THE LAND-USE/TRANSPORT SYSTEM PROBLEM: WHAT CAN WE LEARN FROM THE DUTCH ?

Veronique Van Acker
Frank Witlox

Vakgroep Geografie
Universiteit Gent
Krijgslaan 281, S8
B-9000 Gent
Tel: +32 9 264 46 97
Fax: +32 9 264 49 85
Veronique.VanAcker@UGent.be
Frank.Witlox@UGent.be

Bijdrage aan het Colloquium Vervoersplanologisch Speurwerk 2005,
24 en 25 november 2005, Antwerpen

Inhoudsopgave

Samenvatting

Het Probleem van het Ruimtegebruik/Transport Systeem:
Wat kunnen we van de Nederlanders leren ?

Studies omtrent de invloed van het ruimtegebruik op het verplaatsingsgedrag in België ontbreken nagenoeg. Dit is opmerkelijk daar de ruimtelijke context grondig verschilt van de buurlanden wegens het jarenlange ontbreken van een efficiënte ruimtelijke planning. Deze paper probeert deze leemte op te vullen. De resultaten van onze analyse wordt vergeleken met de resultaten van eerder Nederlands onderzoek. Hierdoor is een vergelijking mogelijk met een ruimtelijke context waarin ruimtelijke planning grondig werd toegepast. Verwacht wordt dat de Belgische context tot een groter autogebruik, langere afstanden en reistijden leidt. Deze analyse toont aan dat dit slechts gedeeltelijk waar is. Belgen leggen meer trips af en een grotere totale afstand voor werken en winkelen, maar de reistijd voor werken en winkelen is daarentegen lager dan de Nederlandse resultaten. Bijgevolg kunnen er vragen gesteld worden bij de hypothese dat een efficiënte ruimtelijke planning het verplaatsingsgedrag grondig kan beïnvloeden.

Summary

The Land-Use/Transport System Problem:
What can we learn form the Dutch ?

There is almost no evidence of the impact of land-use on travel behaviour in Belgium. This is remarkable because the spatial context differs thoroughly from its neighboring countries due to the lack of an efficient spatial planning system for several years. This paper tries to fill in this gap of knowledge. The results of our analysis are compared to results of earlier Dutch research. In this way, a comparison is possible with a spatial context in which spatial planning was systematically applied. We expect a greater car use, longer travel distances and travel times for the Belgian context. Our analysis confirmed that this is partly true. Belgians make more trips and travel longer distances for working and shopping. However, travel times for working and shopping are lower than Dutch results. As a result, someone can question the hypothesis of the impact spatial planning has on travel behaviour.

1. Introduction

Travel has become an everyday activity. Living, working, shopping and recreation are spatially separated activities, thus creating the need to travel if we want to participate in these activities. Therefore, the demand for travel does not derive its utility from the trip itself, but from the need to reach the locations where activities take place. For that reason, the configuration of activities - the land-use pattern - is likely to influence travel behaviour.

Evidence on the relationship between land-use and travel behaviour is mainly based on US data. Only from the late 1990s onwards, European studies were undertaken, especially in Great-Britain and the Netherlands. Although comparable data sets exist (national and regional travel surveys, time use survey, …), limited studies with a Belgian context could be found. This is surprising because the Belgian spatial context differs from its surrounding countries due to the lack of a sound spatial planning system for many years. From 1998 onwards, this seemed to change with the approval of the *Ruimtelijk Structuurplan Vlaanderen* (1998). This plan contains spatial principles which have been applied in other countries before. For instance, in the Netherlands the politics of deconcentrated centralization (1970s and 1980s), the compact city (1980s and 1990s), and urban renewal (1970s until 1990s) were already known. Schwanen et al. (2004) evaluated the consequences of the Netherlands national spatial planning policy for an individual's travel behaviour. They found that the national spatial planning system had been most effective in retaining high shares of cycling and walking in the large and medium-sized cities, in particular for shopping trips. Nevertheless, spatial policy seemed to have been less successful in terms of travel time. Recent spatial strategies, such as the building of new towns and the development of greenfield neighbourhoods close to cities, were found not to reduce commuting times.

In this paper we explore the Belgian land-use/transport system. Did the lack of a spatial planning policy result in longer travel distances and times ? Is the share of car use higher ? In order to answer these questions, we compared our results to those of earlier Dutch research (Dieleman et al., 2002; Schwanen et al., 2002, 2004).

2. Data and Research Design

The 2000-2001 Flemish Regional Travel Survey (Onderzoek VerplaatsingsGedrag (OVG) Vlaanderen) was used to address the research questioned posed. Initiated in 1994-1995, this survey has been carried out each five years. In every survey, at least 2.500 households were asked to participate. Approximately 5.500 individuals filled in a travel diary for two days, including children over the age of 6 years. As in other surveys, non-response is a problem in the OVG. In order to correct for sampling biases, weight factors, based on age, gender and marital status, are provided (Zwerts & Nuyts, 2004). These weights were used in the descriptive analysis. Table 1 compares some basic aspects of the Flemish Regional Travel Survey and the Netherlands National Travel Survey. Both surveys have a similar approach: households are asked to participate by telephone. After this, each member of the household receives a travel diary by post mail to fill in. Respondents have to fill in this diary for two days in Flanders, whereas Dutch respondents have to do this for only one day. Both travel surveys differ in terms of sample size and regularity of organization. Whereas travel surveys were held already from 1978 onwards in the Netherlands, this has recently been set up in Flanders. Furthermore, Dutch travel surveys are held each year contrary to Flanders.

