Three Decades of Transport Infrastructure Development and Travel Behaviour Change in the Netherlands

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1 ABSTRACT

It is argued that improvements in the supply of transport infrastructure networks affect accessibility, which in turn influences the distribution of land uses, activities linked to them and eventually the travel behaviour of individuals. Identifying the extent and rate of change in travel behaviour as a response to change in spatial and socio-demographic characteristics, requires long-term empirical investigation of their interrelation. The assessment of long-term trends can provide guidelines for the type, extent and location of future investments in transport and land use development. This paper explores trends in access to transport infrastructure (proximity to the railway stations), land use (location of inhabitants), socio-demographic characteristics of the travellers and travel behaviour (distance travelled by car, train and active modes and total number of trips per day) over three decades. It uses data from Dutch National Travel Surveys at seven time points of five-year intervals from 1980 to 2010 in the Randstad, the Netherlands. The results indicate that while the total number of trips per day has remained stable over time, total kilometres travelled has risen until the mid-1990s after which it has witnessed a decrease. Further more, the findings suggest that train is increasingly used for travelling longer distances and the location of home municipality and proximity to train stations (within a distance of 500 to 1250 m) are closely related to the total train kilometres travelled.

2 BACKGROUND

Empirical evidence on the long-term relationship between access to transport infrastructure, land use, socio-demographic characteristics and travel behaviour is needed to assess the impact of previous investments in transport infrastructure and applied land use policies. Such evidence can also provide guidelines for the type, extent and location of future investments. However, studies which quantify the development of such relationships over time are very scarce (Ellder, 2014). This paper aims to shed light on the trends in land use and socio-demographic characteristics linked to travel behaviour over time and across various regions of the Randstad (the population and economic core of the Netherlands situated in the west of the country). The main research question is: How have access to transport infrastructure, land use, individual socio-demographic characteristics and travel behaviour evolved in relation to each other in the Dutch Randstad from 1980 to 2010?

3 METHODOLOGY

A long-term geo-referenced database was constructed, bringing together various sources. Spatial, socio-demographic and travel behaviour data were made consistent for seven time points of five-year intervals: 1980, 1985, 1990, 1995, 2000, 2005 and 2010. The spatial unit of analysis is the municipal borders of year 2004 and previous and consequent spatial and travel behaviour data were converted to these boundaries. The development of spatial, sociodemographic and travel behaviour data was analysed by descriptive statistics separately and in relation to each other.

3.1 Travel behaviour variables

Travel behaviour variables were extracted from the Dutch National Travel Survey (NTS) which provides reliable travel diary data since 1979 on an annual basis. The sample was limited to the Randstad (See Figure 1). In some cases previous and proceeding respondents were added to the respondents of a given year (e.g. 1984 and 1986 were added to 1985) in order to increase the sample size at that time point and make it comparable with the sample size at other time points. The respondents were further filtered by their age (those younger than 20 years of age were excluded regarding their constrained mobility) and whether they had reported at least one trip during the survey day. The final eligible number of respondents were: 13.521

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for 1980, 15.328 for 1985, 16.777 for 1990, 35.738 for 1995, 32.747 for 2000, 36.749 for 2005 and 14.368 for year 2010.

The investigated travel behaviour indicators were total kilometres travelled per survey day by i) train, ii) car (passenger/driver), iii) active modes (walking and cycling), and by all the above combined. In addition, the total number of trips by the above modes per survey day was investigated. For multi-modal trips, the transport mode which was used for the longest leg of the trip was determined as the main mode. Trips and kilometres travelled by modes other than the above (e.g. motorcycles, tram, bus, metro) are excluded from this analysis.

3.2 Socio-demographic variables

The chosen socio-demographic variables were the respondents‘ age, gender, level of education, income and household car ownership.

3.3 Land use and access to transport infrastructure variables

The living municipality of respondents was categorised according to the Randstad's "daily urban systems", a concept first introduced by Van der Laan (1998) (Figure 1). Though the Randstad and its borders have evolved, its daily urban systems have been relatively stable over time. The three categories of daily urban systems are "urban centres" (Amsterdam, Haarlem, the Hague, Rotterdam, Dordrecht, Utrecht, Amersfoort and Hilversum), "suburbs" (medium sized cities in the vicinity of the urban centres) and "other", including the Green Heart (a preserved and mainly rural area at the center of the Randstad) and municipalities situated in the outer Randstad ring. Furthermore, the distance from rail was measured as Euclidian distance from the municipality's mean centre (regarding the dispersion of built-up area across the municipality) to the closest rail station.

