitative reasoning must be used when making generalization from our case city to other Danish or European cities. And the same of course also applies to the generalizations drawn from the qualitative interviews with individual households.
- 15 Additive indices for environmental and transport attitudes were constructed, based on seven questions within each category. For each individual question, respondents were requested to express their attitude to a statement using a five-level Likert scale, ranging from totally agree to totally disagree.
- 16 We considered including the whole week in the travel diary. However, given the quite demanding travel activity registration asked of the respondents, we feared that an extension of the period would reduce the response rate too much. Including Friday but not Wednesday and Thursday might perhaps have been a compromise, allowing for more elaborate analyses of the Friday travel characterized by a combination of ordinary, commuting-dominated weekday travel, and the trips of some respondents to second homes at the coast etc. However, since our main purpose was not to investigate the variations in traffic flows in the transport system over the week, but instead to investigate the influence of residential location on the length and travel mode of trips with varying purposes,

we considered the likely cost in terms of a reduced response rate to surmount the value of increased information about Friday travel patterns.

- 17 Regarding both the amount of walk/bike travelling and commuting distances, the arithmetic means are influenced to a much lesser extent by a few respondents with extreme values than for the total travelling distances. For public transport too, arithmetic means appear more relevant than medians: only a minority of the respondents have travelled by train during the period of investigation, and the same applies to bus transport. Both for bus and train, the median values are therefore zero.
- 18 Thanks to Thomas S. Nielsen, who made the desire line maps by means of the GIS programme ArcView.
- 19 The way traditional travel surveys calculate the proportions of the total amount of travel accounted for by different travelling purposes therefore risks being misleading, as it fails to take into account the more basic nature of journeys to work, compared to e.g. shopping trips, and the importance of daily commuting to any other destinations visited on the way to or from work.
- 20 Among our respondents, 21 per cent mentioned 'short distance to the workplace' as one of the three most important out of 17 criteria for the choice of a possible new residence in the future. Seven other criteria obtained higher percentages, notably 'separate garden' (39 per cent), 'low price' (28 per cent), 'short distance to recreational areas in forests, at shores or in the countryside' (28 per cent), and 'short distance to relatives and friends' (28 per cent). See also Chapter 13.
- 21 The centre was defined as City Hall Square. Based on theoretical considerations as well as preliminary analyses of the empirical data, the location of the residence relative to the centre of Copenhagen was measured by means of a variable constructed by transforming the linear distance along the road network by means of a non-linear function. This function was composed of a hyperbolic tangential function and a quadratic function, calculated from the following equation: $Afstfun = ((EXP(cen\text{tafs} * 0.18 - 2.85)) - EXP(-(cen\text{tafs} * 0.18 - 2.85))) / (EXP(cen\text{tafs} * 0.18 - 2.85) + EXP(-(cen\text{tafs} * 0.18 - 2.85))) - (0.00068 * (cen\text{tafs} - 42) * (cen\text{tafs} - 42) - 2.8)$, where *Afstfun* = the transformed distance from the dwelling to central Copenhagen and *cen\text{tafs}* = the linear distance along the road network, measured in kilometres. A further account of the considerations and iterations on which the choice of this function was based is available in a working paper at Aalborg University (Næss, 2001, Danish-language only).
- 22 Based on material from Copenhagen Metropolitan Area Development Council (Hovedstadens Udviklingsråd), the second-order centres were defined as so-called 'urban centres with regionally oriented retail trade'. These centres included the five outer-region towns of Køge, Roskilde, Frederikssund, Hillerød and Helsingør, as well as 14 other sub-regional centres, mainly in Copenhagen and the inner suburbs. Distances to the closest second-order centre were measured logarithmically, from an assumption that the influence of a one-kilometre increase in the distance within the relevant distance intervals (with an average of 6.5 km) would be stronger if the distance is short at the outset than if it is already long.
- 23 Here, urban railway station refers to stations of the so-called S-trains. The S-train lines make up the backbone of the public transport system in Copenhagen Metropolitan Area, comprising a total of 75 stations along routes reaching Klampenborg, Hillerød and Farum

