Evaluation of the mobility impacts of the Dutch Vinex policy

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abstract (keywords in bold)

Mobility reduction was an important aim of the Dutch spatial policy from the nineties (Vinex). This paper reports on a study into the mobility consequences of the developments resulting from implementation of this **Vinex policy**. The study focuses on **spatial characteristics of the residential environment** of all newly built houses from the period 1995-2002 and the **travel behaviour** of their residents. Results were obtained from detailed analyses of spatial characteristics and regression analyses of individual travel patterns. Socio-economic characteristics have been taken into account. We found that the situation in the Vinex developments is largely in accordance with policy intentions, both with regard to proximity and accessibility. Success was achieved with regard to the development of inner city locations, the quality of public transport facilities and the proximity to urban centres. Policy implementation was less successful with regard to mixing land uses and the distances to daily facilities.

The mobility generated varies strongly between different types of locations. New developments, in general, generate more motorised mobility than average. Locations that were developed as part of the Vinex policy do better than non-Vinex developments. Especially the inner city Vinex developments are characterised by low car use, despite a very mobile population composition. Car use is high on Vinex greenfield locations, which can mainly be attributed to the composition of the population. Overall however, the preferred spatial characteristics of Vinex developments, proximity and accessibility, have played a noticeable role in generating a more favourable mobility pattern. Particularly the proximity of urban centres and the accessibility by public transport have contributed to the lower car use in Vinex developments in comparison to non-Vinex.

1 INTRODUCTION

Reduction of mobility (growth), especially by car, was one of the main aims of the Dutch national spatial policy in the nineties of the last century, as documented in de Fourth Report on Spatial Planning Extra (Vinex[1]) [Ministry of HSPE, 1990]. In order to achieve this reduction, new developments should be concentrated in or near existing urban centres. Spatial developments were to ensure that the daily functional relations connected to living and working can take place on the scale of the urban region. Concentrating new developments in or near existing urban centres was to limit the urbanisation of the country, strengthen the cities and reduce mobility growth. Keywords of this policy were proximity and accessibility. Locations within the urban field had priority and should be developed first. Locations on the edge of existing urban areas were seconds and only if no other options existed, locations further away could be developed. Urban design and the location of housing, employment and facilities should ensure optimal accessibility by public transport and by walking and cycling. A strict parking policy was implemented to support public transport and non-motorised modes of transport.

This policy was thus based on the proposition that location choice and spatial structure of new developments are related to the travel behaviour of their inhabitants. This relationships has been the subject of a large number of studies, both within the Netherlands as abroad and the results of these studies are often contradictory. Interpreting them is complicated by a variety of research methods and diverse spatial and cultural contexts [Snellen, 2001].

The Dutch studies are most useful with regard to the spatial en cultural context. Several studies are available, both specifically aimed at developments under the Vinex policy as well as more general studies. Methodologies, however, vary. A well-known model study into the expected effects of several urbanisation concepts was carried out by TNO Inro in 1995 [Verroen *et al*]. It showed that a concentrated development on locations with an orientation in multiple directions was most favourable when aiming for a reduction of car mobility growth.

Empirical studies into the travel behaviour of the Dutch are more common. A study in Dutch medium sized cities [Snellen, 2001] indicates that the influence of spatial structure on travel behaviour is rather limited. Some effects were found from characteristics such as distance to the city centre, the quality of public transport, land use mix and some types of

[1] This report is generally referred to with its Dutch acronym ‘Vinex’. This acronym will also be used in this paper.

transportation networks. Another study [MuConsult, 2000] focussed mainly on location design and found effects of density, walking and cycling 'friendliness' and the presences of home zones (woonerven).

Furthermore, there are some studies that specifically look at new housing developments. In 1996 Konings *et al* examined the journeys to work of residents of newly built housing. However, they could not find significant effects of both location and design characteristics. In 1999 a first evaluation of the travel behaviour on Vinex locations was carried out by Hilbers *et al*, using travel behaviour data from the Dutch national travel survey (OVG). The results showed that especially the greenfield locations have relatively high car use, probably due to the larger distance to the city, poor public transport facilities and low land use mix. Residents of infill locations, especially those in the inner cities, have far lower car use. A second study focussed on orientation patterns of Vinex residents [Wilmink *et al*, 2002]. No striking differences with the patterns of the general Dutch population were found. However, some differences between types of Vinex locations exist. Locations near the city centres, good public transport facilities in multiple directions and ample land use mix are related to a more local orientation of travel patterns.

These earlier studies into the travel behaviour of Vinex residents were carried out at a point in time when only a few Vinex locations had been developed and the travel patterns of the residents had not yet taken their definite shape. By now, more developments are ready or building is in an advanced stage, and there is a demand for a new evaluation of these more mature neighbourhoods and the travel behaviour of their residents. This paper reports on some of the findings of this new evaluation study.