Table 1: Comparison OVG Vlaanderen en OVG Nederland

	OVG Vlaanderen	OVG Nederland
# individuals	5,500	150,000
since	1994-1995, 5 yearly	1978, yearly
age of respondents	+6 years	+11 years (1978-1994), +6 years (1994-xxxx)
survey approach	contacting by phone, travel diary for two days by mail	contacting by phone, travel diary for one day by mail

Source: www.swov.nl, Zwerts & Nuyts (2004)

For the present research, data were used for individuals over the age of 6. The inclusion of the explaining variable ‘age’ is expected to give insight into the different travel behaviour of children and adults. The analysis was further restricted to individuals for whom modal choice, distance travelled and travel time for all their trips were known. In order to make comparisons possible, this analysis has a similar research design as earlier Dutch research (Dieleman et al., 2002; Schwanen et al., 2002, 2004). Three travel behaviour aspects were selected: modal choice, travel distance and travel time. An explanation of these travel behaviour aspects was

given by personal/household attributes and attributes of the residential environment. Five main transport modes were distinguished: walking, cycling, private car (as car driver), public transport (by bus, subway, tram and train) and others (mainly car passenger). Three trip purposes were examined: working, shopping and leisure (culture, social visits, sports, recreation, touring, walking or cycling around). Personal/household attributes included age, educational level, gender, household type, annual personal income and household car ownership. A household typology was constructed based on three dimensions: household size, number of employees and the presence of children (< 12 years). The respondents' residential environment was characterised by whether the municipality of residence is located within or outside the Vlaamse Ruit and on its classification according to the Ruimtelijk Structuurplan Vlaanderen (Ministerie van de Vlaamse Gemeenschap, 1998).

First, the selected travel behaviour aspects are studied by some descriptive statistics. Second, multivariate analysis is used to explain the effect of personal/household attributes and residential environment on modal choice, travel distance and travel time. Because of the limited paper size, only the results for shopping trips by private car are presented. Shopping trips are thought to be less determined by their destination unlike working trips (workplace determines the trip for the greater part), and to have a clearer pattern than leisure trips.

3. Modal choice

Modal choice is probably the most studied aspect of travel behaviour. Numerous studies report on the effects of spatial and/or personal/household characteristics on modal choice. Higher densities, more land-use diversity and design which encourage car travel are thought to result in less car travel and more public transport, walking and cycling (Friedman et al., 1994; Ewing et al., 1994; Frank & Pivo, 1994; Kockelman, 1997; Hess et al., 1999; Gorham, 2002; Zhang, 2004). However, some research results indicate a stronger influence of personal/household characteristics (Cervero & Kockelman, 1997; McNally & Kulkarni, 1997; Krizek, 2000; Meurs & Haaijer, 2001).

3.1 Descriptive analysis

As in other countries, the private car is the dominant transport mode. The amount of walking and cycling trips is remarkable high, but does not outrange the number of trips for some categories of households and residential environments (which is the case for the Dutch situation). The share of public transport is rather low. It is even exceeded by the category ‘others’, mainly car passengers. The relationships between modal choice, type of household, type of residential environment and trip purpose are less clear than in the Netherlands. Generally, families have a larger amount of trips per person than households without children. But the results per mode are somewhat ambiguous. Unlike the Netherlands, the use of the private car is not always higher for households with children. The use of the private car seems to be influenced more by the number of employees. On the other hand, households with children travel more by bike than households without children. Despite a transport policy of free public transport for children, the amount of trips by public transport remains low for households with children. With regard to the number of workers, comparable results were found to the in Dutch research. Households without workers travel more by public transport and especially by bike and on foot. Probably, time pressure is greater in households with workers, leading to more private car use (Table 2).

Table 2. Modal split for all purposes by type of household (number of trips per person)

Household type	Walking	Cycling	Private car (driver)	Public transport (bus, subway, tram)	Train	Other	Total
Family, no workers	0.25	0.93	1.54	0.00	0.00	1.46	4.18
Family, one worker	0.42	0.72	1.31	0.05	0.02	1.18	3.70
Family, two workers	0.30	0.50	1.75	0.04	0.04	1.18	3.81
Couple, no workers	0.43	0.40	1.18	0.08	0.03	0.77	2.89
Couple, one worker	0.38	0.39	1.74	0.05	0.03	0.66	3.25
Couple, two workers	0.34	0.28	2.08	0.03	0.08	0.74	3.55
Single, no worker	0.67	0.52	1.07	0.09	0.04	0.43	2.82
Single, worker	0.49	0.35	2.22	0.08	0.03	0.42	3.59
Others	0.26	0.94	1.08	0.57	0.05	0.51	3.41

Modal split broken down by residential environment illustrates a similar pattern as found in the Dutch research. Less trips are made within the Vlaamse Ruit than outside it. Respondents living in the three largest cities (Antwerpen, Brussel, Gent) travel the least with private car and undertake the most walking trips and trips by public transport. A better supply of public

transport gets people off their bicycles, as in Amsterdam, Rotterdam and Den Haag. Regional and small cities inside and outside the Vlaamse Ruit have similar modal choices. Car use is especially high for those living in the suburbs and rural places outside the Vlaamse Ruit (Table 3).