- to the north, Frederikssund and Høje Taastrup to the west, and Køge to the south (cf. the map in Figure 3.1). Distances to the closest urban railway station (averaging 4.4 km) were measured logarithmically, based on similar consideration as for the distances to the closest second-order centre.
- 24 Local area density was calculated as the sum of inhabitants and workplaces per hectare within a circle of 2 square kilometres (i.e. with a radius of 800 m) around the centroid of the residential area from which the respondents were recruited.
 - 25 From theoretical or common-sense considerations, supplemented with information from the qualitative interviews.
 - 26 In a study of the Danish city Aalborg, analyses were made with the distance from the residence to the city centre and the city's second-order centre, as well as the 'mean opportunity distance', as the main urban structural variables. This study showed that the latter variable yielded slightly weaker power of explanation than the two original variables (Nielsen, 2002).
 - 27 With all 23 independent variables included in the regression model, the four urban structural variables have the following Tolerance levels: Local area density 0.38; Location of the residence relative to central Copenhagen 0.44; Logarithmic distance from the residence to closest second-order centre 0.45; and Logarithmic distance from the residence to the closest urban railway station 0.63. In the models on which Tables 6.1–6.4 have been based, where variables not fulfilling a required significance level below 0.15 have been removed, none of the urban structural variables have a Tolerance level below 0.54. According to Lewis-Beck (1980: 60) problems of high multicollinearity exist if any of the variables of the regression model has a Tolerance level 'close to zero'. Given the fact that the theoretical range of Tolerance levels is from 0 to 1, the Tolerance levels of the urban structural variables can hardly be said to be alarmingly low. Neither are the Tolerance levels of the non-urban-structural variables disquietingly low. Among these, workforce participation and being a pensioner have the lowest values (0.30 and 0.31, respectively, in the original model with all 23 variables included).
 - 28 If only one of the urban structural variables at a time is included in the regression model together with the 19 non-urban-structural variables, the four urban structural variables have Tolerance levels varying from 0.81 to 0.91. Their lower Tolerance levels in the model with all 23 variables included are thus mainly due to mutual correlation between the urban structural variables, in particular between local area density and the location of the residence relative to central Copenhagen. Due to their internal correlation, the mutual relative strengths of the four urban structural variables vary somewhat, depending on which data set is used. In the analyses based on the travel diary data, the effects of local area density are stronger than in the original analysis, and in some cases equally as strong or stronger than the effect of the distance from the city centre. From theoretical considerations, however, the stronger effect of the distance from the city centre than local area density found in our main analyses seems reasonable, and is also best in line with the transport rationales identified in the qualitative part of the study.
 - 29 Analyses of factors influencing travelling distances among individual respondents seldom yield high R^2 values. First, people have different objectives, preferences, values and social networks. This influences the reasons by which their travel behaviour is motivated, both regarding destinations, travel mode and travel frequency. Second, mere chance

may also lead to considerable variation in the transportation carried out during a short investigation period. For example, many people redecorate their house or take part in organizing flea markets or sports events for a local club now and then, and have to drive around a lot in connection with such extraordinary tasks. Whether this occurs in the very period when their travel activities are registered, is a matter of chance. Third, people's behaviour is to a different extent influenced by social norms, and there is also a considerable difference from individual to individual and between different population groups regarding *which* norms are being attended to. Fourth, no action follows by logical necessity from a motive or an intention. There is always a gap between the existing motivations, impulses, etc. and the resulting action, and it is the *choice* that fills this gap (Østerberg 1986). With aggregate units of analysis, for example when comparing different residential areas or cities to each other, much of the individual variations will be leveled out. A larger proportion of the variation in the dependent variable will then be attributable to variables that may be practically surveyed in the investigations. The same applies to studies covering a longer period, e.g. a whole year.

