Urban Studies, Vol. 41, No. 3, 579–603, March 2004

Policies for Urban Form and their Impact on Travel: The Netherlands Experience

Tim Schwanen, Martin Dijst and Frans M. Dieleman

[Paper first received, November 2002; in final form, July 2003]

Summary. This paper documents an evaluation of the consequences of the Netherlands national physical planning policy for an individual's travel behaviour. Four components of this policy are considered: the concentrated decentralisation of the 1970s and 1980s; the strict compact-city policy of the 1980s and 1990s; the *A-B-C* location policy; and the spatial retailing policy. Using data from the 1998 Netherlands National Travel Survey, the article addresses the following questions. Did physical planning reduce the use of the private car and promote the use of public transport together with cycling and walking? Did physical planning lead to shorter travel distances and times? The analysis suggests that national spatial planning has been most effective in retaining high shares of cycling and walking in the large and medium-sized cities, in particular for shopping trips. In terms of travel time, however, spatial policy seems to have been less successful. The building of new towns and, more recently, the development of greenfield neighbourhoods close to cities do not appear to have reduced commuting times. Alternative strategies to promote the use of public transport, the bicycle and walking through the regulation of land use are discussed. Relaxing some of the present spatial planning controls is suggested to reduce car use and travel times.

1. Introduction

Fuelled by general concerns about environmental problems, over the past two decades, spatial planners have paid particular attention to the impact of urban form on mode choice and travel distance, especially for commuting. Compared with the US, where urban development is more often privately financed and less directed by national policies (Cervero, 1995), many European planners and politicians have proposed or implemented measures to limit urban sprawl and promote the development of compact urban forms as a means of reducing energy consumption through transport (Hart, 1992; Williams *et al*. 2000). Other important reasons for influencing and controlling the development of urban forms have been the preservation of agricultural land, open space and environmentally valuable areas, and the promotion of investment in existing built-up areas to halt neighbourhood decline.

The Netherlands has a long history of the intervention by spatial planners in the development of urban forms. In the 1970s and

Tim Schwanen, Martin Dijst and Frans M. Dieleman are in the Urban and Regional Research Centre Utrecht (URU), Faculty of Geosciences, Utrecht University, PO Box 80.115, 3508 TC Utrecht, The Netherlands. Fax: +31 30 254 0604. E-mail: T.Schwanen@geog.uu.nl; M.Dijst@geog.uu.nl; and F.Dieleman@geog.uu.nl. *The research reported here has been made possible by grant 425–13–003 from the Netherlands National Science Foundation (NWO) to the Urban and Regional Research Centre Utrecht. Frans Dieleman was able to work on the theme of this article through a grant of the Royal Netherlands Academy of Arts and Sciences (KNAW) for the Netherlands Visiting Professorship at the University of Michigan, Ann Arbor.*

0042-0980 Print/1360-063X On-line/04/030579–25
DOI: 10.1080/0042098042000178690

1980s, a policy of concentrated decentralisation of urban land use was implemented by developing designated growth centres and prohibiting the growth of small rural settlements (Dieleman *et al*. 1999; Bontje, 2001). In the 1980s, a policy of compact urban growth was formulated; it has been implemented since the 1990s (Hayer and Zonneveld, 2000). This policy was supplemented by policies of large investments in the renewal of the urban housing stock and the strict regulation of the location of retail facilities with a ban on the development of large out-of-town shopping malls (Evers, 2002). Additionally, the national government has tried to channel new employment into nodes that were well served by public transport through the *A*-*B*-*C* location policy (Dijst, 1997).

Because of planners' intensive regulation of spatial development over a long period, the Netherlands provides an interesting case in which to evaluate the impact of national spatial planning policies on the travel behaviour of individuals. This article documents an evaluation of the impact of some of the national spatial policies on the development of urban form and through this on travel patterns in the Netherlands. Which policies have stimulated the use of public transport and of short trips? In what respect did these policies fail to promote walking, cycling and the use of public transport and to reduce travel times and distances, and what were the likely causes of the failure? We support our arguments with empirical data from the 1998 Netherlands National Travel Survey, supplemented by results from our own recent work on travel behaviour and urban form (Schwanen, Dieleman and Dijst, 2001, 2003a, 2003b; Schwanen, Dijst and Dieleman, 2001, 2002) and other studies on this theme.

The next section gives a summary of some of the main spatial policy measures of the post-World-War II era in the Netherlands. Section 3 presents some empirical results on the relationship between urban structure and travel against the spatial policies implemented. In section 4, some conclusions are drawn and some possible ways of making spatial policies more effective in terms of their travel outcomes are discussed.

2. Physical Planning Controls on Urban Dynamics in the Netherlands

A whole range of policy measures has been designed and put into action to regulate urban spatial dynamics in the Netherlands during the past three decades. We briefly summarise spatial planning controls on urban expansion and the compact-city policy, investments in urban renewal and attempts to influence the location choice of firms and retail planning.

In the Second Physical Planning Memorandum (MVRO, 1966), the national government took a powerful stand against suburban sprawl that was at that time threatening to engulf the Green Heart of the Randstad Holland. This is the (relatively) open space surrounded by the major cities in the western part of the Netherlands (Figure 1; Faludi and van der Valk, 1990; Dieleman *et al*., 1999). The report proposed channelling suburbanisation into 'concentrated decentralisation'. More specifically, new urban growth was to be accommodated outside the existing cities in a number of designated overspill centres referred to as growth centres. The Netherlands does not stand alone in this approach. Similar initiatives have been undertaken elsewhere in Europe—for example, in England, Sweden and the Paris region (Cervero, 1995). This policy was put into practice in the late 1970s and early 1980s. It was very successful in terms of concentrating suburban residential growth into the designated growth centres and prohibiting the growth of rural villages in the Green Heart (Faludi and van der Valk, 1990).

Nevertheless, the policy of concentrated decentralisation of urban growth was brought to an end during the 1980s (Dieleman *et al*., 1999; Hayer and Zonneveld, 2000). Inner-city decline became a major issue on the policy agenda. Many government officials and academics blamed this decline on the policy of concentrated decentralisation (see—for example, MVROM, 1988). The

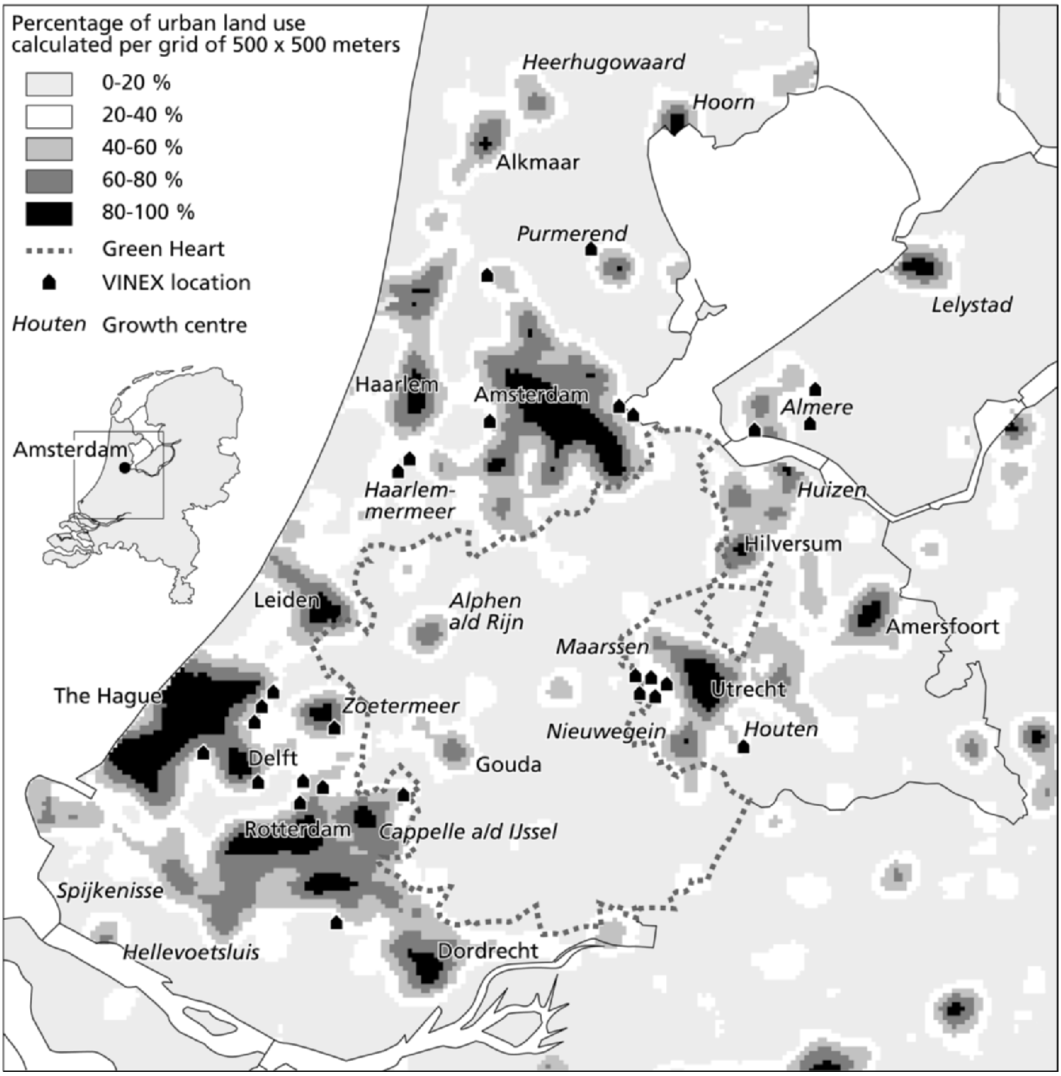

Figure 1. Growth centres and VINEX locations in the western part of the Netherlands.

policy did indeed foster an unprecedented wave of suburbanisation in the Netherlands, leading to substantial income differences between city centres and the suburbs (Dieleman and Wallet, 2003). A new policy of compact urban growth was developed and put into practice. Under this new policy formulated in the Fourth Physical Planning Memorandum Extra (MVROM, 1991) and now being implemented, urban growth is guided into (re)development locations within existing cities (brownfield sites) and towards new greenfield sites directly adjacent to the built-up areas of the larger cities in the Netherlands (Figure 1). Leidsche Rijn—the greenfield development immediately to the west of Utrecht—is the largest of these VINEX locations. Here, some 30 000 dwellings and 10 000 jobs are being created. The compact-city policy also promotes the construction of relatively dense new residential neighbourhoods in suburban settlements that kept expanding and accommodating part of the urban growth outside the VINEX locations.