The next section explains the methodology of the study. Section three sheds light on the spatial characteristics of (different types of) new housing locations, which indicates the spatial implementation of the Vinex policy and the measure in which this was successful. The fourth section describes the relationship between characteristics of the residential environment and the travel behaviour of several sections of the population and the following section discusses the travel behaviour of residents of a number of location types. For each of these location types we report the contribution of groups of variables, such as the population composition and the spatial characteristics. Finally, conclusions are drawn.

2 METHODOLOGY

The data on travel behaviour for this study is from the Dutch national travel survey (OVG). Data from 1998 until 2002 has been combined into one dataset. The information on travel behaviour is linked to spatial characteristics of the respondents' residential environment based on their postal code. Analyses have been performed on the complete set of data. Residents of newly built houses have been distinguished from the rest of the population by a dummy variable. Data on which respondents reside in a newly built house (built since 1995) was obtained by linking the address data from the travel survey with data on changes in house stock from Statistic Netherlands.

The relationship between travel behaviour and spatial characteristics of the residential environment were analysed using regression analysis. In order to take the influence of socio-economic characteristics of the respondents into account, we applied a slightly different method than usual. Most studies include socio-economic characteristics in the regression equation. However, we have chosen to estimate separate regression models for 21 sections of the population. This way we can take differences between population groups in the way their travel behaviour relates to spatial characteristic into account.

The 21 sections of the population have been defined based on their age, work status, education level and the presence of children in the household. From other studies it is known that these characteristics are typically related to travel behaviour. For each of these 21 groups separate regression models have been estimated for car ownership, the total number of kilometres travelled, the number of kilometres driven by car, travelled by public transport and by walking/cycling. In this paper we focus on total number of kilometres travelled, the number of kilometres driven by car and the kilometres travelled by public transport.

This paper only reports results based on regression models with exclusively significant variables (95%). However, due to the size of the dataset (over 1.1 million respondents and over 3.8 million trips), almost all spatial characteristics were significantly related to the travel behaviour of almost each section of the population. The complete results of the regression analyses can be found on the website of the National Institute for Spatial Research (www.rpb.nl).

3 SPATIAL CHARACTERISTICS OF THE LOCATIONS OF NEWLY BUILT HOUSING

First question when evaluating the Vinex policy is to what degree the desired location characteristics and design principles have been implemented. To do so we derived a number of key characteristics that the developments should comply with. Since our intention is to analyse travel behaviour at the individual level, the spatial characteristics were to be defined at the lowest possible level. And since newly built houses under the Vinex principles are built in many locations in our country, the characteristics should also be measurable nationwide. The following criteria have been evaluated:

- distance to main centre of an urban region, other urban centre or minor urban centre[2]
- distance to several daily facilities (supermarket, bakery, primary school, secondary school)
- land use mix within the surrounding area
- distance to nearest public transport stop and level of service (bus, tram, metro and/or train)
- distance to nearest motorway exit

We analysed these criteria for different types of location. We distinguish between:

- Vinex regions (the major urbanised regions assigned for further growth in the Vinex policy)
  - inner city development, within the limits of the built-up area of 1971
  - other locations within the limits of the built-up area of 1996
  - official Vinex greenfield locations, for which agreements were made between national and regional authorities
  - other locations outside the limits of built-up area of 1996.
- non-Vinex (the rest of the Netherlands)
  - inner city development, within the limits of built-up area of 1971
  - other locations within the limits of built-up area of 1996
  - locations outside the limits of built-up area of 1996

[2] 28 centres of urban regions, 48 other urban centres with at least 200 non-food shops and 228 minor centres with at least one department store.

Table 1 shows the distribution of the new houses over the different types of locations. In total 710,000 new houses were built, 62% of which within the Vinex regions. The Vinex houses are concentrated in the Randstad. In this part almost 90% of the new houses where realised within the Vinex regions. In the eastern and southern part of the Netherlands nearly half of the new houses were built within the Vinex regions (47%). In the northern and southwestern part only 30% of the newly built houses is a Vinex house.

*table 1 number of newly built houses 1995-2003, for each type of location and by region (*1000)*

	Randstad	East and South	North and South-west	Total	Total percentage
Vinex within limits 1971	90	51	10	152	21%
Vinex within limits 1996	45	23	7	74	10%
Vinex green field location	94	40	10	144	20%
Vinex other outside limits 1996	38	25	9	71	10%
total Vinex houses	266	139	36	441	62%
non-Vinex within limits 1971	9	44	21	75	11%
non-Vinex within limits 1996	8	45	22	75	11%
non-Vinex outside limits 1996	15	65	38	119	17%
total new houses non-Vinex	33	154	82	269	38%
total new houses	299	293	118	710	100%

The Vinex policy promoted the development at inner city locations successfully. About half of the new houses where built within the existing built-up area and only 20% on one of the official Vinex Greenfield locations, which dominate the discussion about Vinex.

