Journal of Transport Geography 59 (2017) 146–155

Contents lists available at ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo

Residential self-selection and travel behaviour: What are the effects of attitudes, reasons for location choice and the built environment?

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ARTICLE INFO

Article history:
Received 19 April 2016
Received in revised form 30 January 2017
Accepted 30 January 2017
Available online 20 February 2017

ABSTRACT

In studies of the effect of built environment on travel behaviour, residential self-selection is an increasingly important issue. Self-selection implies that households locate in places that provide them with conducive conditions for their preferred way of travelling. In these studies, it is assumed that attitudes toward different travel modes are an important factor in location choice, and that households are unconstrained in choosing their preferred residential location. This paper challenges these assumptions, by distinguishing between the more passive travel attitude and travel considerations as a deliberate reason to locate in a certain place. Based on a survey among 355 recently relocated households in Dutch TOD locations, we find that the association between travel attitude and residential environment is weak, and that the association between travel attitude and travel as a factor in location choice is moderate at best. Multivariate models show that both travel attitude and travel being a reason for location choice influence travel mode use, suggesting that travel attitude is insufficient to fully reflect self-selection processes. In comparison to other travel modes, train travel is most influenced by the fact whether residents deliberately chose to live in an environment conducive to using this mode.

1. Introduction

Over the past decades many studies have investigated how the built environment (BE) influences travel behaviour (e.g. Cervero, 2002; Chen et al., 2008). It is typically found that people living in more urbanised areas more often use bus, tram and subway, due to the closer proximity of origins and destinations to public transport facilities (e.g. Cervero and Kockelman, 1997). In addition, it is found that factors such as density and mixed land use are associated with higher shares of walking and cycling (Faulkner et al., 2009; Saelens and Handy, 2008). An ongoing debate regarding how to interpret such research findings focuses on the phenomenon of residential self-selection (RSS). RSS is commonly defined as the process by which households choose their residential location based on their desired and expected travel behaviour (Boarnet and Sarmiento, 1998; Chatman, 2009; Van Wee, 2009; Cao, 2015). As a consequence, preferences for and attitudes toward travel modes will systematically differ between different geographical settings, and explain at least part of the observed differences in travel behaviour between locations. These attitudes may be related to the use of travel modes, but also to travelling in the first place (Cao and Ettema, 2014; De Vos and Witlox, 2016). This would imply that the built environment effect found in the above mentioned studies cannot be interpreted as a pure built environment effect, and that the effect is therefore overestimated.

An expanding literature has reported methodological and empirical studies of RSS, using various methods of controlling for the systematic variation of travel attitudes between locations (see Bohte et al., 2009; and Mokhtarian and Cao, 2008 for methodological reviews). Handy et al. (2005) found, using a sample from North-California, that attitudes toward travel modes play a dominant role in explaining differences in travel behaviour, implying a RSS effect. Cervero and Duncan (2002) used a nested logit model to simultaneously model location choice and commute mode in the San Francisco Bay Area (USA), and found that both decisions were correlated, implying a self-selection effect. They report that about 40% of the decision whether to commute by rail is explained by residential self-selection. Cao et al. (2006) investigated the influence of neighbourhood characteristics on strolling and pedestrian shopping in Austin (TX), and found that RSS influences walking frequency for both purposes, but that RSS plays a bigger role in explaining pedestrian shopping. In addition, they found that neighbourhood characteristics such as safety and shade influence strolling frequency, whereas availability of walking connections, perception of stores and comfort of walking influenced pedestrian shopping frequency. Cao et al. (2009a) investigated the influence of the built environment on the frequency of non-working car, transit and walking trips. They found that for all modes, built environment characteristics directly influenced trip making, but also via self-selection, as indicated by the significant effect of attitudes toward various travel modes. They report that both the direct effect of BE and the self-selection effect are strongest for walking behaviour, compared to other travel modes. Scheiner (2010) found in a German context, that self-selection

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http://dx.doi.org/10.1016/j.jtrangeo.2017.01.009
0966-6923/

played only a minor role in explaining trip distances, and primarily in the context of shopping. In majority, studies on RSS (see Cao et al. (2009b) for a review of empirical studies) suggest that RSS is at play and explains part of the correlation between built environment and travel, but also that there is an independent effect of built environment, that often outweighs the RSS effect (Naess, 2009).