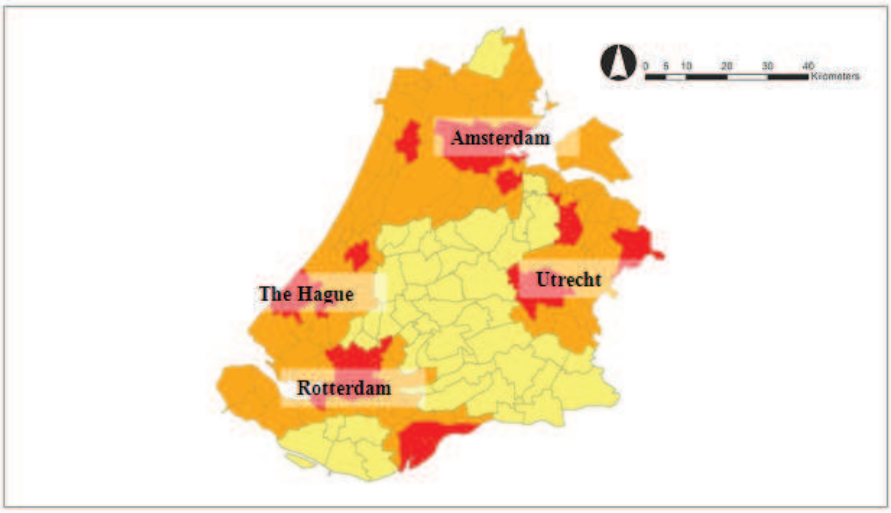

Fig. 1: Classification of "urban centres" (red), "suburbs" (orange) and "other" (yellow) in the Randstad based on daily urban systems (Van der Laan, 1998)

4 TRENDS IN LAND USE, SOCIO-DEMOGRAPHIC AND TRAVEL BEHAVIOUR DEVELOPMENT IN THE RANDSTAD

4.1 Trends in travel behaviour

Figures 2a-d summarise long-term trends in respondents' total kilometres travelled (tkt) by all and separate transport modes (average and median) and total number of trips per survey day from 1980 to 2010.

- Figure 2a shows that the average total kilometers travelled by car is significantly higher than train and active modes. Total kilometres travelled almost mirrors total car kilometres travelled (as car kilometres travelled make up for the most of total kilometres travelled). The tkt has increased from 1980, reaching a peak at 1995, and has been decreasing ever since. However there are two caveats, first, the mean (average) can be greatly influenced by outliers (a limited number of people which travel very long distances by car) and second, car trips are extremely dominant in the sample (at each time point only around 4 % of total trips in the sample were made by train).

- If we look at the trips taken with each transport mode (thus when that mode was chosen), we see that the median of train kilometres travelled is significantly higher than the car kilometres travelled (Figure 2b). Moreover, this median has risen by 10 kilometres over the study period contrary to the median of total car kilometres travelled. This means that train is increasingly being used for travelling longer distances.
- Over the years, the median total number of trips per day has stayed mostly the same, i.e. three trips per day (Figure 2c). However, the share of two trips per day has risen at the expense of four or more trips per day since 1995 (Figure 2d). All in all, we can conclude that while people have changed their total amount of kilometres travelled over time, they have remained stable in their frequency of trips per day.