In the same period in which spatial planning in the Netherlands changed track from concentrating suburbanisation in growth centres to compact urban redevelopment, the national government embarked on an extensive programme of urban renewal. Large subsidies were given to upgrade the quality of the housing stock, particularly in the old cores of the largest cities. Oskamp and colleagues (2002) show how, in 1985, of all the Dutch housing stock, 19 per cent was still in the category of “in poor condition”, whereas this share was reduced to 1 per cent in 2000. The major cities of Amsterdam, Rotterdam, The Hague and Utrecht have benefited most from the urban renewal policy, which has helped to upgrade the old private rental housing stock in the urban cores. However, the urban renewal policy showed little concern for retaining or attracting employment in the core areas of the cities. This neglect has certainly been one of the causes of the rapid development of the larger Dutch cities from monocentric to polycentric functional units. The majority of jobs in many cities can now be found in new employment concentrations outside the old original city centres. The policy of urban renewal has been reformulated in the Big Cities Policy that, notwithstanding its broader scope, has as one of its main aims the renewal and partial replacement of social housing estates built in the 1950s and 1960s (van Kempen and Priemus, 1999; van Kempen, 2000).

The Fourth Physical Planning Memorandum (MVROM, 1988) introduced a policy for the location of firms, the *A-B-C* location policy. This policy was explicitly formulated to discourage the use of the private car and to promote the use of public transport together with cycling and walking. *A* locations were centrally located sites often close to main railway stations and hence readily accessible by public transport. In contrast, *B* locations—typically situated in development nodes outside the larger CBDs and the centres of smaller urban settlements—were reasonably well connected to public transport and readily accessible by car. *C* locations usually had very good motorway access. Typical examples were business zones in the urban fringe area or alongside motorways. The intention of the policy was to guide new employment and public services as much as possible towards *A* and *B* locations.

The *A-B-C* policy turned out to be very hard to implement (MVandW, 1999). Local government authorities often gave higher priority to attracting new employment than to the locational requirements of the new firms. Furthermore, *B* locations were often less accessible by public transport than had been predicted. Most importantly, however, the growth in employment in the office sector was much larger than had been planned in the 1990s and could not be accommodated fully in *A* and *B* locations as originally planned. As a result, the largest employment growth in the 1990s occurred at *C* locations. The location policy has been modified as a result of its malfunction and changes in policy aims. The main aims of this renewed and more broadly defined policy are not only to encourage the optimal use of different transport systems, as in the ‘old’ *A-B-C* policy, but also to encourage economic development, spatial quality and the quality of the living environment (MVROM, 2001).

Finally, it is pertinent to discuss the very specific position taken in the Netherlands with regard to retail planning (Evers, 2002). One of the salient features of the deconcentration of urban land uses in many countries is the growth of out-of-town hypermarkets and shopping malls. In the Netherlands national legislation was enacted to prohibit such developments in 1973, because the establishment of out-of-town shopping malls was seen as a threat to the vitality of town centres and likely to generate extensive car use. Netherlands retail policy has been highly effective in reaching its objectives. Many shops are still located within the built-up area of cities and towns, and within walking and cycling distance for local residents (Evers, 2002). Nowadays, however, traditional retail planning is under heavy pressure. In the current era of deregulation and privatisation, the policy is being blamed for curtailing retail productivity and competitiveness and creating barriers for new firms to enter the retail market.

In short, despite the failure of the *A-B-C* location policy, spatial planning has been fairly successful during the past few decades in guiding residential and retailing developments towards the locations that had been planned. This success can be considered a substantial achievement, given the difficulties often encountered in implementing policies of compact urban growth and containing urban sprawl (Dieleman *et al*., 1999). The question remains, however, to what extent these spatial policies have been successful in terms of their travel-related objectives. Have the policies led to larger shares for public transport and walking and cycling? Or to shorter travel distances and times?

3. Physical Planning and Travel Behaviour: A Confrontation

Using the 1998 Netherlands National Travel Survey (NTS), we have analysed the influence of urban form on travel behaviour in the Netherlands. One-day travel-diary data from male and female heads of households have been used. For these individuals, information is available about all their trips on a single day together with their socioeconomic and demographic situation (Statistics Netherlands, 1999).

The NTS also contains information about a household's residential location at the level of the municipality ($n \approx 550$ in 1998). Two categorisations of these municipalities have been used to represent urban form. The first classifies the degree of urbanisation of the residential environment into six categories (Figure 2); the second distinguishes four types of daily urban systems: one monocentric (centralised) and three polycentric forms (Figure 3). Further details are provided in Appendix 1. All descriptive results presented in the tables are weighted so that they are representative for the whole Dutch population. In our evaluation of Netherlands national spatial planning policy of the past few decades, we focus on three main dimensions of travel behaviour. Sub-section 3.1 reports an assessment of how spatial policies and urban forms may have influenced modal choice, while 3.2 discusses travel distance and time. The focus is not only on commuting, but also on shopping trips and to a lesser degree on leisure travel.

3.1 Modal Choice

Attempts to influence modal choice through spatial planning are usually based on the premise that urban compactness induces higher shares for public transport, cycling and walking at the expense of the private car. The concept of compactness comprises several interrelated urban form dimensions: high density, a land-use mix and short distances to the urban core and suburban concentrations of employment or retailing.

In line with the academic literature (Camagni *et al*., 2002; Cervero, 1996a, 1996b, 2002; Frank and Pivo, 1994), we find that car use for commuting falls and the share for public transport rises with the degree of urbanisation. What is peculiar to the Netherlands is that so many commuters travel by bicycle or on foot. Ranking residential environments within and outside the Randstad Holland from high to low urbanisation shows that the levels of cycling and walking as well as bus/tram/metro use fall with decreasing levels of urbanisation, whereas the share of the car-driver mode rises (Table 1). The larger share for mass transit reflects the fact that higher population densities and levels of land-use mixing facilitate more extensive public transport systems. The greater use of slow modes of transport—cycling and walking—is a result of the fact that, in the more urbanised environments, more activity locations can be accessed within acceptable walking and cycling (time) limits. The effect of the level of urbanisation on modal choice remains strong after account is taken of personal and household attributes; after car ownership, the level of urbanisation is the most important determinant of modal choice (Dieleman *et al*., 2002). Based on these statistics, we may conclude that the policies of redeveloping brownfield sites, urban re-

Table 1. Modal split by trip purpose and level of urbanisation in the Netherlands, 1998.

	Randstad					Rest of the Netherlands	
	Three large cities	Medium-sized cities	Suburbs	Growth centres	Randstad, total	More urbanised	Less urbanised
Percentage of commuters using							
Car driver	37.4	44.4	60.8	56.8	50.6	52.7	64.9
Cycling	31.2	29.5	22.4	18.7	24.5	32.1	22.6
Walking	8.8	8.1	4.7	5.0	6.6	5.2	4.0
Train	11.0	14.5	4.9	9.2	9.1	4.5	1.9
Bus/tram/metro	14.9	4.8	3.7	7.9	7.9	2.3	1.6
Percentage of shoppers using							
Car driver	25.6	28.4	44.0	43.9	35.6	40.3	52.4
Cycling	26.4	38.8	30.4	26.9	30.5	33.8	30.0
Walking	41.0	34.3	22.9	26.5	31.0	23.6	14.7
Train	1.5	2.1	1.5	1.6	1.6	0.9	0.3
Bus/tram/metro	12.2	2.9	1.9	4.2	5.5	1.8	0.9