Recently, increasing attention has been given to heterogeneity in residential location choice and travel preferences. Schwanen and Mokhtarian (2004) were among the first to note that inconsistencies exist between residential location and travel preferences. That is, while urban environments mostly attract residents with a larger preference for public transport (PT) use and active travel and suburban environments mostly attract residents with a larger preference for car use (termed consonants), urban environments will also host residents with a larger preference for car use, and suburban environments will also host residents with a preference for PT use and active travel (termed dissonants). They found that dissonants in urban environments would commute more often by car than consonants, and dissonants in suburban environments would commute less often by car than suburban consonants. More recently, De Vos et al. (2012) replicated this outcome in a study in Flanders (Belgium), and also found differences between consonants and dissonants living in a similar environment in terms of train use, bus/tram use, walking and cycling. Cao (2015) found a similar interaction between attitude toward PT use and living in a suburb. His study indicates that for suburbanites, their attitude toward PT use has a larger influence on PT use than for urbanites. Kamruzzaman et al. (2013) found that TOD residents with a preference for car use where less likely to use PT, whereas people not living in TODs are more likely to use PT if they have a positive attitude toward PT.

The reported interactions between residential location and travel preference imply that households do not necessarily reside in areas that match their travel preferences. One reason is that residential location choice is affected by many other considerations than travel implications (Cao and Chatman, 2016). The literature on residential relocation and housing careers provides overwhelming evidence that a host of other factors influence residential location decisions (e.g. Clark and Huang, 2003; Van Ham and Clark, 2009), including the dwelling characteristics in relation to the household's needs, aesthetics of the dwelling and neighbourhood, neighbourhood safety and social atmosphere. These factors are usually mentioned by movers as being more important than the options offered for travel by specific modes (Naess, 2009; Chatman, 2009). For instance, Lund (2006) describes that of households living in transit oriented developments (TOD) in California, only one third mentions access to public transport as a main reason for residing there, and type and quality of housing, housing cost and quality of the neighbourhood are mentioned much more often as reasons for living in the TOD.

A few studies have investigated the effect of travel being a reason for location choice on travel behaviour. Frank et al. (2007) found that if walkability was a reason for location choice (measured with different indicators), the number of walking trips was higher, both in low and high walkable areas. Kamruzzaman et al. (2015) report that if accessibility of places was a more important reason for location choice, people more often use PT.

Importantly, travel related reasons for location choice cannot be equated to travel preferences (i.e. attitudes toward travel modes) in the context of residential location choice. For instance, someone with a positive attitude toward PT may choose to live in a suburb, because of a strong desire for a large dwelling and a green environment. Also, someone with a positive attitude toward PT may choose to live in a TOD, but mostly because of the quality of the neighbourhood rather than the PT facilities. More generally, for travel attitudes, we can distinguish two situations: the residential location being in line with one's travel attitude (also referred to as consonant, e.g. someone with a positive attitude toward PT living near a railway station) or the residential location not being in line with one's travel attitude (dissonant). Treating 'access to the travel mode being a reason for location choice' also as a binary variable, we can distinguish between four types of outcomes, as illustrated in Table 1.

The question then is, whether the reason for location choice has an independent impact on travel behaviour, in addition to travel related attitudes. If such an independent effect exists, it might have an additional effect next to the travel attitude, if travel was a reason for location choice. Consider two households with a positive attitude toward public transport who move into the same urban area, but one deliberately to live close to public transport facilities, and the other because of the aesthetics and liveliness of the environment. As indicated by Stanbridge and Lyons (2006), the first household will in subsequent stages of the relocation process more actively look for options to actually use public transport and take preparations, probably resulting in a higher use of public transport as compared to the second household. To our knowledge, the only study that combined both attitudes toward travel modes and reasons for residential location choice so far is Naess (2009). He found, among others, that travel related reasons for locating in an area (e.g. whether proximity to public transport stops played a role) had an impact on households' travel behaviour, but that travel attitudes also influenced travel behaviour.

The aim of the present study is to further extend our insight into the process and effects of RSS, by distinguishing between households' attitude toward travel modes and their actual reasons to choose a specific residence. In particular, we will answer the following research questions:

1. To what extent do travel attitudes and travel as a reason for location choice differ: do those with a positive attitude toward a travel mode also have access to that mode as a reason for location choice?
2. To what extent do travel related reasons for location choice and travel attitudes have independent effects on travel behaviour?

These questions will be answered for different travel modes, since we cannot safely assume that RSS based on attitudes toward car, PT and active modes works in the same way. Our analyses take place on data obtained from recent movers into three areas in/near The Hague in The Netherlands, differing in accessibility by various travel modes, who reported their travel attitudes, reasons for moving into their residence and current travel behaviour by various modes.

The paper is organized as follows. Section 2 discusses the data collection and modelling approach. Section 3 presents the results of descriptive analyses, aimed at getting insight into the role of travel attitudes and reasons for relocation across locations. This is followed by the results of Poisson regression analyses, in order to assess the extent and type of self-selection effects for various travel modes. Finally, Section 4 draws general conclusions about travel attitudes and reasons for location choice in relation to residential self-selection, and discusses avenues for further research.