Table 3. Modal split for all purposes by residential environment (number of trips per person)

Residential environment	Walking	Cycling	Private car (driver)	Public transport (bus, subway, tram)	Train	Other	Total
Inside Vlaamse Ruit							
large city	0.74	0.36	1.19	0.28	0.02	0.63	3.22
regional city	0.41	0.57	1.46	0.08	0.08	0.84	3.44
small city	0.30	0.55	1.50	0.05	0.10	0.91	3.41
suburbs	0.36	0.34	1.61	0.10	0.08	0.86	3.35
rural	0.27	0.40	1.55	0.06	0.09	0.87	3.24
Outside Vlaamse Ruit							
regional city	0.36	0.62	1.49	0.05	0.05	0.95	3.52
small city	0.37	0.46	1.59	0.04	0.06	0.91	3.43
suburbs	0.31	0.61	1.81	0.02	0.04	0.88	3.67
rural	0.27	0.49	1.64	0.05	0.04	0.87	3.36

As in the Netherlands, shopping and leisure trips take up a large part of our travel behaviour (Table 4). Compared to the Netherlands, Belgians undertake almost twice as much trips per person for working, shopping en leisure purposes. Unlike the Netherlands, the greater part of these trips is made by private car, even for shopping and leisure trips.

Table 4. Modal split by trip purpose (number of trips per person)

Trip Purpose	Walking	Cycling	Private car (driver)	Public transport (bus, subway, tram)	Train	Other	Total
Working	0.05	0.18	0.96	0.03	0.06	0.23	1.51
Shopping	0.32	0.28	1.01	0.02	0.01	0.46	2.10
Leisure	0.49	0.42	1.05	0.03	0.02	0.97	2.98

3.2 Multivariate analysis

Table 5 indicates the relationships between personal/household attributes, characteristics of the residential environment and modal choice. Parameters for car use and cycling/walking are presented relative to the use of public transport. Furthermore, each attribute has a reference

category to which parameters of any other category are expressed. Of all personal/household attributes, income is the most important determinant of modal choice. People with low, and even moderate, income make more use of public transport than people with large incomes. Type of household does not provide a clear pattern with modal choice. Workers tend to use the car more than non-workers. Young people, aged between 16 and 24, travel more by public transport. If one gets older, car use and cycling/walking increase. Level of education shows a clear relationship with modal choice. Car use is more likely among those with a higher education, whereas public transport is more used by those with a lower education. The attribute car ownership makes clear that who owns more than one car, also use it more than others. Modal choice seems also to be related to residential environment. Car use, but also cycling/walking, is least in the three large cities of the Vlaamse Ruit. Public transport is more frequently used, and differences with other environments can be large.

Table 5: Multinomial logistic regression model of modal choice for shopping trips (reference category = public transport)

	Car		**Cycling/walking**	
	B	S.E.	B	S.E.
Constant	15.794 ***	1.052	15.394 ***	0.986
Gender				
male (ref.)				
female	1.242 ***	0.377	0.808 **	0.374
Household type				
others	0.378	0.585	0.515	0.580
single, non-worker	-0.448	0.830	0.154	0.811
single, worker	1.190	0.958	1.156	0.952
couple, 0 workers	-0.537	0.766	-0.390	0.759
couple, 1 worker	16.738 ***	0.220	16.514	0.000
couple, 2 workers	0.733	0.891	1.018	0.889
family, 0 workers	17.945 ***	1.103	16.585	0.000
family, 1 worker	-0.685	0.792	-0.819	0.787
family, 2 workers (ref.)				
Age				
16-24	-2.144 ***	0.740	-1.582 **	0.727
25-34	1.086	0.802	0.641	0.793
35-44	1.604 *	0.857	1.174	0.850
45-54	-0.085	0.576	-0.444	0.565
55-64	1.362 **	0.623	1.317 **	0.615
65+ (ref.)				
Educational level				
no degree	-2.462 ***	0.670	-1.668 ***	0.651
lower (elementary school)	-0.572	0.672	-0.134	0.665
middle, lower (high school, low level)	-0.663	0.482	-0.545	0.479
middle, higher (high school, high level)	-0.158	0.462	-0.343	0.461

higher (college and higher, ref.)				
Income				
0/20.000 BEF per month	-13.690 ***	0.615	-12.473 ***	0.511
20.001/50.000 BEF per month	-13.052 ***	0.543	-12.491 ***	0.424
50.001/100.000 BEF per month	-13.732 ***	0.345	-13.117	0.000
Car ownership				
no car	-3.393 ***	0.574	-2.034 ***	0.565
1 car	-1.945 ***	0.525	-1.279 **	0.524
2 or more cars (ref.)				
Residential environment				
Vlaamse Ruit				
large city (ref.)				
regional city	3.618 ***	1.087	2.465 **	1.076
small city	19.116 ***	0.250	18.153	0.000
suburbs	1.773 ***	0.528	0.662	0.515
rural	2.425 ***	0.587	0.951 *	0.576
Rest of Belgium				
regional city	2.784 ***	0.623	1.851 ***	0.609
small city	3.081 ***	0.586	1.911 ***	0.574
suburbs	2.671 ***	0.635	1.554 **	0.623
rural	3.119 ***	0.498	1.863 ***	0.485
R^2	0.170			
No. Cases	2,947			

* significant at α = 0.10, ** significant at α = 0.05, *** significant at α = 0.01

4. Travel distance

Researchers believe that accessibility, density, diversity and design influence travel distance. Higher densities and accessibility, more land-use diversity and a design which discourage car use is believed to result in shorter travel distances (Cervero & Kockelman, 1997; Kockelman, 1997; Gorham, 2002; Schwanen, 2002; Krizek, 2003). However, some counter-evidence exists (Boarnet & Sarmiento, 1996; Krizek, 2000; Stead, 2001).