- 30 I.e. four 'city terminals' and 11 other interchange stations serviced by many different railway lines.
- 31 Controlling for non-urban-structural variables but not for other urban structural conditions, there is a lower amount of travel among residents of areas where the streets follow a grid pattern. At first glance this appears to support the conclusions from a number of American studies where travel behaviour among residents living in areas with a grid-shaped street structure has been compared with travel behaviour among residents of suburban districts characterized by curvilinear streets and cul-de-sacs (e.g. Cervero, 2003; Frank *et al.*, 2003). However, in our material, all the investigated residential areas with a grid-shaped street pattern are located in the inner part of Copenhagen Metropolitan Area, with distances to central Copenhagen of maximum 9 km. The relationship between street pattern and travel distance disappears when controlling for the location of the dwelling relative to central Copenhagen. Neither is there any effect of the local street structure on the modal split when controlling for other urban structural and non-urban-structural variables.
- 32 Since a large number of respondents belong to households without a car, the annual driving distance per adult household member in these households is zero. This implies that the dependent variable will obviously not be normally distributed. However, according to Lewis-Beck (1980), this breach of the assumptions on which regression analyses are based is of little importance to the estimation of the effects of the independent variables.
- 33 There is also a slight inconsistency between on the one hand the results of the analyses of the effects of the urban structural variables on the total travel distance during the whole week of investigation, and on the other hand the results of the corresponding analyses of travel on weekdays and at the weekend, respectively. The controlled difference between the most peripheral and the most central areas in the amount of travel is somewhat smaller for the week as a whole than during the five weekdays, in spite of the fact that the peripheral areas have higher travelling distances (controlled for non-urban-structural variables) at the weekend too. Probably, the main cause of this inconsistency is the exclusion of variables with a poorer significance level than $p = 0.15$ from the regression models. This omission may imply that some of the effects fulfilling the required

- significance level either on weekdays or at the weekend turn non-significant and are thus excluded from the regression model when the week is considered as a whole.
- 34 The multivariate analyses included the same non-urban structural control variables as in the analyses in sections 6.3 and 6.4, except for the number of days at the workplace or school during the investigated week, overnight stays away from home of more than three nights during the investigated week, and official trips during the investigated week.
 - 35 The recorded trip distances for journeys to work are not at all affected, as commuting distances have been measured exactly along the road network between the residential and workplace addresses. If these distances had instead been recorded from the travel diary, the length of journeys to work would have been somewhat underestimated for respondents visiting other destinations on the way from home to work (e.g. kindergarten), in particular if these destinations are located significantly closer to the workplace.
 - 36 Fourteen respondents with extreme values on the dependent variable (one-way commuting distances ranging from 70–273 km) have been excluded from the analysis. Among the control variables mentioned in the Appendix, the following six were considered irrelevant to the analysis of commuting distances, as this analysis applies to workforce participants only and does not refer to any specific week of investigation: workforce participation, whether or not the respondent is a student/pupil, whether or not the respondent is a pensioner, number of days at the workplace or school during the investigated week, overnight stays away from home more than three nights during the investigated week, and occupational trips during the investigated week.
 - 37 If we had also controlled for the urban structural situation of the dwelling, the effect of workplace location would refer to a situation where the respondents had chosen residences completely independent of the locations of their workplaces. In this hypothetical case, commuting distances would tend to be significantly shorter to the peripheral than to the centrally located workplaces (Beta = -0.280 , $p = 0.000$). However, this is a highly unrealistic scenario – and from the point of view of reducing car dependency also an undesirable one.
 - 38 The respondents were asked if the move had contributed to an increase, a reduction or no change worth mentioning in the frequency of participation in each of the six activities. There was also a possibility to tick off for the cases where the activity in question was not relevant to the respondent.
 - 39 Respondents with extreme travel distances have been excluded, as these respondents have typically made one single or a few very long trips, which in practice will prevent them from making trips with other purposes. This implies the exclusion of four respondents with travel distances on Monday–Tuesday of 501–1,226 km and seven respondents with travel distances on Saturday–Sunday of 349–1,447 km.
 - 40 The bivariate relationships between the location of the dwelling relative to central Copenhagen and travel time per journey to work are also weak when segmenting travel times by transportation mode, with the following correlation coefficients (Pearson's r) and significance levels: car 0.067 ($p = 0.325$); public transport -0.097 ($p = 0.599$); bike -0.114 ($p = 0.255$). Mean travel time per journey to work is almost the same for car and non-motorized modes (21 and 20 minutes, respectively), but higher for public transport passengers (35 minutes).
 - 41 Respondents with extreme travel distances have been excluded.