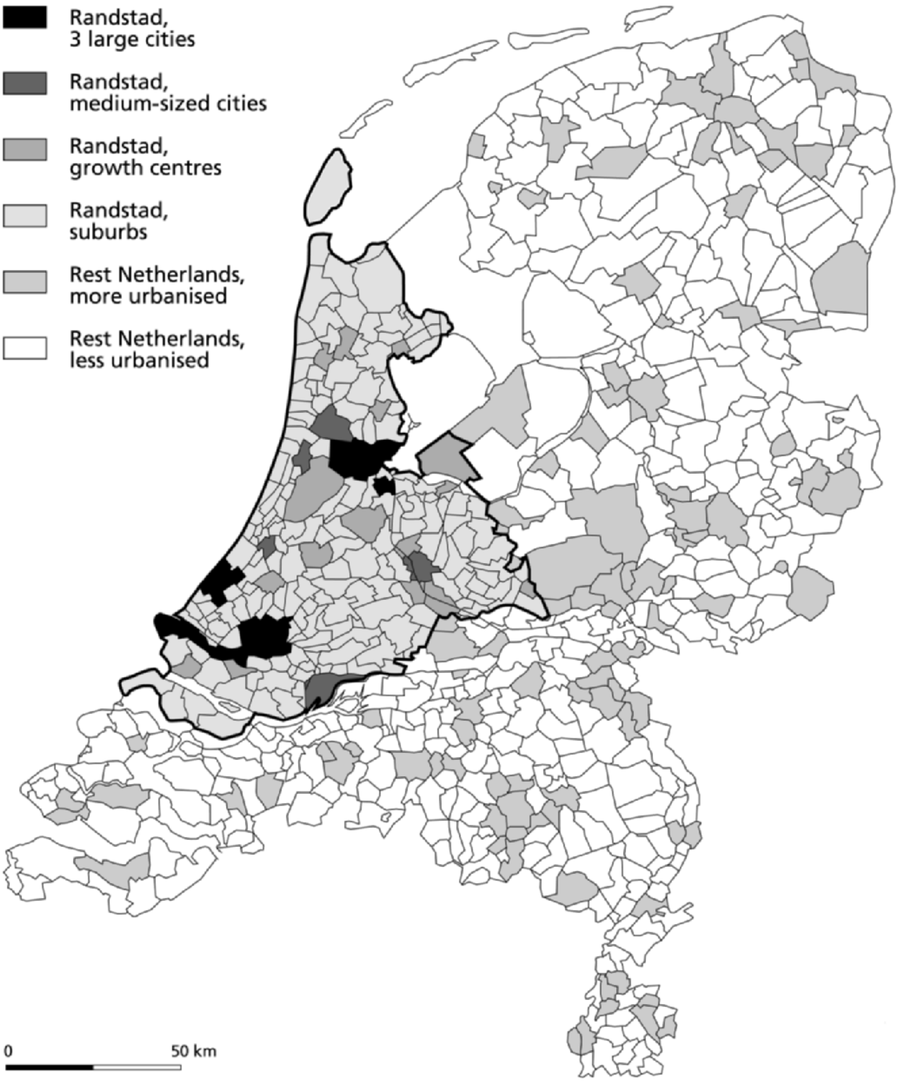

Figure 2. Classification of municipalities in the Netherlands: degree of urbanisation.

newal and upgrading the inner-city housing stock have contributed to a modal split for commuting in the large and medium cities in which walking, cycling and the use of public transport predominate (Table 1).

In terms of influencing the modal split for shopping trips, the policies of creating compact cities and retail planning seem to have been even more successful. As Table 1 indicates, the importance of walking and cycling is even more pronounced for shopping than for commuting. Of the people engaging in shopping in the three large cities and the medium-sized cities of the Randstad Holland, no less than 41 per cent and 34 per cent respectively travel on foot. These percentages stand in sharp contrast with the mere 14 per cent for the least urbanised environments outside the Randstad Holland. Furthermore, in the Netherlands many people use a bicycle for shopping. In all residential environments, over a quarter of the population cycle to the shops; this percentage is highest in the medium-sized cities and more urbanised munic-

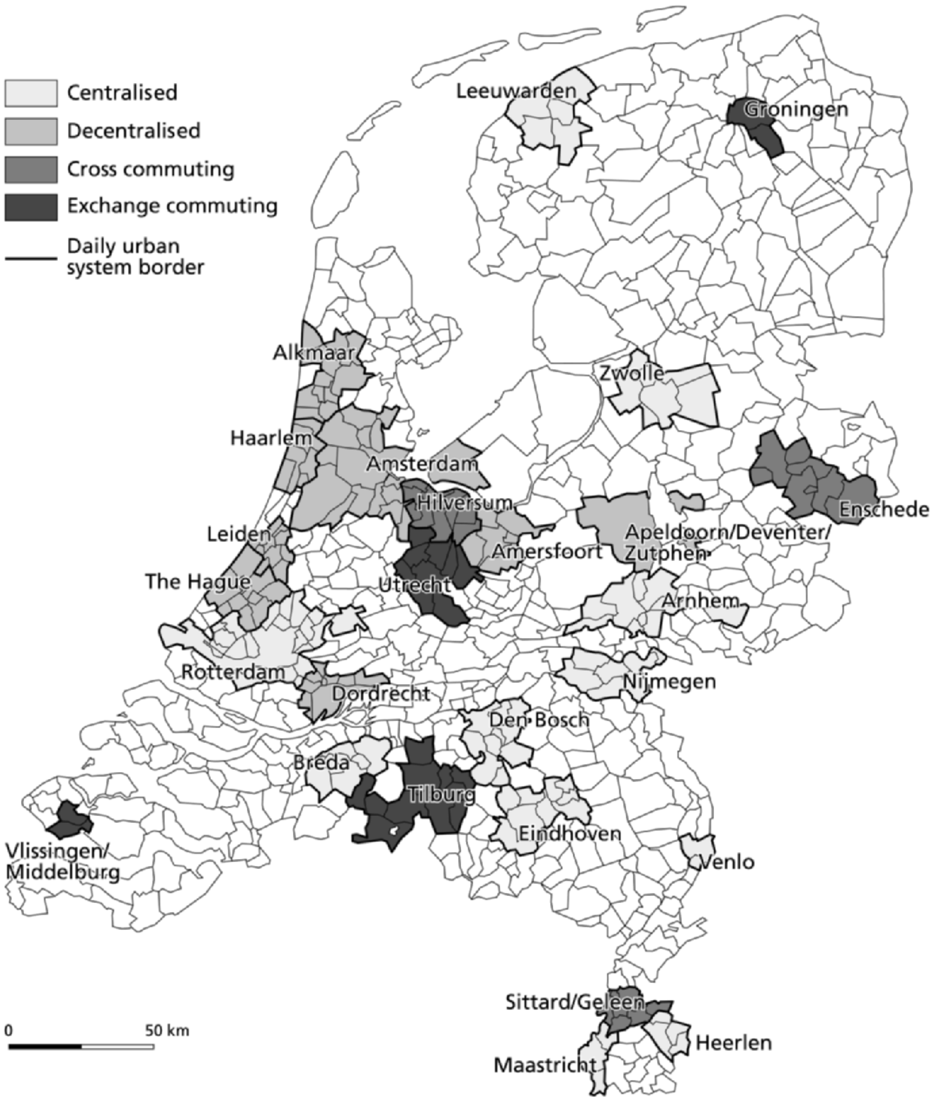

Figure 3. Classification of municipalities in the Netherlands: urban structure. *Source*: Based on Van der Laan (1998).

ipalities outside the Randstad Holland. A survey of the relevant academic literature indicates that these high shares of the slow modes of transport are exceptional. While elsewhere the bicycle is rarely used for shopping, particularly in the US, there is some evidence that in some high-density, mixed neighbourhoods in the UK and the US shares for walking do tend to mirror those for the largest cities in the Netherlands. In general, however, the level of car use for shopping seems to be much higher in urban areas in these countries (see—for example, Frank and Pivo, 1994; Handy and Clifton, 2001; Van and Senior, 2000). Credit for this lower level of car use in the Netherlands can undoubtedly be attributed to the policies of stimulating the development of compact and diverse residential neighbourhoods and limiting retail sprawl.

While the strict compact-city policy of the past decade has had beneficial effects in terms of modal split, the impact of its predecessor—the policy of concentrated decentralisation—seems to have been more mixed. As explained in section 2, in the 1970s and early 1980s, national spatial planning focused on the development of growth centres to accommodate suburban growth. A comparison of the modal split in the growth centres and the suburbs of Randstad Holland, which represent a more dispersed decentralisation pattern, shows that the inhabitants of the growth centres are somewhat less dependent on the private car for commuting. The level of commuting by train is higher, reflecting the fact that almost all growth centres are directly connected by rail to the main employment centres. However, the level of bicycle use is lower in the growth centres, which seems to be related to the qualitative mismatch between residents and employment in many new towns (section 3.2). With regard to shopping, the results again indicate that the relatively good public transport connections between the new towns and the main urban centres lead to greater use of the bus/tram/metro. The share of the private car for shopping trips in the growth centres is as large as in the suburbs of Randstad Holland. Although conclusions about the effectiveness of spatial policy should be drawn from these results with caution, it seems that the impact of the policy of concentrated decentralisation on modal split is relatively limited.

There are also several aspects of spatial planning policy that seem to have had less favourable consequences for modal choice. Focusing again on the more recent policy of concentrating residential development within and adjacent to existing built-up areas, it can be argued that there are second-order effects of a compact-city policy (Priemus *et al.*, 2001). The more compact the city, the more likely are some urban functions to relocate to the suburbs. It may well be that the 'cramming' (Counsell, 2001) of housing into the built-up and redeveloped parts of Dutch cities has accelerated the deconcentration of employment towards *C* locations situated near the motorways (section 2). Such location behaviour will almost certainly have resulted in greater car use, because these locations are not well served by public transport and neither are they suited to bicycle travel.

In addition, although in the more urbanised environments the car is partly substituted for by public transport, its higher shares are sometimes reached at the expense of cycling. Comparison of the medium-sized and three large cities for shopping in Table 1 provides some evidence for the substitution of public transport for cycling. In other words, higher-quality public transport at the local level seems to compete not only with the private car, but also with the bicycle (Dieleman *et al.*, 2002). Similar evidence was found for leisure travel by Dutch senior citizens (people aged 50 or older and living independently in a one- or two-person household) (Schwanen, Dijst and Dieleman, 2001) and in a comparative study of commuting behaviour in 11 European cities (Schwanen, 2002).