4.1 Descriptive analysis

The longest distances travelled are made by single workers. If households with children or workers are compared to household without them, similar conclusions can be drawn as with Table 2. Households with children do not travel longer distances by car than households without children. Instead, they travel longer distances by bike and public transport. The use of the private car seems to be influenced more by the number of workers. For other modes, the relationship between household type and travel distance is somewhat ambiguous (Table 6).

Table 6. Average travel distance (in km.) per person per day for all purposes, by type of household and travel mode

Household type	Walking	Cycling	Private car (driver)	Public transport (bus, subway, tram)	Train	Other	Total
Family, no workers	0.08	1.88	15.83	0.00	0.00	24.94	42.73
Family, one worker	0.62	2.52	12.85	0.85	1.06	15.33	33.23
Family, two workers	0.38	1.63	20.21	0.82	1.98	14.59	39.61
Couple, no workers	0.62	2.29	12.69	0.58	1.30	10.31	27.79
Couple, one worker	0.64	1.28	19.59	0.50	0.74	7.89	30.64
Couple, two workers	0.64	1.33	30.78	0.49	3.76	13.12	50.12
Single, no worker	1.67	5.20	19.30	1.18	2.61	6.30	36.26
Single, worker	0.87	2.74	60.28	0.70	3.39	15.36	83.34
Others	0.56	2.09	19.61	1.10	3.44	12.63	39.43

A more obvious pattern can be noticed between residential environment and travel distances. The distances travelled by private car are much lower in the large cities than in the suburbs or rural places within the Vlaamse Ruit. Regional and small cities hold the middle ground in this respect. Same results can be found in the Dutch research. Whereas the use of public transport (bus, subway, tram and train) in the Netherlands is important for new towns, large and medium-sized cities, this is true for small cities, suburbs and rural places within the Vlaamse Ruit and regional cities outside the Vlaamse Ruit (Table 7).

Table 7. Average travel distance (in km.) per person per day for all purposes, by residential environment and travel mode

Residential environment	Walking	Cycling	Private car (driver)	Public transport (bus, subway, tram)	Train	Other	Total
Inside Vlaamse Ruit							
large city	1.13	1.74	17.18	1.91	0.82	9.74	32.52
regional city	0.56	1.62	19.87	0.64	2.73	10.53	35.95
small city	0.37	2.74	19.79	0.58	3.99	14.56	42.03
suburbs	0.49	1.39	20.03	1.32	2.83	12.40	38.46
rural	0.48	1.75	20.94	0.81	3.68	14.51	42.17
Outside Vlaamse Ruit							
regional city	0.79	2.09	18.09	0.80	3.50	12.99	38.26
small city	0.62	2.09	22.43	0.82	2.44	12.32	40.72
suburbs	0.41	2.21	24.30	0.43	2.94	11.82	42.11
rural	0.51	2.09	21.87	0.74	1.76	12.61	39.58

Of all trips, the largest number of kilometres travelled is made for working and leisure trips. As in the Netherlands, the private car is frequently used compared. A comparison of Tables 4 and 8 makes clear that commuting trips occur over a longer distance than shopping or leisure

trips. After all, the number of trips per person is similar for different travel purposes but the number of kilometres travelled differs.

Table 8. Average travel distance (in km.) per person per day, by trip purpose and travel mode

Trip Purpose	Walking	Cycling	Private car (driver)	Public transport (bus, subway, tram)	Train	Other	Total
Working	0.05	0.57	14.46	0.41	2.01	3.37	20.87
Shopping	0.20	0.31	4.11	0.13	0.11	2.86	7.72
Leisure	0.69	1.78	7.77	0.23	0.66	8.27	19.40

Note: Averages for all persons in the sample

4.2 Multivariate analysis

For shopping trips, distance travelled by car depends mostly on gender. Women travel to shops over shorter distances by car than men. Concerning household type, households with children tend to travel to nearby shops; whereas households with workers travel longer distances. Age does not influence shopping trips strongly. All age categories travel longer distances than its reference category (65+). More highly educated people travel relatively long distances by car for shopping purposes. Income and car ownership do not have a strong impact. Residential environment plays an important role in the distance travelled by car. People living outside the large cities of the Vlaamse Ruit tend to travel longer distances by car for shopping purposes. Especially, those living in a rural environment outside the Vlaamse Ruit have longer travel distances (Table 9).