- 42 The larger difference in total travel time on Monday–Tuesday than for commuting trips only may partly be a result of how trips and trip purposes were defined.
- 43 The use of linear regression in this analysis could be questioned, as a large majority of respondents have been either five or zero days at the workplace/place of education during the week of investigation. If we instead limit the analysis to those respondents who have been at the workplace/place of education at all during the week of investigation, and investigate (by means of logistic regression) factors influencing whether the persons have been at the workplace at least five days or up to four days, we find a weak, negative effect of local area density. The higher the density, the more often the respondents tend to have appeared fewer than five days at the workplace. This weak tendency to more frequent part-time work or telecommuting among respondents from dense local areas shows, combined with the absence of effects from any of the other urban structural variables, that there is no evidence in our material of any 'compensatory' reduced frequency of appearance among respondents living in the peripheral parts of the metropolitan area (cf. also Chapter 7).
- 44 Including the northern suburban areas R1–R6 as well as the northern inner-city areas C2 and C3, cf. Figure 3.3.
- 45 Including the southern suburban areas T1–T6 as well as the southern inner-city areas C1 and C5, cf. Figure 3.3.
- 46 Short distances to work, train station, bus stop, school/kindergarten, and shopping facilities.
- 47 Private garden, good opportunities for 'do it yourself' activities, undisturbed location, proximity to 'rural' recreation areas, nice view, distance from social housing estates, distance from heavy trafficked road/railway.
- 48 Yet, the separate effect of the location of the dwelling relative to central Copenhagen on the distance travelled on weekdays is strong within this group.
- 49 It should be noted that the percentages to the right in the table are not quite consistent with the result among the total sample of respondents, probably because the smaller sub-sample sizes make some of the relationships too uncertain, thus excluding them from the regression models.
- 50 Since the dependent variable is measured in five different intervals and does not follow a normal distribution, ordinal logistic regression has been preferred to ordinary least squares regression. Ordinal logistic regressions are also used in the analyses of flights later in the chapter, as these variables too are non-normally distributed and have only a few different values each (five).
- 51 A closer look at the data shows that the highest frequencies of trip-making outside Zealand are found among the travel diary respondents from the most peripheral parts of the metropolitan area. This tendency, which is not surprising given the fact that these respondents live closer to the mainland or neighbouring islands, may explain why the ordered logistic regression model does not show any effects of the urban structural variables. If the quartile of respondents living furthest away from inner-city Copenhagen are excluded from the analysis, the ordinal logistic regression analysis too shows a statistically significant ($p = 0.017$) tendency to more frequent trip-making outside Zealand among travel diary respondents living close to the city centre of Copenhagen.
- 52 It should also be noted that the compensatory effect of a high local area density on the amount of (car) travel at the weekend is only present as long as control is made for car