Furthermore, while the development of housing on brownfield sites within the existing urban fabric may lead to less car travel, it remains to be seen whether the development of compact greenfield sites adjacent to the existing built-up areas of cities reduces the probability of using a car. Some preliminary evidence is available for people who have recently moved to the newly built VINEX neighbourhood of Leidsche Rijn situated on the fringe of the city of Utrecht (Figure 1). Dijst and colleagues (2000) found that, after moving to Leidsche Rijn, a shift from any other means of transport to the private car occurred more often than the reverse. Relocating to this greenfield development is thus associated with higher levels of car dependence. This may be attributed to the fact that, in order to minimise operational deficits, most public transport services in these locations are only made available after most residential units have been completed. In addition, Leidsche Rijn has very good access to motorways and the residents are to a large extent young, two-earner couples and families with a relatively high income. The women in such households in particular rely on the private car for commuting to ease the combination of paid labour with household maintenance activities (Hjorthol, 2000; Schwanen *et al.*, 2003b). Furthermore, it appears that policy-makers have incorrectly assumed that the new residents of Leidsche Rijn would be employed in the city of Utrecht and its surroundings. However, since Leidsche Rijn provides excellent access to jobs located in many parts of the Randstad Holland (van Ham *et al.*, 2001), many residents commute by private car to work locations outside the Utrecht area.

3.2 Travel Distance and Time

Since the amount of energy used for transport depends on distance travelled as well as mode choice, many previous studies have focused on the impact of urban form on travel distance. We have therefore also assessed the impact of spatial planning policies on the distance people travel per day for commuting, shopping and leisure activities. However, since "time use is … a critical element for a thorough understanding of travel behaviour" (Kitamura *et al.*, 1997, p. 171), we have also considered how time spent on travelling varies with the characteristics of the built environment.

With respect to distance travelled, many previous studies have indicated that a higher degree of urbanisation is associated with shorter travel distances in general as well as distance travelled by private car (Næss *et al.*, 1995; Kenworthy and Laube, 1999; Kockelman, 1997). Compact urban structures thus result in travel patterns that are efficient in the sense that the distances travelled are shorter than in lower-density or more dispersed urban areas (Camagni *et al.*, 2002). Evidence for shorter daily travel distances with a higher level of urbanisation is also borne out for shopping in Table 2. For commuting, the average distance travelled as a car driver is somewhat lower in the three large cities of Amsterdam, Rotterdam and The Hague and in the more urbanised municipalities outside Randstad Holland than elsewhere.

The relationship between degree of urbanisation and travel time appears to be more complicated. For the US, Levinson and Kumar (1997) found that commuting times by private car first decrease with population density, but then start to rise with the number of persons per square mile above some density threshold. In the Netherlands, travel times for car drivers tend to rise somewhat with the level of urbanisation for shopping (Table 2) and leisure (not shown due to space limitations). For commuting, the results are again a little more complicated. Nevertheless, the average for the medium-sized cities is higher than for the suburbs. In addition, the average for the Randstad Holland as a whole is higher than that for the rest of the Netherlands. Furthermore, the difference between the more urbanised and less urbanised environments outside the Randstad Holland is much smaller than in the case of commuting distance.

Because the results in Table 2 may partly reflect differences in population composition and the variation around the mean values is considerable, we have estimated four multilevel regression models with sociodemographic factors and the typology of residential environments as independent variables. Multilevel regression modelling is an elaboration of standard ordinary least squares regression. Compared with standard regression modelling, parameter estimates and t-statistics especially for variables at the higher levels of analysis (the residential municipality) are improved, because residual variance is not captured by one but by several variance terms. Technical details are provided in Appendix 2. The sociodemographic variables included in the analysis reflect socioeconomic status (household income, education), transport availability (car availability), life-cycle (age, household type) and role within the household (gender, interactions of gender and household type). They were selected on the basis of extensive preliminary analysis. Their estimated coefficients (Table 3) are consistent with expectations and previous analyses. For instance, in line with numerous other studies (Johnston-Anumonwo, 1992; Turner and Niemeier, 1997), our models show that gen-

Table 2. Daily travel distance (km) and time (minutes) per person as a car driver, by trip purpose and level of urbanisation of the residential municipality in the Netherlands, 1998

	Commuting				Shopping			
	Distance		Time		Distance		Time	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Randstad Holland								
Three large cities	39.6	44.2	53.2	40.8	14.9	21.0	31.5	32.6
Medium-sized cities	43.9	50.6	56.6	45.4	15.5	21.4	29.6	23.5
Suburbs	41.9	45.9	52.5	40.8	15.7	21.9	28.1	25.0
Growth centres	43.9	45.2	56.1	43.5	16.9	23.8	29.5	25.7
Total	42.0	46.2	53.8	42.0	15.7	21.9	29.3	26.8
Rest of the Netherlands								
More urbanised	38.7	49.0	48.6	42.7	13.8	18.3	27.2	23.0
Less urbanised	41.4	49.1	49.5	42.9	16.3	26.0	27.4	24.3

Note: Data are averages for people who drive a car to work or for shopping.

Table 3. Multilevel regression models for total daily travel distance and time as a car driver for commuting and shopping

	Commuting				Shopping			
	Distance		Time		Distance		Time	
	Coefficient	*T*-statistic	Coefficient	*T*-statistic	Coefficient	*T*-statistic	Coefficient	*T*-statistic
Fixed part								
Constant	2.989	42.78	3.271	61.98	1.975	34.93	2.761	81.95
Sociodemographic factors								
Age (in years)	− 0.002	− 1.69	0.004	4.93	0.004	4.38	0.007	11.64
Female	− 0.535	− 17.54	− 0.293	− 13.42	− 0.266	− 11.23	− 0.141	− 8.84
Single female, working > 12 h per week	0.171	3.03	0.113	2.35	0.258	4.01	0.237	3.72
Single female, working 0–12 h per week	1.180	3.73	0.819	3.51				
Female in two-worker couple	0.239	6.32	0.133	4.86				
Female in one-worker couple	0.347	4.60			− 0.099	− 1.32		
Female in one-worker family					− 0.107	− 2.01		
Single person, working > 12 h per week			− 0.059	− 1.90			− 0.122	− 2.71
Single person, working 0–12 h per week	− 0.370	− 1.80	− 0.327	− 2.13				
Two-worker couple					0.167	5.02		
One-worker couple					0.195	3.60		
Zero-worker couple					0.111	2.58		
Two-worker family							− 0.081	− 3.71
One-worker family	0.075	2.89	0.041	2.10	0.104	2.38		
Family with adult(s) working 0–12 h per week	0.290	1.71	0.273	2.17				
Other household types	0.059	2.52	0.041	2.42	0.070	2.33		
Car availability index	0.229	8.94	0.132	6.91	0.114	3.74		
Employed for > 30 h per week	0.237	8.40	0.173	8.31				
Low educational attainment	− 0.228	− 10.09	− 0.142	− 8.49	− 0.028	− 1.34		
Medium educational attainment	− 0.141	− 6.78	− 0.107	− 6.95				
Household income	0.003	5.46	0.002	4.07				
Household income is unknown	− 0.022	− 0.85	0.027	0.02				

Residential environment								
Randstad Holland, three big cities	− 0.136	− 2.55	0.069	2.05	− 0.122	2.37	0.121	3.71
Randstad Holland, medium-sized cities	− 0.017	− 0.29	0.126	3.51	− 0.074	− 1.37	0.112	3.45
Randstad Holland, suburbs	− 0.008	− 0.27	0.057	2.91	− 0.050	− 1.64	0.014	0.69
Randstad Holland, growth centres	0.072	1.30	0.139	4.11	− 0.033	− 0.64	0.062	1.98
Rest Netherlands, more urbanised	− 0.155	− 5.01	− 0.035	− 1.77	− 0.123	− 4.15	0.018	0.96
Rest Netherlands, less urbanised	0		0		0		0	
Random part								
Variance term for individual level (σ^2_{e0})	1.073	85.90	0.589	86.05	1.041	24.07	0.570	24.07
Variance term for household level (σ^2_{u0})					0.115	2.76	0.674	29.54
Variance term for municipal level (σ^2_{v0})	0.024	6.09	0.006	3.70	0.011	3.00	0.000	0.00
Number of observations	15 215		15 215		12 034		12 034	
− 2 log likelihood at constant	45 819.8		36 277.1		36 347.6		29 117.7	
− 2 log likelihood at convergence	44 492.9		35 260.0		35 985.3		28 713.7	
Chi-squared model improvement	1 327.0		1 017.2		362.2		403.9	
Dependent variable	LN(daily travel distance as a car driver for commuting)		LN(daily travel time as a car driver for commuting)		LN(daily travel distance as a car driver for shopping)		LN(daily travel time as a car driver for shopping)	

der is an important determinant of commuting distance and time, but its effect depends on household structure. Table 3 also shows that travel patterns for shopping are to a lesser degree dependent on sociodemographic situation than commuting travel.

Regarding the residential environment, the estimated coefficients largely corroborate the observations on the basis of Table 2. Both for commuting and shopping travel, distance as a car driver tends to fall with the degree of urbanisation within and outside Randstad Holland. For travel time, the conclusions are almost opposite: travel time rises with urbanisation level for shopping, while for commuting time the highest coefficients are associated with the growth centres and the medium-sized cities of the Randstad Holland. Only small differences exist in travel time between more and less urbanised municipalities outside Randstad Holland.