Table 1
Examples of combinations of travel attitude and travel as a reason for location choice.

	Travel is a reason for location choice	Travel is not a reason for location choice
Attitude toward travel mode in line with residential location (consonant)	Someone with a PT preference choosing to live in a TOD because of access to stations	Someone with a PT preference choosing to live in a TOD because of housing quality
Attitude toward travel mode not in line with residential location (dissonant)	Someone with a PT preference living in a car dependent area because of a car dependent work location	Someone with a PT preference living in a car dependent area due to housing market restrictions

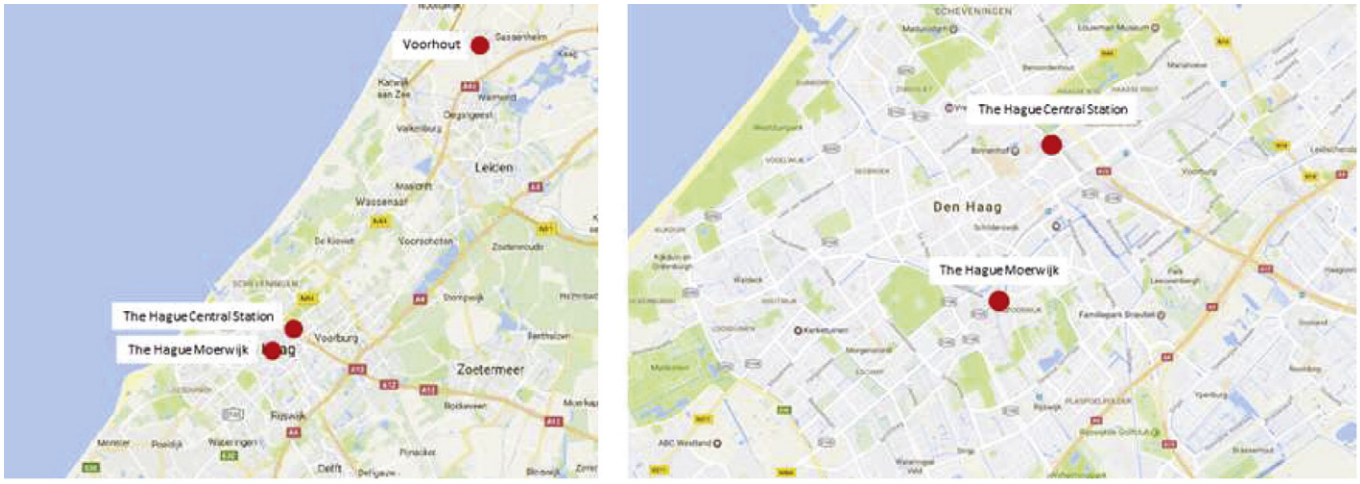

Fig. 1. Location of research areas in the Province South-Holland (left) and in The Hague (right).

2. Methods and data

2.1. Study design

A survey was held in March 2014 under recent movers (defined as having moved in maximum two years ago) living in three TOD locations near/in The Hague, The Netherlands: Voorhout (VH), The Hague Central Station (CS), The Hague Moerwijk (MW) (see Fig. 1). We chose to approach recent movers to avoid that they would adjust their attitude toward travel modes, based on their travel experience in their new residential environment. Near each location dwellings have recently been developed, which fits into the idea of TOD of urban development near public transport nodes. The places differ, however, in character. Voorhout is a village of 15,000 inhabitants that has good access to the The Hague-Amsterdam railway line. However, density (4361 inh/km^2) is considerably lower than in the Hague, and car accessibility is higher, due to the adjacent A44 motorway. The Hague CS is located near the central station, offering rail access to all major cities. The area has a higher population density (5979 inh/km^2) and a high degree of mixed land use, with high densities of employment an retail facilities. The area is highly accessible by foot and bicycle. The Moerwijk area has the highest population density (11,721 inh/km^2), but offers fewer retail opportunities in the area as well as fewer jobs. The area is especially well served by tram and bus lines, but also has good train connections. The three areas were selected as they differ in accessibility by various travel modes, which may have influenced location decisions of recent movers. It is recognized, though, that accessibility by various modes will differ between addresses within these areas, so that area is a crude measure of accessibility.