- ownership and transport attitudes. However, these latter variables are themselves influenced by residential location (cf. Chapter 9).
- 53 A similar tendency was found in Oslo metropolitan area (850,000 inhabitants, Holden and Norland, 2004) and Aalborg (160,000 inhabitants, Nielsen, 2002), but not in the little town of Frederikshavn (Næss and Jensen, 2004). Given its small size (26,000 inhabitants in the continuous urban area and 35,000 in the municipality), urban-cosmopolitan lifestyles are hardly widespread in Frederikshavn, not even in its central parts.
- 54 Travel time may of course be a relevant variable if the purpose of the analysis is to investigate welfare or economic consequences of transport, e.g. how simple or time-consuming it is to reach the locations where daily or weekly activities take place.
- 55 Røe (1999) has found a similar pattern among respondents in Oslo, cf. section 7.8.
- 56 According to Dryzek (1997), five major strands of environmental discourse can be identified in contemporary modern societies: Prometheanism, Environmental problem solving, Sustainability, Survivalism and Green radicalism. Of these, the first mentioned one (named from Prometheus who according to Greek mythology stole fire from Zeus and thereby vastly increased human capacity to manipulate the world for human ends) denies that the natural environment poses any limits to the volume or content of economic growth. In spite of the emergence of alternative discourses placing more emphasis on environmental protection, the Promethean discourse must still be considered the dominant one, in particular with respect to the policies actually implemented. See also Colby (1989).
- 57 Confer, for example, the strong opposition against hydroelectric development projects in countries like Norway, Chile and China, and the increasing opposition in Denmark and the Netherlands to wind farms.
- 58 The Brundtland Commission (1987: 171) has illustrated this by means of scenarios showing a possible implication of the combination of technological development in developing countries and a 'ceiling' for the total energy use at a global scale. In the 'low energy' example, the world's total energy use increases by 10 per cent during the period 1980–2020, but distributed in such a way that the energy use in industrial countries is reduced by 45 per cent, accompanied by a 120 per cent increase in developing countries. Even after such redistribution the energy use per inhabitant in EU countries would be much higher than the level in most developing countries. For example, energy use per capita in Denmark today is more than 200 times higher than in Burkina Faso.
- 59 Besides, our information about flights is not sufficiently detailed to make possible any inclusion of energy use for flights in the statistical analyses.
- 60 Our material shows a certain tendency among respondents living in dense local areas to own smaller cars than their suburban counterparts.
- 61 Details about the factors used in these calculations are given in Næss and Jensen (2005, p.430).
- 62 In Copenhagen Metropolitan Area, CO₂ emissions from the relevant modes of travel are nearly completely proportional to energy use. For car and bus travel there is a full proportionality, whereas there is a slight deviation for urban rail travel, as a certain part of the electricity used to drive the trains is supposed to stem from wind turbines. However, in spite of this slight difference, the standardized regression coefficients and significance

levels of the effects of the independent variables on energy use and CO₂ emissions are identical.

- 63 Travelling patterns in the typical holiday weeks (July–August, Easter and the schools' winter and autumn holidays) will of course deviate from weeks without any particular holidays. However, as already mentioned, some of our respondents recorded their travel in a week including Whit Monday as an ordinary day off and possible extension of the holiday period with additional days off before or after the Whitsun weekend proper. Yet, most of our respondents recorded their travel in the subsequent week, which was not affected by the Whitsun weekend. On average, our registration period(s) probably do not deviate much from the average proportion of holidays on an annual basis.
- 64 The deviation between these percentages and the corresponding, calculated percentages of energy use is probably due to the fact that the CO₂ figures include emissions resulting from energy production itself (i.e. including the loss resulting from the efficiency of thermal power plants being lower than 100 per cent). Distinct from that, our accounts of Denmark's energy use are based on *end use*, i.e. the energy actually used in the different sectors. The latter account is the most appropriate when comparing our respondents' energy use for transport. In total for all sectors, Denmark's end use of energy is 22 per cent lower than the gross energy use. However, for the transportation sector there is practically no difference.
- 65 Assuming 80 per cent apartments and 20 per cent two-story terrace houses in the 'bike hub' alternative, 80 per cent one-story single-family houses and 20 per cent two-story terrace houses in the 'car tyres' alternative, and average dwelling sizes of 90, 100 and 150 square metres for apartments, terrace houses and single-family homes, respectively, the differential between the alternatives amounts to approximately 3,600 kWh per person annually (Duun *et al.*, 1988).
- 66 Turning undeveloped areas into areas to be developed will to a large extent imply irreversibility. If a natural area is developed, it is practically impossible to reverse it – at any rate this will frequently take hundreds of years. The same thing applies for agricultural areas.

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