For travel modes other than the private car, the association between the degree of urbanisation and travel time is similar to that between distance and urbanisation level. Whereas there is no discernible relationship between time spent walking to shops and residential environment, the average distance and time travelled by bicycle are greater in more urbanised environments (Table 4). The same is true for commuting and leisure travel (Dieleman *et al.*, 2002; Schwanen, Dijst and Dieleman, 2002). In contrast, travel distance and time for public transport modes tend to be lower in more urbanised environments. This finding is related to the fact that, in the three large cities and medium-sized cities, more people make use of public transport systems at the city or daily urban system level. Such systems operate at higher frequencies here than elsewhere in the Netherlands.

What conclusions about the effectiveness of national spatial planning policies can be drawn from Tables 2–4? A first conclusion is that, despite the fact that the commute distance and time for car drivers vary with the type of residential environment, the importance of urban form in influencing commuting behaviour should not be overestimated. The variation within residential environment types is large, as the standard deviations in Table 2 show. Furthermore, the variance terms estimated in the multilevel models in Table 3 can be used to determine the share of the municipal level in the total variation in a dependent variable. These shares can be calculated by dividing the estimate for the residential level in a model with only a constant included as an explanatory variable by the sum of all variance estimates in such a model (Snijders and Bosker, 1999). For the four variables analysed here, these shares are: 2.6 per cent (commuting distance as a car driver); 1.7 per cent (commuting time as a car driver); 1.0 per cent (distance as a car driver for shopping); 0.4 per cent (travel time as a car driver for shopping). These results clearly illustrate that variations between travellers *within* residential municipalities are much larger than differences *between* such spatial units. Similar conclusions can be found in Herz (1983) and Weber and Kwan (2003).

The fact that travel times tend to be longer in more urbanised environments is both a positive and a negative outcome of national physical planning policy. On the one hand, the slightly greater travel times in more urbanised environments depress car use. Thus, for shopping travel we might infer that the combination of strict retail planning and the concentration of housing development within or adjacent to existing built-up areas has contributed to travel patterns that are less detrimental from an environmental perspective than would have been the case had many large-scale shopping malls been developed in urban fringe areas. On the other hand, the longer travel times in the more urbanised environments may have important second-order effects (Priemus *et al.*, 2001). It has repeatedly been shown that households tend to favour residential locations providing good access, or limited travel time, to employment locations (Brun and Fagnani, 1994; McDowell, 1997) as well as shopping opportunities (Lerman, 1976) and recreational activities (Guo and Bhat, 2002). Many households might thus prefer residential

Table 4. Average daily travel distance (km) and time (minutes) per person for shopping activities, by transport mode other than the private car and level of urbanisation in the Netherlands, 1998

	Cycling				Walking				Train				Bus/tram/metro			
	Distance		Time		Distance		Time		Distance		Time		Distance		Time	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Randstad Holland																
Three large cities	4.6	4.6	25.2	23.5	1.7	1.7	20.7	20.3	32.9	22.7	73.9	43.8	10.0	7.9	46.6	42.3
Medium-sized cities	4.4	3.6	23.3	18.6	1.7	1.7	21.1	21.2	52.5	35.9	80.1	38.7	12.9	12.4	51.4	31.1
Suburbs	4.2	4.3	21.5	19.1	1.8	1.7	21.6	21.5	60.6	60.4	89.6	59.3	18.4	13.3	50.7	32.5
Growth centres	4.4	4.0	22.2	16.6	1.7	1.7	20.3	25.4	38.6	27.5	61.6	26.5	20.6	17.4	54.4	36.8
Total	4.4	4.2	23.0	20.0	1.7	1.7	21.0	21.4	48.1	44.2	79.3	47.9	12.4	11.2	48.4	39.6
Rest of the Netherlands																
More urbanised	4.4	3.9	22.4	19.5	1.7	1.7	20.8	23.3	93.3	98.0	107.2	82.9	16.0	26.9	44.4	45.9
Less urbanised	3.9	3.9	19.9	17.3	1.5	1.5	20.8	27.9	49.4	36.2	69.9	35.3	22.0	16.4	47.9	28.5

Note: Data are averages for people who go shopping and use a given mode.

locations where travel to relevant activities takes less time and therefore choose to relocate to a lower-density environment if they were given the opportunity to do so. In other words, a further suburbanisation of households may be one of the longer-term consequences of the compact-city policy and this may offset some of the short-term benefits, such as fewer car trips and car kilometres travelled.

In short, we may conclude that spatial policies have probably only made a modest contribution to an increase in travel efficiency in terms of travel distance and time in certain parts of the urban system or in travel behaviour in the country as a whole. Some additional empirical evidence can be given to support this conjecture.

First, while comparisons of travel patterns in urban areas in different countries are difficult because of large differences in type of analysis and level of detail, some empirical evidence about travel distance and time is available to put the above results in an international perspective. This material suggests that, notwithstanding its strong planning tradition, commuting patterns in the Netherlands are not exceptionally efficient. A study that compared average commuting distances and times across metropolitan regions revealed that Amsterdam takes an intermediate position in Europe (Schwanen, 2002). For the country as a whole, the evidence points at a less rather than a more efficient commute. The Dutch commute on average 46 minutes per day, substantially more than in many other countries in Europe (NRC Handelsblad, 2001). This comparatively long time seems to result from a combination of longer commute distances (Jansen, 1993) and more severe road congestion (Jansen *et al*., 2002; Bovy and Salomon, 2002). However, the Netherlands do differ from other west European countries in terms of the share of total distance that is covered by slow transport modes. Whereas the share of walking and bicycling in the total distance was 4 per cent in 1990 for western Europe as a whole (Hart, 2001), this share was 12 per cent for the Netherlands (Dieleman *et al*., 1999). Explanations for this difference are, for instance, the pro-public transport and bicycle planning and less positive attitudes towards the car in the Netherlands.

Secondly, the policy of concentrated decentralisation does not seem to have resulted in more efficient commuting patterns. Tables 2 and 3 indicate that, for car drivers, total commute distances and times are larger in growth centres than in other suburban parts of the Randstad Holland. These high averages seem to be primarily related to the quantitative and qualitative mismatch between workers and employment in the new towns. In quantitative terms, the number of jobs has long lagged behind the number of houses in these growth centres, turning them into dormitory towns (van der Laan, 1998). Over time, however, the number of jobs in these settlements has increased. Nevertheless, many workers in growth centres reside elsewhere and many residents of these new towns work elsewhere, suggesting that the skills and preferences of growth-centre residents correspond less with the available jobs than in other suburban communities (qualitative mismatch). For shopping, the differences between growth centres and other suburban localities are less pronounced, indicating that over time retailing supply in the new towns has reached a mature state, comparable with that in other communities.

Thirdly, a comparison of commuting behaviour in monocentric and polycentric areas of the daily urban systems (DUS) in the Netherlands provides little evidence of spatial planning efforts having created efficient travel patterns. Rather, the reverse seems to be the case. It has often been argued that polycentric urban areas have developed because of households' and employers' preference for locations where congestion is limited (Anas *et al*., 1998; Carlino and Chatterjee, 2002). To escape congestion, households and their members periodically change jobs and/or residential location, so that they can travel shorter distances, or use less congested routes. Employers move to lower-density environments for similar reasons. Nevertheless, there is a tendency among

Table 5. Average daily travel distance (km) and time (minutes) for commuting as a car driver, by type of daily urban system in the Netherlands, 1998

	Commuting distance		Commuting time	
	Average	Standard deviation	Average	Standard deviation
Centralised	37.6	46.1	49.5	41.1
Decentralised	40.9	45.3	53.6	41.9
Cross commuting	35.5	44.4	47.4	38.2
Exchange commuting	42.9	54.2	53.3	50.7

Note: Data are averages for car-driving commuters.

firms to concentrate in suburban nodes of development, or edge cities (Garreau, 1991), where they can benefit from agglomeration economies resulting from the presence and proximity of other firms. This line of reasoning is known as the co-location hypothesis; Gordon and colleagues (1989a, 1989b and 1991) and Levinson and Kumar (1994) present some empirical support with data from a range of US urban areas. However, the contention that polycentrism leads to more efficient commuting patterns has been challenged. Clark and Kuijpers-Linde (1994) and Cervero and Wu (1998), for example, found that car travel times and distances are higher in polycentric than in monocentric areas.[1] By comparing commuting behaviour in 26 urban areas in the Netherlands, we have investigated how polycentrism is associated with lower commute times and distances for car drivers in the Netherlands. The classification of daily urban systems (DUSs) developed by van der Laan (1998) and shown in Figure 3 has been used for this.

By and large, commuting is less efficient for car drivers in polycentric than in monocentric regions (Table 5). Only in archetypal polycentric regions consisting of several relatively self-contained concentrations of employment and residences outside the old city centre (cross-commuting DUSs) are average commute distances and times lower than in traditional, centralised DUSs. However, the number of cross-commuting systems in the Netherlands is very small (Figure 3); most polycentric regions belong to the decentralised type, where average commute times and distances are much higher. Schwanen *et al*. (2003b) show that the differences between monocentric and polycentric urban areas persist after accounting for differences in the sociodemographic variables, residential density, urban size and other metropolitan structure indicators.

In our view, spatial planning policies can be held to account at least in part for the relatively large commute distances and times in most polycentric-oriented urban regions in the Netherlands. While residential growth has been concentrated in central-city locations and VINEX neighbourhoods, the *A*-*B*-*C* location policy has failed and much employment was situated on car-accessible locations that were poorly served by public transport and could not be reached readily on foot or bicycle. As a consequence, a limited number of new housing units have been built near new or strongly growing employment concentrations, many of which can be found at a considerable distance from existing residential areas. Several reasons for this mismatch can be given, including high land prices and the relatively scarcity of land. This scarcity for development is at least partly the result of the national government's sustained efforts to keep the Green Heart open. A chain of events has led this scarcity of land to become one of the causes of the severe distortions of the Dutch housing market, which is currently characterised by insufficient new construction, extremely high prices in the owner-occupier stock and long waiting-lists in the extensive social-rented sector.[2] For many households, it has become very difficult to rent or buy a dwelling near the main breadwinner's workplace location, or to find employment at a short distance from the household's residential location.