For each of these location types the scores on the above mentioned evaluation criteria were calculated using the lowest possible aggregation level, the six-digit postal code (450,000 zones!). Each house was assigned the score of the six-digit postal code it is located in. Table 2 shows the median scores in each location type.

New houses are located further away from centres and facilities than the existing housing stock. The types of locations differ in their distances to centres and facilities. Distances are lower in the Vinex regions. The inner city locations are close to all types of centres and facilities. At Vinex greenfield locations the distance to centres are above average for Vinex regions but lower than the median distance for new houses outside the Vinex regions. Vinex greenfield locations have high averages for bakeries and secondary schools. These facilities have not (yet) found their way into these locations.

table 2 median distance from house to centres and facilities

	centre major urban region	other urban centre	minor urban centre	super market	bakery	primary school	secundary school
Vinex within limits 1971	3.1	2	1.2	0.28	0.32	0.30	0.41
Vinex within limits 1996	6.9	4.7	2.4	0.51	0.61	0.41	0.72
Vinex green field location	7.6	4.7	2.5	0.64	1.20	0.41	1.12
Vinex other outside limits 1996	6.7	5	2.4	0.71	0.85	0.50	0.94
all new houses Vinex regions	6.1	3.8	2.0	0.50	0.64	0.36	0.71
all houses Vinex regions	4.6	3.0	1.6	0.32	0.40	0.30	0.50
non-Vinex within limits 1971	19.3	8.9	1.3	0.28	0.32	0.30	0.51
non-Vinex within limits 1996	19.7	9.8	3.6	0.60	0.72	0.41	1.02
non-Vinex outside limits 1996	20.7	8.9	3.3	0.78	0.92	0.51	1.17
all new houses non-Vinex	20.1	9.1	3.0	0.57	0.67	0.41	0.90
all houses non-Vinex	19.2	9.4	3.5	0.45	0.54	0.32	0.86
all new houses	9.9	5.1	2.6	0.50	0.64	0.40	0.76
all houses	8.7	4.5	2.5	0.36	0.42	0.32	0.60

Table 3 shows the scores on land use mix in the distinguished location types. Land use mix was defined as the ratio between number of jobs and the sum of jobs and houses. This proportion was calculated for 100 by 100 metre cells and for a radius of 1, 3 and 10 kilometres. Inner city locations have a better mixture of jobs and houses within a 1 kilometre radius. The official Vinex greenfield locations show a lack of jobs in the immediate surroundings. Hardly any differences are found in the 3 and 10 kilometres radius.

table 3 average land use mix score

	1km	3km	10km
Vinex within limits 1971	0.48	0.53	0.52
Vinex within limits 1996	0.39	0.49	0.52
Vinex green field location	0.27	0.46	0.52
Vinex other outside limits 1996	0.36	0.49	0.52
all new houses Vinex regions	0.38	0.49	0.52
all houses Vinex regions	0.43	0.51	0.52
non-Vinex within limits 1971	0.46	0.50	0.50
non-Vinex within limits 1996	0.38	0.47	0.50
non-Vinex outside limits 1996	0.36	0.47	0.49
all new houses non-Vinex	0.40	0.48	0.49
all houses non-Vinex	0.40	0.47	0.49
all new houses	0.39	0.49	0.51
all houses	0.42	0.50	0.51

A last item was the supply of (public) transport facilities. Table 4 shows what kind of local and regional public transport is provided at walking distances (within 500 meter for bus and

tramway, and within 750 meter for underground and fast tramway). 45% of all new houses have good quality local public transport: a frequent bus, tram or underground service. In the Vinex regions about 60% of new houses has that quality available, outside the Vinex regions only 17 percent. The Vinex inner city locations are well provided, but still 16% of the official Vinex greenfield location offer a poor quality: no busses at all, or only one or two bus services per hour.

table 4 availability of local and regional public transport

	no services	bus 1x per hour	bus 2x per hour	bus 4 x per hour	tramway	underground/ fast tramway
Vinex within limits 1971	2%	3%	13%	53%	18%	12%
Vinex within limits 1996	9%	7%	29%	44%	5%	5%
Vinex green field location	13%	3%	32%	43%	7%	1%
Vinex other outside limits 1996	24%	9%	27%	28%	1%	11%
all new houses Vinex regions	10%	5%	24%	44%	9%	7%
all houses Vinex regions	5%	4%	18%	50%	14%	9%
non-Vinex within limits 1971	8%	17%	38%	36%	0%	1%
non-Vinex within limits 1996	30%	23%	35%	11%	0%	0%
non-Vinex outside limits 1996	42%	19%	28%	9%	0%	0%
all new houses non-Vinex	30%	20%	33%	17%	0%	0%
all houses non-Vinex	24%	22%	33%	21%	0%	1%
all new houses	18%	10%	27%	34%	6%	5%
all houses	12%	11%	24%	38%	9%	6%