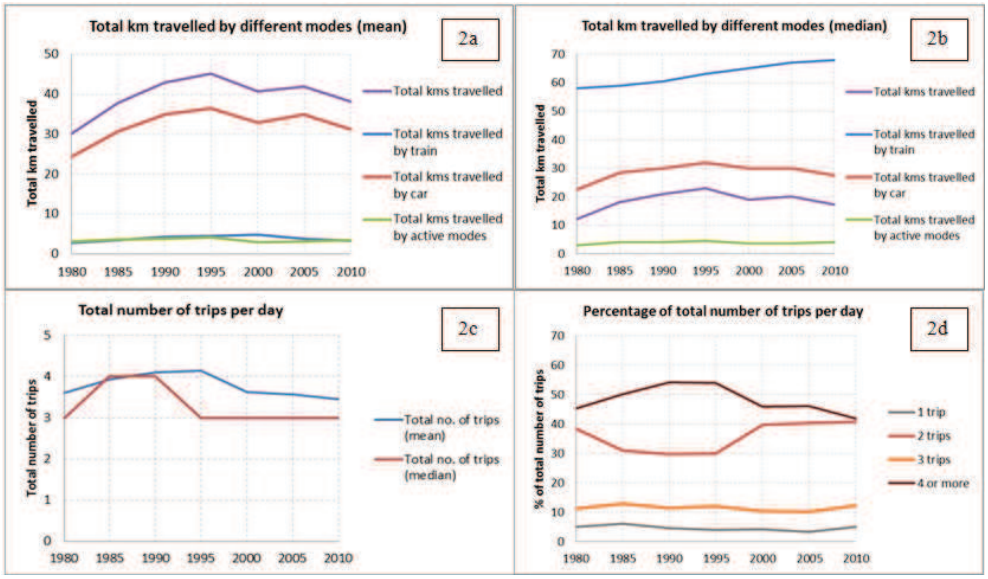

Fig. 2a-d: Trends in mean/median total kilometres travelled by all and separate modes and mean/median total number of trips per day in the Randstad 1980-2010

4.2 Trends in travel behaviour in relation to socio-demographic and land use variables

Figures 3a-h compare the relationship between a number of socio-demographic and land use variables and total kilometres travelled by car versus train.

- As expected, total kilometres travelled (by all and separate modes) generally decrease as age increases. However, people in their 30s followed by those in their 40s have the highest car kilometres travelled while people in their 20s (followed by pensioners till 1995) have the highest train kilometres travelled.
- Men travel longer distances by car compared to women (Figure 3c). Interestingly, this difference reduces significantly when it comes to total train kilometres travelled (Figure 3d).
- As figures 3e-f demonstrate, location is linked to the amount of kilometres travelled. As respondents' home municipality moves from the central urban cores to suburban and other (outer ring and the Greet Heart) municipalities, the total amount of travelled kilometres by car rises, while the total kilometres travelled by train decreases. The difference between central and other municipalities is more significant especially in the case of total kilometres travelled by train. This is likely because municipalities belonging to urban cores benefit from a better access to railway infrastructure supplies and services.
- Figures 3g-h demonstrate the relationship between the distance to the closest railway station and total car and train kilometres travelled. The thresholds of 500, 1250, 2500 and 3750 m radii were chosen based on the distance travelled at five-minutes intervals with the speeds of 3 and 15 km/hr for walking and cycling respectively. Total train kilometres travelled is highest within the "500 – 1250 m" distance buffer from the train station, After 1250 m a distance decay trend is observable. Contrary to expectation, living in the "0 – 500 m" radius is not related with the highest train kilometres travelled. The proximity to rail stations and total car kilometres travelled seem unrelated.

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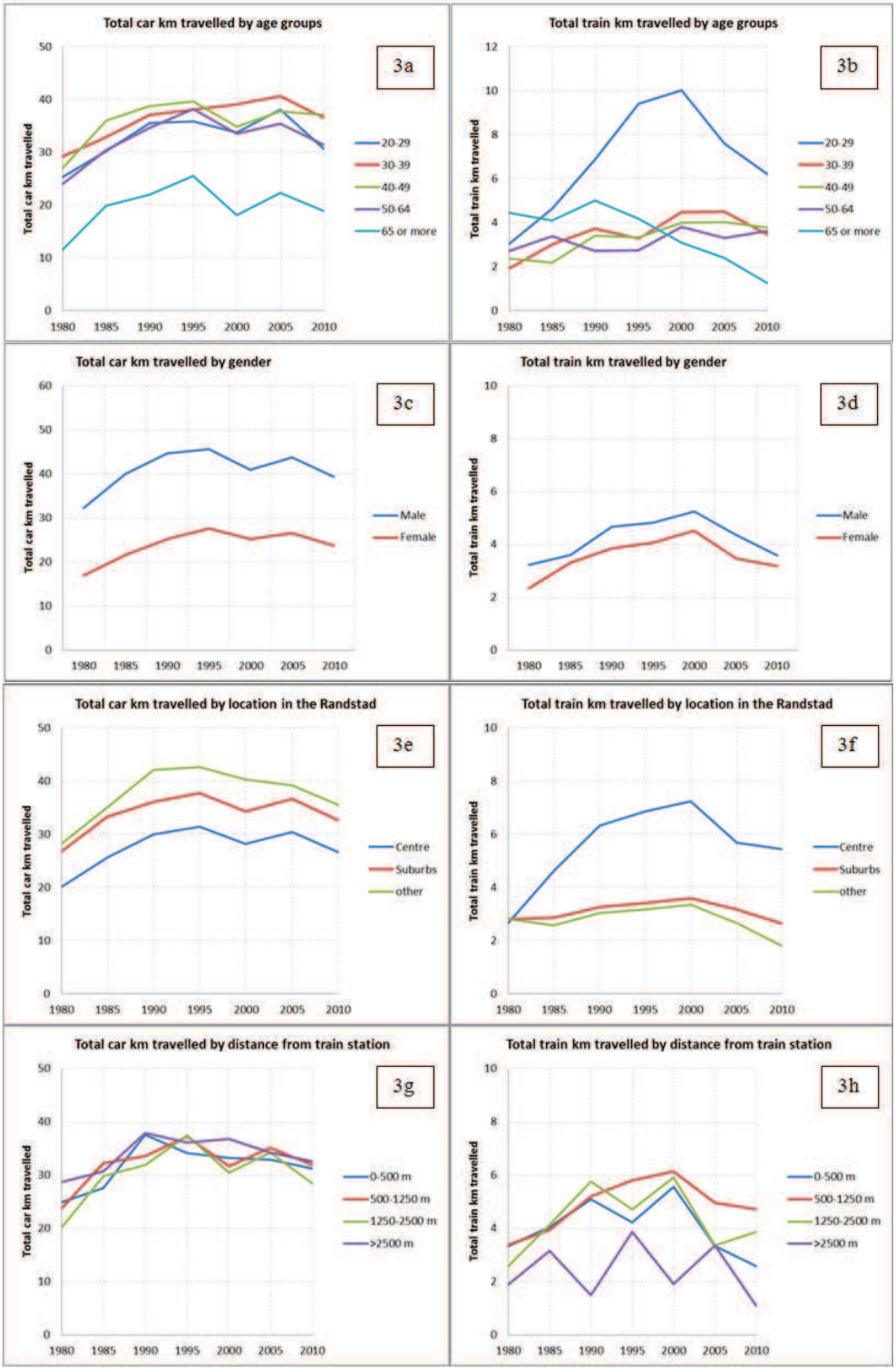