4. Conclusions and Discussion

The aim of this study was to assess the impact of Dutch spatial policies on modal split and efficiency in travel distance and time. Table 6 summarises the implications for travel patterns of the main spatial policies discussed in section 2: the policy of concentrated decentralisation of the 1970s and 1980s; the strict compact-city policy of the 1980s and 1990s; the *A-B-C* policy in the 1990s; retail planning policy in the past three decades. It should be stressed that Table 6 does not present the results of formal tests of the impact of each of the policies mentioned on travel. Instead, the table reflects our evaluation of how national spatial planning has affected travel behaviour in the Netherlands through its regulation of the development of urban form. In addition, it is difficult to separate the impact of physical planning on travel patterns from other influences, such as pricing measures impacting travel costs. However, we do feel that these tentative results illuminate some of the strengths and weaknesses of spatial planning policy and hence may have some relevance for policy-makers seeking to influence travel behaviour through spatial-planning measures.

As Table 6 indicates, the policy of concentrated decentralisation—the development of growth centres—has probably stimulated the use of public transport, but has not led to more cycling or walking. As a result, car use is only slightly lower in growth centres than in suburban environments. Furthermore, travel distance and time are large in growth centres. The strict compact-city policy, the successor to the policy of creating growth centres, seems to have had some positive outcomes in terms of travel patterns. The empirical evidence presented indicates lower travel distances as well as higher shares for public transport and cycling and walking. It has been suggested, however, that the strict compact-city policy might have some less beneficial effects in the longer term. It may encourage the suburbanisation of households to lower-density environments because of travel time considerations, which would result in higher shares for and larger distances by the private car. The *A-B-C* policy should have led to more public transport use, but few of the aims of (re)directing employment growth have been met. The policy's impact on travel behaviour seems to have been slight; the only effect seems to have been that, as a result of developments in the vicinity of large railway stations, the shares of public transport for commuting at these locations have increased slightly. Perhaps the greatest success of Netherlands national spatial planning so far is that, thanks to spatial retail planning, walking and cycling for shopping still prevail and that, compared with other European countries, the use of the car for shopping is relatively limited.

Having said that spatial planning policy influenced travel behaviour in the Netherlands, but only to a limited extent and not always as intended, we may ask ourselves whether further efforts should be made to try to influence travel behaviour through spatial planning. The discussants in the debate on the role of planning can be broadly divided into two camps. There are the 'liberals', like Gordon and Richardson (1997), who argue that market mechanisms result in efficient settlement patterns in terms of travel and energy use. In their view, land-use regulations and subsidies destabilise the market; direct investment in central cities and public transport lead to inefficient land-use patterns. Then there are the 'regulators', like Ewing (1997) and Cervero (1998), who advocate the regulation of the development of urban form by planners to curtail the costs of urban sprawl, such as the growing use of the private car.

The discussion in the previous sections on physical planning and travel patterns in the Netherlands does not provide a convincing answer to the question whether spatial plan-

Table 6. Performance of national spatial planning policies in the Netherlands in terms of travel efficiency

	Modal choice				
	Reduction of driving	Stimulation of public transport	Stimulation of cycling and walking	Shorter travel distance (private car)	Shorter travel time (private car)
Policy of concentrated decentralisation (1970s and 1980s)	=	+	–	–	–
Strict compact-city policy (1980s and 1990s)	+	+	+	+	–
A-B-C location Policy	=	+	=	=	=
Retail planning	+/++	=	++	+	–

'+' policy made positive contribution; '=' policy had little (neutral) effect; '-' policy made negative contribution.

ning helps to create travel patterns that are more efficient in terms of travel distance and time. The message from the preceding sections is that the promotion of relatively compact urban structures can have positive effects on walking, cycling and the use of public transport. However, strict designation of a small number of greenfield sites where deconcentration and urban growth are to be accommodated is counter-productive, because short travel times and distances would not be the result. On the contrary, these latter aims might have been reached more readily under a regime of fewer land-use controls. In that case, the co-location of residences and employment in close proximity to each other might have occurred to a greater extent (Gordon and Richardson, 1997; Levinson and Kumar, 1994).

The argument the liberals use—that it is less rather than more land-use control that makes travel patterns efficient—is very important, given the fact that we are currently heading towards a network society, also in geographical terms (Castells, 1996; Hayer and Zonneveld, 2000). This type of society is characterised by highly diversified and spatially expanding activity and travel patterns which have to be realised within tight time budgets. The growth of the network society seems to undercut the ideas of proximity and land-use control as ways to influence socio-spatial development. New spatial configurations emerge that can probably be characterised better by nodes and flows than in terms of land-use patterns. As a consequence, travel will increasingly be perceived in time spent rather than distance covered (Dijst, 1999; Hayer and Zonneveld, 2000). In our opinion, spatial planners have underestimated this temporal dimension of travel behaviour in their policies. For instance, the planning concept of the compact city uses geographical proximity as the organising principle and may become less relevant in the light of the emerging network society.

Although a situation of more freedom in location choice behaviour—that is fewer restrictions imposed by physical planning policies—might result in time-efficient settlement patterns, it will probably result in a dispersion of urban functions to lower-density environments and areas that are now being used for agriculture, recreation and nature conservation. In relation to this dispersion, the potential for public transport will be vastly reduced. This reduction will have a negative impact on the daily life of those who cannot afford a car because of financial constraints or physical impairments; many people in this category belong to low-income households, are female and/or have reached retirement age.

Planners are thus facing a dilemma. The best way to resolve it, we believe, is to develop a spatial planning approach combining ‘the best of both worlds’. In the remainder of this paper, we discuss an outline of such an approach. It aims to optimise the competitiveness of public transport and the slow transport modes in terms of patronage and time efficiency. Although the approach is tailored to the Dutch situation, we believe that the underlying principles have a wider applicability, in particular to other countries in north-west Europe.

First, the use of public transport and walking and cycling can best be promoted by stimulating relatively compact urban areas. With respect to mode choice, Dutch spatial planning has been most effective in the Randstad Holland (section 3). In terms of travel time and travel distance, however, the more urbanised settlements outside the Randstad (at least 25 000–50 000 inhabitants) perform quite well. These results lead us to think that spatial policies aiming at the concentration of land uses in smaller cities would be highly beneficial from a travel-behaviour perspective. For the UK, Banister (1992) reached a comparable conclusion.

This national spatial policy is a necessary, but not sufficient, condition for improving the competitiveness of public transport. The policy has to be supplemented by investments in relatively high-speed public transport systems, such as intercity trains at the national level and light-rail and metro systems at the conurbation level (Newman and Kenworthy, 2000). These systems can guarantee travel times which are competitive with the private car (Bovy *et al*., 1990; van den Heuvel, 1997). On the other hand, at the local level, competition between the bicycle—a cheap and flexible transport mode—and public transport should be prevented as far as possible. Rather, the complementarity of the environmentally friendly transport systems of the bus/tram/metro and the bicycle should be promoted. The integration of both systems could be improved by allowing the transport of bicycles on public transport vehicles such as trams and metros. Furthermore, demand-responsive public transport could replace line-haul local systems to guarantee public transport to all potential users.

The competitiveness of public transport may also be improved by local land-use policies focusing on nodes in the public transport system. In general, the attractiveness of public transport decreases rapidly beyond 500–800 metres from a public transport stop. It is therefore necessary to encourage high-density, mixed-use development within 500–800 metres of a public transport stop (Cervero, 1996b). In our opinion, a system of financial incentives would contribute to the development of such public transport nodes. Two types of incentive might be offered. On the demand side, firms and facilities would receive an incentive when locating in public transport nodes. The magnitude of this incentive would depend on the distance to the stop and the amount of land occupied. Short walking distances and efficient use of space (high-rise buildings for example) would be rewarded. In addition, incentives would be offered to real-estate developers on the supply side of the market. The more varied in terms of land use a (re)developed public transport node became, the greater the incentive the developers could receive. Because short walking and cycling distances would be promoted, these locational incentives would favour not only the use of public transport but also walking and cycling.

Opponents of the regulations described here may argue that this approach would not improve the efficiency of travel times or distances. A strict designation of new building sites for commercial use at a small number of public transport nodes would not be capable of providing sufficient opportunities for households, firms and services to (re)locate to sites in close proximity to each other. Hence, 'the best of both worlds' planning approach should also include a partial deregulation of the land and housing markets.

According to the World Bank (1993), one way of making the housing market work more efficiently would be to select a large number of competitive new greenfield sites for development and equip these with the necessary infrastructure provisions (such as road and rail networks) far in advance of the construction of new housing and other land uses. Such a partial deregulation could yield three kinds of travel-related benefit. First, a large supply of new building sites in public transport nodes would improve the competitiveness of public transport, cycling and walking as outlined above. Secondly, the supply of high-quality public transport in new residential areas before the arrival of the first new residents would offer better opportunities for discouraging the development of car-based travel patterns. Finally, a large supply of housing would encourage residential mobility, which could result in more efficient travel times and distances for both public transport and private car users.