For longer distances, a train connection and a connection to the motorway system becomes more important. Table 5 shows the median distances to a railway station, a railway station with intercity or fast train services and to an exit of the motorway system. It also shows the percentage of houses with some kind of good public transport[3].

The average distance toward a railway station is 2.4 kilometres for a new house, compared to 2.1 kilometres for all houses. In the Vinex regions these distances are shorter, especially for inner city locations. The median for Vinex greenfield locations is 2.5 kilometres, evidently better than the 3.1 kilometres score for the other Vinex locations outside the limits of 1996. Stations with fast train services are scarce outside the Vinex regions. 12 to 13 kilometres is a normal distance to that kind of train station for non-Vinex locations. Summarising the available public transport facilities into one indicator, we find that within the Vinex regions, 70% of the new houses have good public transport available. At inner city

[3] Good public transport available is defined as having a train station within 1,500 metres and/or an underground station within 750 metres and/or a bus or tramway service at least 4x hour within 500 metres.

locations this score is 92% while at Vinex greenfield locations it is 60%. Outside the Vinex regions, only 38% of the new houses have good public transport facilities available. Motorway exits are more at hand, at 3 to 4 kilometres. Vinex greenfield locations have the shortest distances to motorway exits (1.8 kilometres). The Vinex policy did not aim at this. It is unintentional side effect of the fact that motorways and these locations are both situated at the edges of the existing cities.

table 5 median distance to a railway station and a motorway exit and percentage of new houses with good public transport

	local train	fast train	motorway exit	% good public transport
Vinex within limits 1971	1.3	2.2	2.2	92%
Vinex within limits 1996	2.3	4.3	2.0	65%
Vinex green field location	2.5	4.4	1.8	61%
Vinex other outside limits 1996	3.1	4.7	2.2	49%
all new houses Vinex regions	2.1	3.8	2.1	70%
all houses Vinex regions	1.7	3.0	2.0	82%
non-Vinex within limits 1971	2.3	12.7	3.3	62%
non-Vinex within limits 1996	4.2	13.0	3.9	31%
non-Vinex outside limits 1996	3.9	12.8	4.1	28%
all new houses non-Vinex	3.6	12.8	3.9	38%
all houses non-Vinex	3.8	12.5	4.0	41%
all new houses	2.4	5.3	2.4	58%
all houses	2.1	4.9	2.4	66%

table 6 population composition of residents of newly built houses

	under 18 years	65 years and over	students	other 18-65 years	not working	working part time	working full time	lower education	medium education	higher education	families without children	families with childern
Vinex within limits 1971	18%	20%	3%	55%	13%	8%	37%	18%	18%	21%	43%	14%
Vinex within limits 1996	28%	10%	3%	57%	11%	11%	36%	17%	21%	20%	35%	23%
Vinex green field location	29%	5%	3%	61%	9%	12%	42%	18%	25%	20%	38%	25%
Vinex other outside limits 1996	32%	3%	2%	61%	10%	12%	40%	17%	25%	20%	34%	29%
non-Vinex within limits 1971	18%	27%	2%	51%	13%	8%	30%	19%	20%	13%	36%	16%
non-Vinex within limits 1996	29%	7%	3%	58%	12%	11%	36%	20%	24%	15%	35%	25%
non-Vinex outside limits 1996	31%	5%	2%	60%	12%	12%	38%	20%	26%	16%	35%	27%
total new houses	27%	10%	2%	58%	11%	11%	37%	18%	23%	18%	37%	23%
total population	23%	13%	4%	59%	16%	10%	34%	24%	20%	15%	42%	17%

A last important factor in understanding differences in mobility behaviour is the population composition. Since highly educated full time working people travel much more than children or elderly, the distribution of the population over the different socio-economic groups has to be taken into account. Table 6 gives an overview of the population composition of each of the location types.

Compared to the total population, there are more children, more fulltime workers and more people with a higher education living in newly built houses. Students, elderly people, non-working and lower educated people are less represented. This pattern is stronger at the Vinex greenfield locations and the other new houses outside the limits of 1996 in Vinex regions. At inner city locations a remarkable high share of elderly people is found, both within Vinex and non-Vinex regions.