Table 9: Regression model for travel distance by car for shopping trips

	B	S.E.	Odds ratio	β	*R^2 change*
Constant	1.479 ***	0.233	4.389		
Gender					*0.021*
male (ref.)					
female	-0.324 ***	0.060	0.723	-0.177	
Household type					*0.008*
others	-0.109	0.079	0.897	-0.059	
single, non-worker	0.013	0.079	1.013	-0.003	
single, worker	0.312 **	0.128	1.366	0.056	
couple, 0 workers	0.013	0.135	1.013	-0.008	
couple, 1 worker	-0.177	0.124	0.838	-0.042	
couple, 2 workers	0.017	0.096	1.017	-0.029	
family, 0 workers	-0.210	0.392	0.811	-0.021	

family, 1 worker	-0.139	0.122	0.870	-0.043	
family, 2 workers (ref.)					
Age					*0.002*
16-24	0.036	0.174	1.037	-0.001	
25-34	0.001	0.144	1.001	-0.002	
35-44	0.039	0.139	1.040	0.018	
45-54	0.113	0.134	1.120	0.061	
55-64	0.045	0.116	1.046	-0.002	
65+ (ref.)					
Educational level					*0.001*
no degree	-0.282	0.193	0.754	-0.051	
lower (elementary school)	-0.153	0.124	0.858	-0.029	
middle, lower (high school, low level)	-0.051	0.077	0.950	-0.009	
middle, higher (high school, high level)	0.003	0.063	1.003	0.016	
higher (college and higher, ref.)					
Income					*0.001*
0/20.000 BEF per month	0.152	0.196	1.164	0.022	
20.001/50.000 BEF per month	0.081	0.154	1.084	-0.008	
50.001/100.000 BEF per month	0.073	0.149	1.076	0.014	
more than 100.000 BEF per month (ref.)					
Car ownership					*0.001*
no car	-0.099	0.118	0.906	-0.025	
1 car	0.018	0.058	1.018	-0.014	
2 or more cars (ref.)					
Residential environment					*0.013*
Vlaamse Ruit					
large city (ref.)					
regional city	0.081	0.175	1.084	0.013	
small city	0.267	0.173	1.306	0.052	
suburbs	0.216	0.157	1.241	0.043	
rural	0.258	0.148	1.294	0.085	
Rest of Belgium					
regional city	-0.036	0.152	0.965	-0.016	
small city	0.205	0.142	1.228	0.064	
suburbs	0.225	0.153	1.252	0.079	
rural	0.357 **	0.135	1.429	0.179	
R^2	0.046				
No. cases	1,708				

* significant at α = 0.10, ** significant at α = 0.05, *** significant at α = 0.01

5. Travel time

Research on travel time remains somewhat underexposed, especially when compared to modal choice. Several research studies resulted in similar conclusions. Higher densities, more land-use diversity and greater accessibility are considered to result in shorter travel times. On

the other hand, a linear relationship has been found between urban size and travel time (Gordon et al., 1989; Ewing et al., 1994; Gorham, 2002; Schwanen, 2002).

5.1 Descriptive analysis

In general, families have a longer daily travel time than household without children and workers travel longer than non-workers. Daily travel time of singles, however, outranges travel time of all other households. Whereas an assignment of tasks is possible in families or couples, singles are responsible for all tasks themselves, resulting in longer daily travel times. The greater part of daily travel time has been made by private car (Table 10).

Table 10. Average daily travel time (in min.) per person per day for all purposes, by household type and travel mode

Household type	Walking	Cycling	Private car (driver)	Public transport (bus, subway, tram)	Train	Other	Total
Family, no workers	1.74	8.03	21.87	0.00	0.00	30.81	62.45
Family, one worker	10.26	10.27	17.90	1.40	1.38	24.25	65.46
Family, two workers	4.76	6.89	25.51	1.97	2.58	19.47	61.18
Couple, no workers	10.07	10.45	19.81	2.47	1.91	16.16	60.87
Couple, one worker	8.21	5.73	27.65	1.21	1.22	11.29	55.31
Couple, two workers	7.23	4.90	38.60	1.34	5.31	14.99	72.37
Single, no worker	24.26	21.50	27.39	3.92	3.11	12.27	92.45
Single, worker	13.23	12.77	68.58	3.79	4.00	15.33	117.70
Others	6.32	8.89	25.05	3.05	4.52	16.64	64.47

The relationship between daily travel time and residential environment is less clear. Even though they travel smaller distance, daily travel time for those living within the Vlaamse Ruit is among the highest. Congestion within cities may be the reason for this. Those living in rural areas outside the Vlaamse Ruit have the shortest total travel times. Daily travel times by car are higher outside the Vlaamse Ruit, whereas the use of public transport results in higher travel times for residents within the Vlaamse Ruit (Table 11).

Despite the sprawled situation in Flanders, daily travel time remains lower than in the Netherlands. Daily travel time to work in the Netherlands is twice as high as in Flanders except for walking. Also longer daily travel times for shopping and leisure by car, bicycle, public transport and train can be noticed for the Netherlands. This may indicate some

'advantage' of the urban sprawl: daily shops, sports clubs, … are within everybody's vicinity. For shopping, and especially for leisure, the slow modes of travel – walking and cycling – predominate. Despite the lack of a sound spatial planning system, people kept on walking and cycling for purposes others than working (Table 12).