Fig. 3a-h: Trends in total car and train kilometres travelled by age, gender, location in the Randstad and distance from train station in the Randstad 1980-2010

5 CONCLUSION

A summary of relationships between a selection of socio-demographic factors, land use and different indicators of travel behaviour are presented in Table 1. While the majority of these relationships have remained stable over the study period, there are a number of exceptions, some of which were discussed in the previous section.

	Total km travelled by all modes	Total km travelled by train	Total km travelled by car	Total km travelled by active	Total no. of trips per day

				modes	
Age	─	─*	─*	*	─*
Gender (from male to female)	─	─	─	+	+
Education	+	+	+	*	+
Income	+	+	+	─	*
Household car ownership	+	─	+	─	*
Location (from centres to outer rings)	+	─	+	─	─*

Notes: ─ = negatively related; + = positively related; +/─*= overall positively/negatively related, however there are exceptions regarding some sub-categories; *= varying relationship.

Table 1: Summary of relationships between socio-demographic factors, location and travel behaviour indicators

The findings of this explorative study corroborate prior research in the field: where people live –which is related with the 5 D's of Density, Diversity, Design, Destination accessibility, Distance to transit– is significantly related to their mode choice and kilometres travelled (Ewing and Cervero 2010).

This study also provides some evidence for the hypothesis that a paradigm shift could be emerging where total passenger kilometres in motorised modes has slowed its acceleration in industrialised countries (Millard-ball and Schipper 2011).

Moreover, the results indicate that train is increasingly being used for travelling longer distances. Thus further investment in transport policies to facilitate long-haul commuter trains, especially the high speed railway, could benefit from and reinforce this trend. Interestingly, median total kilometres travelled per day in the Randstad has remained under 30 kilometres, even at its highest point in 1995. In other words, half of the inhabitants of the Randstad have been travelling no more than 30 kilometres a day over the past thirty years. This makes alternative transport modes with relatively limited range such as electric cars and bikes suitable for the Dutch context and especially the Randstad.

Living within 500-1250 m distance of a train station is shown to be related with highest amount of train kilometres travelled. Further detailed investigation into the thresholds within which train station proximity could affect the travel behaviour of inhabitants is required. The findings can have implications for designating the stations' impact area in Transit Oriented Development plans.

Finally, future research should incorporate multivariate analysis to measure the specific share of various factors in explaining travel behaviour, and their rate of changes in the long-run (e.g. Susilo and Maat, 2007). Various land use and transport accessibility indicators need to be tested to see which is more suitable to capture the change in transport network and land use development over time. A promising approach to measure the long-term share of spatial and socio-demographic factors in travel behaviour is the use of pseudo panel analysis (Tsai et al. 2014). This emerging method applies panel analysis to repeated cross section data (such as NTS) and manages to benefit from disaggregated data while dealing with the limits of repeated cross section data.

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