4 THE RELATIONSHIP BETWEEN SPATIAL CHARACTERISTICS AND TRAVEL BEHAVIOUR

In this paragraph we analyse how the travel behaviour of residents of newly built houses is related to differences in socio-economic groups and the spatial characteristics of the residential environment. The analyses are based on regression models estimated on data from the national travel survey for the years 1999-2002. From this survey distance, mode and purpose of each trip is available, as well as socio-economic information on the respondents and the six-digit postal code of their home address. We combined these data with the spatial characteristics of the six-digit location and assigned a dummy variable indicating newly built houses[4]. Some of the distance indicators underwent a transformation, introducing a maximum distance above which no influence was expected.

Regression models were estimated for the distances travelled per person per day per mode. As explained in section 2, separate regression models were estimated for 21 population groups. In this way we can not only account for differences in travel behaviour between socio-economic groups but also for differences in the way spatial characteristics of the residential environment affect these groups. With 21 socio economic groups for which 22 spatial factors explain at least 3 mobility indicators, we have to limit the presentation of results. Table 7 shows the

[4] See section 2 for further details on how newly built houses were discerned.

distance travelled per person per day for each population group, using the parameters of the separate models while keeping the scores for the spatial characteristics at the average national level. The differences are substantial and will be a factor of importance for the explanation of mobility of residents of newly built houses. A high level of total mobility is found for students and full time working and highly educated people. Car use is high for full time working and highly educated people. Public transport use is very high for students, due to the special card that gives students free use of public transport at weekends or on working days.

table 7 average number of kilometres travelled per day,

	all modes	car driver	public transport
under 18 years old	18.0	0.0	2.5
65 years or older	17.6	7.8	2.8
student	42.5	6.9	23.4
not working, low education, no children	21.9	8.3	2.2
not working, low education, with children	18.3	7.7	1.2
not working, medium education, no children	30.5	14.8	3.3
not working, medium education, with children	22.9	10.3	1.7
not working, high education, no children	39.3	21.4	6.2
not working, high education, with children	32.0	15.1	2.6
part time working, low education, no children	29.0	13.0	3.6
part time working, low education, with children	26.1	13.8	2.4
part time working, medium education, no children	36.1	15.6	6.6
part time working, medium education, with children	30.3	16.5	2.4
part time working, high education, no children	47.1	23.0	8.7
part time working, high education, with children	40.1	22.2	4.6
full time working, low education, no children	39.6	26.3	3.9
full time working, low education, with children	40.2	29.1	3.0
full time working, medium education, no children	47.7	32.5	5.5
full time working, medium education, with children	48.0	37.1	3.6
full time working, high education, no children	62.5	42.5	9.1
full time working, high education, with children	59.5	45.4	5.9
total population	31.0	15.7	4.5

Spatial characteristics are also related to travel behaviour. Table 8 shows how the different factors are associated with the number of kilometres travelled per person per day for the average population composition of residents of newly built houses. Due to the enormous data set, significant relationships were found for most groups and for most independent variables. The extent of the impact can vary. It depends on the combination of a high coefficient and a large range in the score on a variable.

Proximity matters. For almost all independent variables describing an element of proximity, a longer distance is related to more mobility. Land use mix shows reasonably sized coefficients

but remember that in the previous paragraph only small differences in the scores were found. Furthermore, distance to a railway station is related to more use of public transport as well as to less car use. A motorway exit nearby is related to more car use and less use of public transport. Frequent bus services and especially (light) rail are associated with lower car mobility and larger numbers of public transport kilometres. The location of housing in the Netherlands (East/South or North/Southwest as opposed to the Randstad) is only slightly related to differences in travel behaviour. More important is the lower mobility, the lower car use and the higher use of public transport in the four major cities. Finally, the results show that living in a newly built house is related to more kilometres travelled in total and by car, and to fewer kilometres by public transport than residents of existing houses with the same socio-economic and spatial characteristics. We have named this effect the 'newly built house' effect.

table 8 relationship between spatial characteristics of the residential environment and travel behaviour