Table 11. Average daily travel time (in min.) per person per day for all purposes, by residential environment and modal split

Residential environment	Walking	Cycling	Private car (driver)	Public transport (bus, subway, tram)	Train	Other	Total
Inside Vlaamse Ruit							
large city	15.62	7.49	25.14	9.35	1.30	15.47	74.37
regional city	8.04	7.24	25.75	2.76	4.15	15.82	63.76
small city	5.08	12.52	25.80	1.61	6.24	18.55	69.80
suburbs	6.66	6.21	27.31	3.32	4.55	16.44	64.49
rural	6.85	7.42	27.39	2.33	4.59	20.05	68.63
Outside Vlaamse Ruit							
regional city	10.22	9.19	24.25	2.07	3.75	17.71	67.19
small city	8.50	8.82	27.23	1.52	3.58	16.34	65.99
suburbs	5.46	10.61	29.53	0.77	2.53	16.61	65.51
rural	6.42	8.80	27.69	1.89	2.45	16.32	63.57

Table 12. Average daily travel time (in min.) per person per day, by trip purpose and modal split

Trip Purpose	Walking	Cycling	Private car (driver)	Public transport (bus, subway, tram)	Train	Other
Working	16.48	18.27	27.52	44.21	59.57	28.07
Shopping	18.57	12.30	14.36	32.10	33.78	18.99
Leisure	47.25	45.36	24.16	45.68	81.30	30.11

Note: Averages for people travelling for a given trip purpose by a given mode

5.2 Multivariate analysis

As in Schwanen et al. (2002), we used a participation and substantial regression model to estimate the effects of personal/household attributes and residential characteristics on travel time. Although this procedure is out of date, we applied it to make comparisons possible. This two-step procedure is necessary to correct for selectivity bias. This bias stems from the fact that the decision to travel for a given purpose by a given mode may be related to the expected travel time. To correct for this bias, we applied Heckman's two-step procedure (Heckman, 1979). First, a participation model estimates the probability that someone uses the car for shopping purposes. This probability is then transformed and incorporated as the independent

variable λ in the substantial model for travel time. To avoid multicollinearity between λ and other independent variables, the sets of independent variables in the two models must be sufficiently different. Therefore, the variable 'day of the week' was added to the participation models.

Table 13. Regression model for travel time by car for shopping trips

	Participation			**Travel time**			
	B	S.E.	Odds ratio	B	S.E.	β	*R² change*
Constant	-5.522	885.357	0.004	3.165 ***	0.394		
Gender							*0.020*
male (ref.)							
female	-0.738 ***	0.102	0.478	0.034	0.124	0.023	
Household type							*0.009*
others	-0.120	0.148	0.887	-0.074	0.066	-0.046	
single, non-worker	-0.615 **	0.293	0.541	0.297	0.204	0.059	
single, worker	0.196	0.238	1.217	-0.016	0.108	-0.005	
couple, 0 workers	-0.117	0.220	0.890	0.035	0.111	0.015	
couple, 1 worker	0.284	0.220	1.328	-0.053	0.111	-0.018	
couple, 2 workers	-0.389 **	0.173	0.678	0.085	0.097	0.034	
family, 0 workers	0.840	0.739	2.316	-0.166	0.350	-0.015	
family, 1 worker	0.454 **	0.227	1.575	-0.227 *	0.121	-0.072	
family, 2 workers (ref.)							
Age							*0.015*
16-24	-0.855 ***	0.257	0.425	0.125	0.204	0.035	
25-34	0.480 **	0.231	1.616	-0.396 ***	0.136	-0.216	
35-44	0.452 **	0.219	1.571	-0.325 **	0.131	-0.194	
45-54	0.420 **	0.205	1.522	-0.085	0.125	-0.047	
55-64	0.162	0.173	1.176	-0.117	0.096	-0.057	
65+ (ref.)							
Educational level							*0.001*
no degree	-0.931 ***	0.270	0.394	0.331	0.229	0.059	
lower (elementary school)	-0.762 ***	0.183	0.467	0.202	0.168	0.063	
middle, lower (high school, low level)	-0.177	0.129	0.838	0.024	0.067	0.013	
middle, higher (high school, high level)	0.104	0.114	1.110	-0.015	0.053	-0.009	
higher (college and higher, ref.)							
Income							*0.002*
0/20.000 BEF per month	-0.717 **	0.340	0.488	0.367 **	0.177	0.175	
20.001/50.000 BEF per month	0.090	0.325	1.094	0.052	0.125	0.0.35	
50.001/100.000 BEF per month	-0.112	0.321	0.894	0.181	0.119	0.115	
more than 100.000 BEF per month (ref.)							
Car ownership							*0.000*
no car	-1.440 ***	0.177	0.237	0.453 *	0.270	0.132	
1 car	-0.782 ***	0.103	0.457	0.259 **	0.127	0.172	
2 or more cars (ref.)							

Residential environment							*0.005*
Vlaamse Ruit							
large city (ref.)							
regional city	0.732 ***	0.203	2.079	-0.318	0.196	-0.089	
small city	1.064 ***	0.191	2.898	-0.305	0.202	-0.086	
suburbs	0.748 ***	0.222	2.113	-0.292	0.203	-0.101	
rural	1.015 ***	0.229	2.759	-0.407 *	0.234	-0.169	
Rest of Belgium							
regional city	0.867 ***	0.264	2.380	-0.329 **	0.181	-0.127	
small city	1.187 ***	0.223	3.277	-0.222	0.172	-0.109	
suburbs	0.803 ***	0.259	2.232	-0.275	0.211	-0.105	
rural	0.927 ***	0.234	2.527	-0.271	0.213	-0.171	
Day of the week							
weekday (ref.)							
Saturday	0.164	0.106	1.178				
Sunday	-0.076	0.140	0.927				
λ				-0.644 *	0.333	-0.337	*0.003*
No. Cases	2,895			No. Cases	1,648		
Dependent variable	1 = shopping by car 0 = not shopping by car			Dependent variable	ln(travel time in min.)		