The combination of spatial policies at national and local levels, investments in public transport systems and a system of locational incentives would give ample opportunities to households, firms and services to make efficient locational choices. At the same time, this spatial planning approach would provide public-transport captives with sufficient opportunities for travelling in today's society and preserve valuable cultural and natural landscapes.

Notes

1. A detailed review of these and other studies is presented in Schwanen *et al.* (2002 and 2003a).

2. The problematic situation of the Dutch housing market can be illustrated by means of the number of housing units available per 1000 inhabitants. For the Netherlands, this figure is 406, whereas the weighted mean for 9 other European countries is 443 (Feddes and Dieleman, 2000).

References

ANAS, A., ARNOTT, R. and SMALL, K. A. (1998) Urban spatial structure, *Journal of Economic Literature,* 26, pp. 1426–1464.

BANISTER, D. (1992) Energy use, transport and settlement patterns, in: M. J. BREHENY (Ed.) *Sustainable Development and Urban Form*, pp. 160–182. London: Pion Ltd.

BONTJE, M. (2001) Idealism, realism and the Dutch compact city, *Town and Country Planning,* December, pp. 336–337.

BOVY, P. H. L. and SALOMON, I. (2002) Congestion in Europe: measurements, patterns and policies, in: E. STERN, I. SALOMON and P. H. L. BOVY (Eds) *Travel Behaviour: Spatial Patterns, Congestion and Modelling*, pp. 143–179. Cheltenham: Edward Elgar.

BOVY, P. H. L., BAANDERS, A. and WAARD, J. VAN DER (1990) Hoe kan dat nou? De discussie over de substitutiemogelijkheden tussen auto en openbaar vervoer [How is that possible? The discussion about substitution between the private car and public transport], in: J. M. JAGER (Ed.) *Colloquium Vervoersplanologisch Speurwerk: Measuring, Modelling, Monitoring, Recent Developments in Research Methods*, pp. 121–142. Delft: CVS.

BRUN, J. and FAGNANI, J. (1994) Lifestyles and locational choices—trade-offs and compromises: a case-study of middle-class couples living in the Ile-de-France region, *Urban Studies,* 31(6), pp. 921–934.

CAMAGNI, R., GIBELLI, M. C. and RIGAMONTI, P. (2002) Urban mobility and urban form: the social and environmental costs of different patterns of urban expansion, *Ecological Economics,* 40, pp. 199–216.

CARLINO, G. and CHATTERJEE, S. (2002) Employment deconcentration: a new perspective on America's postwar urban evolution, *Journal of Regional Science,* 42(3), pp. 445–475.

CASTELLS, M. (1996) *The Rise of the Network Society: Economy, Society, Culture*. Oxford: Blackwell.

CERVERO, R. (1995) Planned communities, self-containment and commuting: a cross-national perspective, *Urban Studies,* 32(7), pp. 1135–1161.

CERVERO, R. (1996a) Traditional neighborhoods and commuting in the San Francisco Bay Area, *Transportation,* 23, pp. 373–394.

CERVERO, R. (1996b) Mixed land uses and commuting: evidence from the American Housing Survey, *Transportation Research A,* 30, pp. 361–377.

CERVERO, R. (1998) *The Transit Metropolis: A Global Inquiry.* Washington, DC: Island Press.

CERVERO, R. (2002) Built environments and mode choice: toward a normative framework, *Transportation Research D,* 7, pp. 265–284.

CERVERO, R. and WU, K.-L. (1998) Sub-centring and commuting: evidence from the San Francisco Bay Area, *Urban Studies,* 35, pp. 1059–1076.

CLARK, W. A. V. and KUIJPERS-LINDE, M. (1994) Commuting in restructuring urban regions. *Urban Studies*, 31, pp. 465–483.

COUNSELL, D. (2001) A regional approach to sustainable urban form?, *Town and Country Planning*, December, pp. 332–335.

DIELEMAN, F. M. and WALLET, C. (2003) Income differences between central cities and suburbs in the Dutch urban regions, *Tijdschrift voor Economische en Sociale Geografie,* 94(2), pp. 265–275.

DIELEMAN, F. M., DIJST, M. and BURGHOUWT, G. (2002) Urban form and travel behaviour: micro-level household attributes and residential context, *Urban Studies,* 39, pp. 507–527.

DIELEMAN, F. M., DIJST, M. J. and SPIT, T. (1999) Planning the compact city: the Randstad Holland experience, *European Planning Studies,* 7(5), pp. 605–621.

DIJST, M. J. (1997) Spatial policy and passenger transportation, *Netherlands Journal of Housing and the Built Environment,* 12(1), pp. 91–111.

DIJST, M. J. (1999) Action space as a planning concept in spatial planning, *Netherlands Journal of Housing and the Built Environment,* 14(2), pp. 163–182.

DIJST, M., TIMMERMANS, P. and STEENBRINK, P. A. (2000) Parkeren voor de deur? Mobiliteit in Leidsche Rijn [Parking in front of the home? Travel behaviour in Leidsche Rijn], in: *Leidsche Rijn Monitor 2000. Viva Vinex?*, pp. 31–44. Utrecht: Berenschot, Universiteit Utrecht, Utrechts Nieuwsblad.

EVERS, D. (2002) The rise (and fall?) of national retail planning, *Tijdschrift voor Economische en Sociale Geografie,* 93(1), pp. 107–113.

EWING, R. (1997) Is Los Angeles-style sprawl desirable?, *Journal of the American Planning Association,* 63(1), pp. 107–126.

FALUDI, A. and VALK, A. VAN DER (1990) *De Groeikernen als Hoekstenen van het Nederlands Ruimtelijke Ordeningsdoctrine* [The Growth Centres as Cornerstones of the Dutch Spatial Planning Doctrine]. Assen/Maastricht: van Gorcum.

FEDDES, A. and DIELEMAN, F. M. (2000) Recept voor een functionerende woningmarkt [Prescription for a functioning housing market], *Vastgoedmarkt*, April, pp. 38–41.

FRANK, L. D. and PIVO, G. (1994) Impacts of mixed use and density on utilization of three modes of travel: single-occupant vehicle, transit, and walking, *Transportation Research Record*, 1466, pp. 44–52.

GARREAU, J. (1991) *Edge City: Life on the New Frontier*. New York: Doubleday.

GOLDSTEIN, H. (1995) *Multilevel Statistical Models*. London: Edward Arnold.

GORDON, P. and RICHARDSON, H. W. (1997) Are compact cities a desirable planning goal?, *Journal of the American Planning Association,* 63, pp. 95–106.

GORDON, P., KUMAR, A. and RICHARDSON, H. W. (1989a) The influence of metropolitan spatial structure on commuting time, *Journal of Urban Economics,* 26, pp. 138–151.

GORDON, P., KUMAR, A. and RICHARDSON, H. W. (1989b) Congestion, changing metropolitan structure and city size in the United States, *International Regional Science Review*, 12, pp. 45–56.

GORDON, P., RICHARDSON, H. W. and JUN, M.-J. (1991) The commuting paradox: evidence from the top twenty, *Journal of the American Planning Association,* 57, pp. 416–420.

GUO, J. and BHAT, C. (2002) *Residential Location Modeling: Accommodating Sociodemographic, School Quality and Accessibility Effects*. Austin, TX: Department of Civil Engineering, University of Texas, Austin.

HAM, M. VAN, HOOIMEIJER, P. and MULDER, C. H. (2001) Urban form and job access: disparate realities in the Randstad, *Tijdschrift voor Economische en Sociale Geografie,* 92(2), pp. 231–246.

HANDY, S. L. and CLIFTON, K. J. (2001) Local shopping as a strategy for reducing automobile travel, *Transportation,* 28, pp. 317–346.

HART, T. (1992) Transport, the urban pattern and regional change, *Urban Studies,* 29(3/4), pp. 483–503.

HART, T. (2001) Transport and the city, in: R. PADDISON (Ed.) *Handbook of Urban Studies*, pp. 102–123. London: Sage Publications.

HAYER, M. and ZONNEVELD, W. (2000) Spatial planning in the network society: rethinking the principles of planning in the Netherlands, *European Planning Studies,* 8, pp. 337–355.

HERZ, R. (1983) Stability, variability and flexibility in everyday behaviour, in: S. CARPENTER and P. JONES (Eds) *Recent Advances in Travel Demand Analysis*, pp. 385–400. Aldershot: Gower.

HEUVEL, M. G. VAN DEN (1997) *Openbaar Vervoer in the Randstad: Een Systematische Benadering* [Public Transport in the Randstad Holland: A Systematic Approach]. Amsterdam: Thesis Publishers.

HJORTHOL, R. J. (2000) Same city—different options: an analysis of the work trips of married couples in the metropolitan area of Oslo, *Journal of Transport Geography,* 8, pp. 213–220.

JANSEN, G. R. M. (1993) Commuting: home sprawl, job sprawl, traffic jams, in: I. Salomon, P. BOVY and J.-P. ORFEUIL (Eds) *A Billion Trips a Day: Tradition and Transition in European Travel Patterns*, pp. 101–127. Dordrecht: Kluwer Academic Publishers.

JANSEN, G. R. M., HILBERS, H. and WILMINK, I. (2002) Transport networks and mobility: a comparison of the Randstad, the Rhine–Ruhr and the Antwerp–Brussels–Ghent region, in: E. STERN, I. SALOMON and P. H. L. BOVY (Eds) *Travel Behaviour: Spatial Patterns, Congestion and Modelling*, pp. 20–36. Cheltenham: Edward Elgar.

JOHNSTON-ANUMONWO, I. (1992) The influence of household type on gender differences in work trip distance, *The Professional Geographer,* 44, pp. 161–169.