	all modes	car driver	public transport
distance to centre major urban regions (per km)	0.13	0.08	0.03
distance to urban centre (per km)	0.08	0.07	-0.03
distance to minor urban centre (per km)	0.35	0.27	0.01
distance to bakery (per km)	0.58	0.44	0.00
distance to supermarket (per km)	0.55	0.64	-0.23
distance to primary school (per km)	-0.12	-0.05	-0.28
distance to secondary school (per km)	0.04	0.02	0.00
land use mix within 1km (1.00 versus 0.00)	-1.13	-0.41	-0.32
land use mix within 3km (1.00 versus 0.00)	0.02	-1.02	1.03
land use mix within 10km (1.00 versus 0.00)	3.25	-2.35	-1.23
distance to station slow train (per km)	-0.10	0.54	-0.61
distance to station fast trains (per km)	0.06	0.09	-0.08
distance to motorway exit (per km)	-0.23	-0.18	0.04
dummy bus service 1x per hour at walking distance	-0.19	-0.26	-0.1
dummy bus 2x per hour at walking distance	0.23	-0.11	-0.15
dummy bus 4x per hour at walking distance	-0.08	-0.91	0.62
dummy tramway at walking distance	-3.72	-3.63	0.47
dummy underground/fast tramway at walking distance	-2.31	-2.46	1.46
dummy East/South	-0.76	0.02	-0.47
dummy North/Southwest	0.02	-0.35	0.19
dummy Amsterdam/Rotterdam/the Hague/Utrecht	-1.76	-2.15	1.58
dummy newly built house	2.63	1.78	-0.34

In order to find out if the effect found for the dummy variable 'newly built house' changes over time (when the house gets older and is inhabited longer) we extended the analyses with extra dummy variables for different age groups of houses. Table 9 reports the results. The

'newly built house' effect is not decreasing but even increasing over time. It appears that after a few years the second car is introduced into the households, which relates to more car use and less use of public transport.

table 9 results for dummy variables for different age groups of newly built houses

	all modes	car driver	public transport
dummy newly built house 0-1 year old	1.5	1.1	-0.4
dummy newly built house 2-3 year old	2.0	1.7	-0.3
dummy newly built house 4-5 year old	3.4	2.0	-0.3
dummy newly built house 6-8 year old	3.2	2.2	-0.6

5 TRAVEL BEHAVIOUR

In this paragraph we use the results of the regression models described in the previous section in order to better understand the differences in travel behaviour between the locations types. First, table 10 shows the average number of kilometres travelled per day, in total, as car driver and by public transport for each of the location types, as measured in the Dutch national travel survey.

table 10 average number of kilometres travelled per person per day

	all modes	car driver	public transport
Vinex within limits 1971	30.0	14.7	6.1
Vinex within limits 1996	35.1	19.0	3.7
Vinex green field location	38.7	20.9	4.0
Vinex other outside limits 1996	38.5	19.9	4.8
non Vinex within limits 1971	32.5	18.3	2.8
non Vinex within limits 1996	38.4	20.8	3.0
non Vinex outside limits 1996	38.8	21.8	3.4
all newly built houses	36.2	19.4	4.0
total Netherlands	32.2	16.3	4.6

Residents of new houses travel more than the average population: 36.2 kilometres per person per day as opposed to the national average of 32.2. Most of the extra kilometres are made as a car driver, while public transport use is lower. There are substantial differences between the different types of locations. At inner city locations, the distances travelled and car use are much lower, and the use of public transport is higher. The highest total mobility is found at greenfield locations (outside the limits of existing urban areas), both in Vinex and in non-Vinex regions. Use of public transport is low outside the Vinex regions.

Subsequently we have analysed how socio-economic characteristics, spatial factors and the 'newly built house' factor contribute to these differences. Table 11 gives an overview for the total amount of kilometres travelled while table 12 breaks down the combined effect of the spatial characteristics of the residential environment.

The spatial characteristics are only a minor factor in explaining the difference in kilometres travelled between residents of the existing housing stock and residents of newly built houses. Only 0.5 of the 4.0 kilometres difference can be explained by spatial factors, while 1.1 kilometre is explained by socio-economic characteristics of the population and 2.4(!) can be related to the 'newly built house' factor. Spatial characteristics, however, are important for understanding the differences between the location types. At Vinex inner city locations spatial factors can explain a reduction of 2,9 kilometres in total mobility, while at greenfield locations outside Vinex regions spatial characteristics explain 2.8 kilometres travelled more. Spatial characteristics cannot explain the high level of mobility at Vinex greenfield locations. Socio-economic characteristics explain higher mobility levels at most types of locations, especially at Vinex greenfield locations and other Vinex locations outside the limits of 1996. The large amount of elderly people at non-vinex inner-city locations explains a lower mobility (-2.1 kilometres) for these locations. The models can explain not all the differences between the location types. Total mobility remains lower than expected at inner city locations, and higher than expected at Vinex greenfield locations.

table 11 contribution of groups of factors to explaining the difference in total kilometres travelled between location types and the national average

	population	newly built houses factor	spatial characteristics.	unexplained	total
Vinex within limits 1971	1.4	2.3	-2.9	-3.0	-2.2
Vinex within limits 1996	1.0	2.7	-0.1	-0.7	2.9
Vinex green field location	2.2	2.2	0.3	1.7	6.5
Vinex other outside limits 1996	2.8	2.3	-0.2	1.4	6.3
non-Vinex within limits 1971	-2.1	2.3	0.9	-0.9	0.3
non-Vinex within limits 1996	0.4	2.7	2.5	0.6	6.2
non-Vinex outside limits 1996	0.9	2.3	2.8	0.6	6.6
all newly built houses	1.1	2.4	0.5	0.0	4.0