* significant at α = 0.10, ** significant at α = 0.05, *** significant at α = 0.01

The probability of shopping by car increases with presence of children in the household, educational level, personal income and car ownership. Age has a nonlinear relationship: up to the age of 25 the probability to shop by car increases, but it decreases afterwards.

Generally, variables of the participation model show the opposite pattern in the substantial model for travel time by car. Gender and age are important determinants of travel time for shopping by private car. Because of their maintenance tasks, women tend to spend more time for shopping purposes then men do. Older people are likely to spend more time on shopping. Travel time decreases with presence of children in the household, educational level, personal income and car ownership. The number of workers in the household does not have a clear relationship with travel time. Residential environment has a somewhat unexpected relationship with travel time for shopping. Inhabitants of the three large cities have the longest travel times for shopping by car. The suburbanization of shops may be an explanation for this. Whereas shops used to be concentrated in the inner city, shops are nowadays relocated along the city's approach roads. In general, inhabitants of the residential environments outside the Vlaamse Ruit have longer travel times than their counterparts within the Vlaamse Ruit.

6. Conclusion

This paper reported on the question whether the lack of a severe spatial planning system resulted in a higher amount of car trips, longer travel distance and travel times in Belgium. The research design was similar to the one used by Dieleman et al. (2002) and Schwanen et al. (2002) in order to compare with a situation where spatial planning was extensively used. Descriptive analyses were made of modal choice, travel distance time for all purposes and modes. Only shopping trips by car were investigated further by regression analysis.
Initially, data were incorporated into the analysis of persons older than 6 years. Age, divided into 8 categories, was one of the explaining personal variables. Regression analysis (tables 4, 8 and 12) resulted, however, in coefficients with large standard error terms for the two youngest age categories. This indicates a greater variety within the category than between categories. Therefore, these results were left out.

Table 14 presents an overview of the most important differences between our results and the results of earlier Dutch research.
In both countries, *modal choice* is dominated by car use, whereas usage of public transport remains low. Although the amount of walking/cycling is high in Belgium, this is even higher in the Netherlands. Modal choice broken down by household type points out that Belgian households with children travel more by bike and less by car than Dutch households do. The relationship between modal choice and residential environment for both countries was found to be analogous. The descriptive analysis of trip purpose made clear that Belgians travel much more for all purposes. Almost twice as much trips than the Dutch were undertaken. A multivariate analysis indicated the importance of income for modal choice in Belgium, whereas car ownership influences modal choice in the Netherlands. Whereas large differences in modal choice were found between different Belgian residential environments, this is less the case in the Netherlands. The reverse is true for household type.
Travel distance by household type has a similar pattern as modal choice. Concerning travel distances, longest distances by public transport are travelled by residents of environments outside the three largest cities. A similar pattern can be noticed for the Netherlands. Comparable to modal choice by trip purpose, we found that travel distances for working and shopping trips in Belgium are twice as long as in the Netherlands. Multivariate analysis

indicated that gender, and secondly residential environment, has the most important influence on travel distance in Belgium. Empirical evidence from the Netherlands found that income and household type were most influential.

Generally, the analysis of *travel time* demonstrates a similar pattern between Belgium and the Netherlands. Inhabitants of the largest cities of both countries have the longest total travel time. Longest daily travel time by car is made by suburban and rural residents. Although travel distances were twice as long for working and shopping trips, travel time is twice as short compared to the Netherlands. Socio-economic variables, namely gender and age, seemed to have the greatest influence on travel time. Furthermore, results of a multivariate analysis were similar for both countries. Residents of the largest cities have the longest travel time for shopping trips by car. The presence of children in a household results in shorter travel times, whereas the pattern for households with workers was found to be ambiguous.

Table 14. Comparison of shopping trips by car in Belgium and the Netherlands

	Belgium	**the Netherlands**
MODAL CHOICE		
1. Descriptive analysis		
- general	dominance of the car	idem
	low usage of public transport	idem
	high amount of walking/cycling	very high amount of walking/cycling
- household type	HH with workers: car	idem
	HH with children: bicycle	HH with children: car
- residential environment	large cities: least total trips, most public transport	idem
	suburbs/rural: most car trips	idem
- trip purpose	twice as much trips for all purposes than the Netherlands	
	greater part by car	idem
2. Multivariate analysis		
- most important	income	car ownership
- residential environment	large cities: public transport	idem
	large differences between environments	less differences between environments
- household type	ambiguous pattern	clear pattern
		HH with children: more car use
		HH with workers: more car use
TRAVEL DISTANCE		
1. Descriptive analysis		
- household type	HH with workers: car	idem
	HH with children: bicycle or public transport	HH with children: car
- residential environment	large cities: shortest total distance	idem

	travelled	
	small cities, suburbs, rural areas within Vlaamse Ruit & regional cities outside Vlaamse Ruit: longest distances by public transport	suburbs and rural areas within the Randstad & rest of the Netherlands: longest distances by public transport
- trip purpose	travel distances for working and shopping are twice as long as for the Netherlands	
	greater part by car	idem
2. Multivariate analysis		
- most important	gender (2nd: residential environment)	income (2nd: household type)
- residential environment	large cities: shortest travel distances (except regional cities outside the Vlaamse Ruit)	
- household type	HH with children: shorter travel distances	idem
	HH with workers: longer travel distances	HH with workers: shorter travel distances
TRAVEL TIME		
1. Descriptive analysis		
- household type	HH with workers: car	-
	HH with children: others (mainly car passengers)	-
- residential environment	largest cities: longest total travel time	idem
	suburbs & rural: highest daily travel time by car	idem
- trip purpose	travel time for working and shopping are twice as short as for the Netherlands (except for walking)	
2. Multivariate analysis		
- most important	gender (2nd: age)	-
- residential environment	large cities: longest travel time	idem
- household type	HH with children: shorter travel time	idem
	HH with workers: ambiguous pattern	idem