KEMPEN, R. VAN (2000) Big cities policies in the Netherlands, *Tijdschrift voor Economische en Sociale Geografie,* 91, pp. 197–203.

KEMPEN, R. VAN and PRIEMUS, H. (1999) Undivided cities in the Netherlands: present situation and political rhetoric, *Housing Studies,* 14, pp. 641–657.

KENWORTHY, J. R. and LAUBE, F. B. (1999) Patterns of automobile dependence in cities: an international overview of key physical and economic dimensions with some implications for urban policy, *Transportation Research A,* 33, pp. 691–723.

KITAMURA, R., HOORN, T. VAN DEN and WIJK, F. VAN (1997) A comparative analysis of daily time use and the development of an activity-based traveller benefit measure, in: D. ETTEMA and H. TIMMERMANS (Eds) *Activity-based Approaches to Travel Analysis*, pp. 171–188. Oxford: Pergamon.

KOCKELMAN, K. M. (1997) Travel behavior as a function of accessibility, land use mixing, and land use balance, *Transportation Research Record*, 1607, pp. 116–125.

LAAN, L. VAN DER (1998) Changing urban systems: an empirical analysis at two spatial levels, *Regional Studies,* 32, pp. 235–247.

LERMAN, S. R. (1976) Location, housing, automobile ownership, and mode to work: a joint choice model, *Transportation Research Record,* 610, pp. 5–11.

LEVINSON, D. M. and KUMAR, A. (1994) The rational locator: why travel times have remained stable, *Journal of the American Planning Association,* 60, pp. 319–332.

LEVINSON, D. M. and KUMAR, A. (1997) Density and the journey to work, *Growth and Change*, 28(2), pp. 147–172.

MCDOWELL, L. (1997) The new service class: housing, consumption and lifestyle among London bankers in the 1990s, *Environment and Planning A,* 29, pp. 2061–2078.

MVRO (MINISTRY OF HOUSING AND PHYSICAL PLANNING) (1966) *Tweede Nota Ruimtelijke Ordening* [Second Physical Planning Memorandum]. The Hague: Ministry of Housing and Physical Planning.

MVROM (MINISTRY OF HOUSING, PHYSICAL PLANNING AND THE ENVIRONMENT) (1988) *Vierde Nota Ruimtelijke Ordening* [Fourth Physical Planning Memorandum]. The Hague: Ministry of Housing, Physical Planning and the Environment.

MVROM (MINISTRY OF HOUSING, PHYSICAL PLANNING AND THE ENVIRONMENT) (1991) *Vierde Nota Ruimtelijke Ordening Extra* [Fourth Spatial Planning Memorandum Extra]. The Hague: Ministry of Housing, Physical Planning and the Environment.

MVROM (MINISTRY OF HOUSING, PHYSICAL PLANNING AND THE ENVIRONMENT) (2001) *Vijfde Nota Ruimtelijke Ordening 2000/*2020: *Ruimte Maken, Ruimte Delen* [Fifth Spatial Planning Memorandum: Making Space, Sharing Space]. The Hague: Ministry of Housing, Physical Planning and the Environment

MV&W (MINISTRY OF TRANSPORT AND PUBLIC WORKS) (1999) *Perspectievennota Verkeer en Vervoer* [Report of Perspectives on Traffic and Transport]. The Hague: Ministry of Transport and Public Works.

NÆSS, P., RØE, P. G. and LARSEN, S. (1995) Travelling distances, modal split and transportation in thirty residential areas in Oslo, *Journal of Environmental Planning and Management,* 38, pp. 349–370.

NEWMAN, P. and KENWORTHY, J. (2000) Sustainable urban form: the big picture, in: K. WILLIAMS, E. BURTON and M. JENKS (Eds) *Achieving Sustainable Urban Form*, pp. 139–148. London: E & FN Spon.

NRC HANDELSBLAD (2001) The Dutch are working and commuting extensively, 12 April.

OSKAMP, A., POULUS, C. and GORDIJN, H. (2002) Stadsvernieuwing gemeten [Measuring urban renewal], *Kwartaalbericht ABF Research*, 1, pp. 3–6.

PRIEMUS, H., NIJKAMP, P. and BANISTER, D. (2001) Mobility and spatial dynamics: an uneasy relationship, *Journal of Transport Geography,* 9(3), pp. 167–171.

SCHWANEN, T. (2002) Urban form and commuting behaviour: a cross-European perspective, *Tijdschrift voor Economische en Sociale Geografie,* 93(3), pp. 336–343.

SCHWANEN, T., DIELEMAN, F. M. and DIJST, M. (2001) Travel behaviour in Dutch monocentric and polycentric urban systems, *Journal of Transport Geography,* 9(3), pp. 173–186.

SCHWANEN, T., DIELEMAN, F. M. and DIJST, M. (2003a) Car use in Netherlands daily urban systems: does polycentrism result in lower commute times?, *Urban Geography,* 24(5), pp. 340–360.

SCHWANEN, T., DIELEMAN, F. M. and DIJST, M. (2003b) *A multilevel analysis of the impact of metropolitan structure on commute behaviour of urban residents in the Netherlands*. Paper presented at the *82nd Annual Meeting of the Transportation Research Board*, January, Washington, DC.

SCHWANEN, T., DIJST, M. and DIELEMAN, F. M. (2001) Leisure trips of senior citizens: determinants of modal choice, *Tijdschrift voor Economische en Sociale Geografie,* 92(3), pp. 347–360.

SCHWANEN, T., DIJST, M. and DIELEMAN, F. M. (2002) A microlevel analysis of residential context and travel time, *Environment and Planning A,* 34(8), pp. 1487–1507.

SNIJDERS, T. A. B. and BOSKER, R. J. (1999) *Multilevel Analysis: An Introduction to Basic and Advanced Multilevel Modeling*. London: Sage Publications.

STATISTICS NETHERLANDS (1999) *Onderzoek Verplaatsingsgedrag 1998: Documentatie voor Tape-gebruikers* [1998 National Travel Survey: Documentation for Tape-users]. Voorburg/ Heerlen: Statistics Netherlands.

TURNER, T. and NIEMEIER, D. (1997) Travel to work and household responsibility: new evidence, *Transportation,* 24, pp. 397–419.

VAN, U.-P. and SENIOR, M. (2000) The contribution of mixed land uses to sustainable travel in cities, in: K. WILLIAMS, E. BURTON and M. JENKS (Eds) *Achieving Sustainable Urban Form*, pp. 139–148. London: E & FN Spon.

WEBER, J. and KWAN, M.-P. (2003) Evaluating the effect of geographic contexts on individual accessibility: a multilevel level approach, *Urban Geography,* 24 (Forthcoming)

WILLIAMS, K., BURTON, E. and JENKS, M. (2000) *Achieving Sustainable Urban Form*. London: E & FN Spon.

WORLD BANK (1993) *Housing: Enabling Markets to Work*. Washington, DC: The World Bank.

Appendix 1

Degree of urbanisation is a composite variable which incorporates various dimensions of urban form: urban size, residential density, distance to the urban core, the degree of land-use mixing and provision of infrastructure. The variable distinguishes first between the *Randstad Holland* and the *Rest of the Netherlands*, because residential densities in the former are much greater and more public transport infrastructure is available. Within the Randstad Holland, we discern from most to least urbanised: *three large cities* (Amsterdam, Rotterdam, The Hague); *medium-sized cities*; and *suburbs*. The *growth centres* are considered to be a separate category. The national government consciously planned these settlements during the 1970s and 1980s to become self-contained communities, in order to curb the decentralisation of households and firms from the larger cities. However, they turned into dormitory towns whose inhabitants had to travel extensively to reach the destinations they preferred to visit. Outside the Randstad Holland, a distinction has been drawn between *more urbanised* and *less urbanised* areas.

With regard to *urban structure*, we use a classification of daily urban systems in four categories based on van der Laan (1998), rather than drawing a distinction between monocentric or polycentric urban areas

(1) *Centralised*: these resemble monocentric systems in which morning peak-hour commuting is primarily directed towards the core city of the DUS.
(2) *Decentralised*: many morning commuters are attracted to the suburban parts of the system, where much employment is located.
(3) *Cross commuting*: these structures resemble the classic polycentric region consisting of relatively independent, self-contained development nodes. Suburban commuters tend to work in the suburbs; core-city residents often work in the core city.
(4) *Exchange commuting*: these systems have many reciprocal relationships between the suburbs and the core city. Many suburban commuters work in the city, while many central-city residents work in the suburbs.

Appendix 2

Multilevel models expand the random part of a model; rather than summarising the residual variance in a single random parameter as in ordinary least squares regression, more than one random term is estimated to accommodate the nested structure of the data. A random-intercept model with three levels of analysis—for instance, individuals within households within municipalities—can be written as (Goldstein, 1995)

$$y_{ijk} = \beta_0 + \beta_i X_{1ijk} + (e_{0ijk} + u_{0ijk} + \nu_{0k})$$

where, y_{ijk} represents the dependent variable at the lowest level of analysis; β_0 indicates the intercept; X_{1ijk} is an independent variable at the level of the individual; and β_1 a fixed regression; coefficient to be estimated. The parentheses in the equation indicate the random part of the model. The random term e_{0ijk} refers to the individual, u_{0jk} to the household; and ν_{0k} to the municipality of residence. These random terms are assumed to be mutually independent and to be normally distributed—that is, they have a mean of zero and can be summarised by their variances σ^2_{e0}, σ^2_{u0} and σ^2_{v0}, respectively. The coefficients of multilevel models are estimated with maximum likelihood estimation procedures (more details in Goldstein, 1995).