Table 12 goes more into detail about the explanatory power of the individual spatial characteristics. Proximity of city centres appears to be the main factor. The distance to facilities, public transport quality and the proximity of motorway exits can also explain a reasonable amount of the variation.

table 12 contribution of spatial factors to explaining the difference in total kilometres travelled between location types and national average

	region	proximity	facilities	land use mix	public transport quality	motorway exit	total
Vinex within limits 1971	-0.3	-1.6	-0.4	0.1	-1.0	0.2	-2.9
Vinex within limits 1996	0.1	-0.6	0.1	0.1	0.1	0.2	-0.1
Vinex green field location	0.0	-0.6	0.4	0.2	0.0	0.3	0.3
Vinex other outside limits 1996	0.0	-0.6	0.3	0.1	-0.2	0.2	-0.2
non-Vinex within limits 1971	0.0	1.0	-0.2	-0.1	0.5	-0.2	0.9
non-Vinex within limits 1996	0.1	1.8	0.3	0.0	0.6	-0.4	2.5
non-Vinex outside limits 1996	0.1	1.9	0.5	0.0	0.5	-0.3	2.8
all newly built houses	0.0	0.2	0.2	0.1	0.0	0.0	0.5

Car use is analysed in table 13 and 14. The pattern is roughly similar to the results for total mobility. The differences between the newly built housing stock and the existing housing stock are mainly explained by the 'newly built house' factor and by socio economic factors. Spatial characteristics explain a relatively large amount of the divergent travel behaviour at Vinex inner city locations and non-Vinex locations outside the existing built-up area. For car use at Vinex inner city locations a relatively large amount of the variation is not explained. Car use is substantially lower here than expected.

table 13 contribution of groups of factors to explaining the difference in car kilometres travelled between location types and the national average

	population	newly built houses factor	spatial characteristics.	unexplained	total
Vinex within limits 1971	1.7	1.7	-3.6	-1.4	-1.5
Vinex within limits 1996	1.0	1.7	-0.2	0.2	2.7
Vinex green field location	1.9	1.6	0.1	1.0	4.6
Vinex other outside limits 1996	2.4	1.6	0.1	-0.5	3.6
non-Vinex within limits 1971	-0.6	1.5	0.9	0.2	2.0
non-Vinex within limits 1996	0.4	1.7	2.5	-0.1	4.5
non-Vinex outside limits 1996	0.8	1.5	2.8	0.2	5.5
all newly built houses	1.2	1.6	0.3	0.0	3.1

Table 14 illustrates again the importance of proximity and public transport quality as explaining factor between Vinex inner city versus non-Vinex outside the existing built-up area. 0.5 kilometres lower car use for the category 'region' for Vinex locations within the limits of 1971 can be attributed to the lower levels of car use in the four major cities. The

proximity of motorway exits of Vinex location types is associated with slightly higher car use compared to non-Vinex regions.

table 14 contribution of spatial factors to explaining the difference in car kilometres travelled between location types and national average

	region	proximity	facilities	land use mix	public transport quality	motorway exit	total
Vinex within limits 1971	-0.5	-1.2	-0.4	0.0	-1.6	0.2	-3.6
Vinex within limits 1996	0.1	-0.4	0.0	0.0	0.0	0.2	-0.2
Vinex green field location	0.0	-0.4	0.3	0.0	-0.1	0.2	0.1
Vinex other outside limits 1996	0.0	-0.4	0.3	0.0	0.1	0.2	0.1
non-Vinex within limits 1971	0.2	0.7	-0.3	-0.1	0.5	-0.2	0.9
non-Vinex within limits 1996	0.2	1.2	0.2	0.1	1.0	-0.3	2.5
non-Vinex outside limits 1996	0.2	1.2	0.5	0.1	1.1	-0.3	2.8
all newly built houses	0.0	0.1	0.1	0.0	0.1	0.0	0.3

Table 15 and 16 focus on public transport. The patterns are, again, comparable to those of total mobility and car use, however, the direction of the differences are reverse. For the newly built housing stock overall, the 'newly built house' factor and socio-economic factors remain the most important in explaining differences. Spatial characteristics explain higher public transport use at Vinex inner city locations and lower use at non-Vinex locations outside the existing built-up areas. The combined explaining power of spatial characteristics for Vinex greenfield locations is virtually nonexistent.