One of the main differences in travel behaviour of both countries resulted from modal choice, travel distance and time by trip purpose. Belgians seem to undertake twice as much trips, travel longer distances but shorter times for working and shopping purposes. However, other travel behaviour aspects were found to be similar. Even thought a severe spatial planning system was missing in Belgium for several decades, we can conclude that several aspects of our travel behaviour compares to the Dutch situation. Especially the results for travel time show a similar pattern. This imposes the question whether travel behaviour of the Dutch is influenced by factors others than their spatial planning system.

References

Boarnet, M.G. & Sarmiento, S. (1996). *Can Land Use Policy Really Affect Travel Behavior ? A Study of the Link Between Non-Work Travel and Land Use Characteristics*. Paper presented at Lincoln Land Institute TRED Conference, October 11-12.

Cervero, R., Kockelman, K. (1997). Travel Demand and the 3D's: Density, Diversity and Design. *Transportation Research D*. 2 (3), pp. 199-219.

Dieleman, F.M., Dijst, M., Burghouwt, G. (2002). Urban Form and Travel Behaviour: Micro-level Household Attributes and Residential Context. *Urban Studies*, 39 (3(), 507-527.

Ewing, R., Haliyur, P., Page, G.W. (1994). Getting Around a Traditional City, a Suburban Planned Unit Development, and Everything in Between. *Transportation Research Record*. 1466, pp. 53-62.

Frank, L.D., 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.

Friedman, B., Gordon, S.P., Peers, J.B. (1994). Effect of Neotraditional Neighborhood Design on Travel Characteristics. *Transportation Research Record.* 1466, pp. 63-70.

Gordon, P., Kumar, A., Richardson, H.W. (1989). The Influence of Metropolitan Spatial Structure on Commuting Time. *Journal of Urban Economics*. 26, pp. 138-151.

Gorham, R. (2002). Comparative Neighborhood Travel Analysis: An Approach to Understanding the Relationship Between Planning and Travel Behaviour. In: Mahmassani, H.S. (ed.). *In Perpetual Motion: Travel Behavior Research Opportunities and Application Challenges*. Pergamon, Amsterdam, pp. 237-259.

Hess, P.M., Moudon, A.V., Snyder, M.C., Stanilov, K. (1999). Site Design and Pedestrian Travel. *Transportation Research Record*. 1674, pp. 9-19.

Kockelman, K.M. (1997). Travel Behavior as Function of Accessibility, Land Use Mixing, and Land Use Balance. Evidence form San Francisco Bay Area. *Transportation Research Record*. 1607, pp. 116-125.

Krizek, K.J. (2000). Pretest-Posttest Strategy for Researching Neighborhood-Scale Urban Form and Travel Behavior. *Transportation Research Record*. 1722, pp. 48-55.

Krizek, K.J. (2003). Residential Relocation and Changes in Urban Travel: Does Neighborhood-Scale Urban Form Matter ? *Journal of the American Planning Association.* 69 (3), pp. 265-281.

McNally, M.G., Kulkarni, A. (1997). Assessment of Influence of Land Use-Transportation System on Travel Behavior. *Transportation Research Record*. 1607, pp. 105-115.

Meurs, H., Maaijer, R. (2001). Spatial Structure and Mobility. *Transportation Research Part D*. 6, pp. 429-446.

Ministerie van de Vlaamse Gemeenschap, 1998. *Ruimtelijk Structuurplan Vlaanderen: integrale versie*. Ministerie van de Vlaamse Gemeenschap, Brussel, 594p.

Schwannen, T. (2002). Urban Form and Commuting Behaviour: a Cross-European Perspective. *Tijdschrift voor Economische en Sociale Geografie*. 93 (3), pp. 336-343.

Schwanen, T., Dijst, M., Dieleman, F.M. (2002). A Microlevel Analysis of Residential Context and Travel Time. *Environment and Planning A*, 34, 1487-1507.

Schwanen, T., Dijst, M.J., Dieleman, F.M. (2004). Policies for Urban Form and Travel: the Netherlands Experience. *Urban Studies*, 41 (3), 579-603.

Stead, D. (2001). Relationships Between Land Use, Socioeconomic Factors and Travel Patterns in Britain. *Environment and Planning B*. 28, pp. 499-528.

Zhang, M. (2004). The Role of Land Use in Travel Mode Choice: Evidence from Boston and Hong Kong. *Journal of the American Planning Association*. 70 (3), pp. 344-360.

Zwerts, E., Nuyts, E. (2004). *Onderzoek Verplaatsingsgedrag Vlaanderen 2 (januari 2000-januari 2001). Deel 1: Methodologische Analyse*. Provinciale Hogeschool Limburg, Departement Architectuur, Onderzoekscel Architectuur Mobiliteit Omgeving, 38p.