table 15 contribution of groups of factors to explaining the difference in public transport kilometres travelled between location types and the national average

	population	new house factor	spatial characteristics.	unexplained	total
Vinex within limits 1971	0.2	-0.4	1.5	0.1	1.4
Vinex within limits 1996	-0.2	-0.4	-0.1	-0.4	-1.0
Vinex green field location	-0.3	-0.3	0.0	-0.1	-0.7
Vinex other outside limits 1996	0.0	-0.3	-0.3	0.7	0.1
non-Vinex within limits 1971	-0.6	-0.3	-0.4	-0.5	-1.8
non-Vinex within limits 1996	-0.4	-0.3	-0.7	-0.2	-1.6
non-Vinex outside limits 1996	-0.4	-0.3	-0.8	0.3	-1.3
all newly built houses	-0.2	-0.3	-0.1	0.0	-0.6

Table 16 breaks up the total effect of spatial characteristics in explaining differences in public transport use. The higher use of public transport in the four major cities attributes to a 0.5 score for the variable 'region' for Vinex inner city locations. Proximity of city centres and

facilities explains only a very small part of the differences while public transport quality explains the high level of public transport use at Vinex inner city locations and the low level at non-Vinex locations outside the existing built-up area.

Finally, although the quality and use of public transport on Vinex greenfield locations is much in discussion in the Netherlands, the results of these analyses do not support the notion that spatial characteristics, including the quality of public transport, can be held accountable for substantial lower levels of public transport use.

table 16 contribution of spatial factors to explaining the difference in public transport kilometres travelled between location types and national average

	region	proximity	facilities	land use mix	public transport quality	motorway exit	total
Vinex within limits 1971	0.5	-0.1	0.1	0.1	1.0	-0.1	1.5
Vinex within limits 1996	0.0	-0.1	0.0	0.0	0.1	0.0	-0.1
Vinex green field location	0.1	0.0	-0.1	0.0	0.0	0.0	0.0
Vinex other outside limits 1996	0.0	-0.1	-0.1	0.0	-0.1	0.0	-0.3
non-Vinex within limits 1971	-0.3	0.1	0.1	0.0	-0.3	0.0	-0.4
non-Vinex within limits 1996	-0.3	0.2	-0.1	0.0	-0.7	0.0	-0.7
non-Vinex outside limits 1996	-0.2	0.3	-0.2	0.0	-0.8	0.0	-0.8
all newly built houses	0.0	0.0	0.0	0.0	-0.1	0.0	-0.1

6 CONCLUSIONS

The implementation of the Vinex policy, with proximity and accessibility as keywords, has been relatively successful. Analyses of the spatial characteristics of the residential environment of housing developed under this policy show that over half of them have been built within the existing built-up areas and relatively close to urban centres. We also found that the public transport facilities for Vinex housing is noticeably better than in other, comparable, developments elsewhere. However, the implementation is less successful with regard to proximity of daily urban facilities and land use mixing.

Regression analyses of the relationship between travel behaviour and spatial characteristics of the residential environment show that especially public transport facilities and the location of housing in relation to urban centres and daily facilities are important. Larger distances are associated with more kilometres travelled. The proximity of a minor urban centre and the distance to daily facilities such as a supermarket or a primary school are most important. A

location in one of the four major Dutch cities is related to less mobility in total and by car and to more kilometres travelled by public transport. Good public transport facilities are also associated with less car use and more use of public transport.

Residents of newly built houses travel 4 kilometres more per person per day than the average Dutchman. This is mainly by car while public transport use is lower. 2.4 extra kilometres can be attributed to the sole fact that they live in newly built houses. The population composition of residents of newly built houses is also an important factor. Spatial characteristics attribute only little to the effects found.

However, spatial factors do contribute notably to explaining the differences between location types. These differences are considerable. Despite a highly mobile population composition and the above mentioned 'newly built house' effect, Vinex inner city locations have a lower total mobility and lower car use and considerably higher public transport use than the Dutch average. Spatial characteristics explain a difference of 3 kilometres in total mobility and almost 3,5 kilometres in car mobility. This can mainly be attributed to the proximity of urban centres and of daily facilities and to the quality of the public transport.

In the official Vinex greenfield locations, the contribution of spatial characteristics to explaining differences in travel behaviour is rather limited. Negative effects of the distance to daily facilities, the lower land use mix and the proximity of a motorway exit annul positive effects of proximity of urban centres. The considerably higher mobility at these locations can mainly be explained by the composition of the population and by the 'newly built house' effect.

Outside the Vinex regions, the number of kilometres travelled is highest, while public transport use is relatively low. Residents of newly built houses located outside the existing urban area travel most, especially by car. This can mainly be explained by the larger distances to urban centres and to daily facilities and to the lower quality of public transport facilities.

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