From municipal registers, which record all households moving into out of and within the municipality, addresses were obtained of all inhabitants of areas within a circle of 1.2 km from the railway stations Voorhout, The Hague CS and The Hague Moerwijk, who had moved to their current address in 2012 or later. Only recent these movers were included in order to obtain reliable indicators of the reasons for residential location choice. A letter was sent in March 2014 by the municipalities to all 7107 households who had moved into the study areas in the past 24 months, based on the civil register with the invitation to complete an online questionnaire. Respondents were asked about their travel behaviour by answering the following question for each travel mode (car, train, bus/tram, cycling): "On how many days in the past week did you use MODE X". This was not asked for walking, as everyone is expected to walk on a daily basis for at least short trips around the house, and this variable would not be sufficiently distinctive. The advantage of this indicator is that it covers trips made for different purposes, on week and weekend days, and is available for all travel modes. This is an advantage over indicators such as the commute mode on weekdays, which covers only one trip purpose and assumes that mode use does not vary between days of the week. Given the multimodal character of the study locations and the fact that 84.3% of the sample uses multiple travel modes throughout the week, this is seen as an advantage over binary mode choice indicators that ignore the fact that travel modes differ across days and are restricted to one trip purpose only. It is acknowledged that asking about the number of days a mode was used leads to a loss of information. In particular, we cannot distinguish between those making more or fewer trips per day by the same mode. By ignoring this variation in behaviour, our results may become less pronounced. However, recording the total number of trips per mode per week would require that respondents fill out a trip diary for a full week, which poses a severe burden on respondents and would lower the number of usable responses.

In addition, the questionnaire contained items regarding attitudes toward various travel modes, questions about the particular reason for choosing their specific residential location and questions about socio-demographic variables and car ownership.[1]

2.2. Response rate and sample description

Overall, 355 questionnaires were completed, implying a response rate of 5.0% overall. Response rates were 13.5% (78 respondents), 7.0% (201 respondents) and 2.2% (76 respondents) in Voorhout, CS and Moerwijk respectively. One reason for the low response rate could be that households who recently relocated are highly occupied with activities relating to their recent move. An additional reason is that, since surveys were sent out via the municipalities, it was not possible to send a reminder. A potential reason for the particularly low response in Moerwijk is that inhabitants in Moerwijk on average fall in lower income groups (65% of households have a low income), and also include a relative large share of ethnic minorities (56%) (Table 2), which are factors known to lower response rates in general. Yet, the total number of respondents in Moerwijk (76) warrants inclusion of these respondents in our analyses.

Sample descriptives are displayed in Table 2. Average age is around 40 years in all locations. The Moerwijk sample has slightly more representatives in the older age categories. The sample includes 52.3% women, who are overrepresented especially in Moerwijk (57.0%). Income levels differ considerably between locations. Voorhout and CS are well represented in the higher income categories, whereas respondents from Moerwijk more often fall into lower income classes. Also

[1] The questionnaire included more questions. Only the questions used for this study are described.

Table 2
Population and sample characteristics.

	Voorhout	The Hague CS	The Hague Moerwijk
Population (all inhabitants)			
% non-Western immigrants	5%	32%	56%
% low income households	30%	48%	65%
% high income households	30%	19%	6%
Sample (recent movers)			
Age (mean)	40.7	38.7	41.5
% women	54.2%	49.8%	57.0%
Income (€/month)			
- <1350	12.6%	16.0%	37.0%
- 1350–3150	32.4%	28.0%	38.3%
- >3150	38.0%	44.0%	11.1%
Household type			
	20.8%	36.3%	48.8%
	2.8%	3.0%	7.5%
- Single, no children	33.3%	43.8%	23.8%
- Single parent	41.7%	13.5%	17.6%
- Couple, no children	1.4%	3.5%	2.5%
- Couple with children			
- Other			
% high education (higher vocational and university)	70.8%	84.1%	44.4%
Car ownership			
	10.0%	38.6%	50.6%
	55.7%	50.3%	45.6%
- no car	34.3%	11.1%	3.8%
- 1 car			
- 2+ cars			

household types differ considerably between locations. In Voorhout, couples with children dominate the sample. In CS and Moerwijk the share of single households is much lower, and households with children are less represented. Regarding education level, respondents from CS are about 80% higher educated, with 61% having a university degree. Respondents from Voorhout are 70% higher educated, split evenly between university and higher vocational degree. In Moerwijk only 40% is higher educated. Finally, car ownership rates differ strongly between locations. Whereas in Moerwijk half of the respondents does not own a car and around CS 38.6%, this is only 10% in Voorhout. Comparison with population statistics of the whole populations indicate that income differences between the three areas are reflected in the sample. However, recent movers are likely to differ from the population in terms of variables such as age, household type and occupation. Statistics of the sampling frame could unfortunately not be obtained from the municipalities. Given the low response rate (in particular in Moerwijk) and the fact that statistics of the sampling frame are lacking, we cannot safely assume that our sample is representative and the results are generalizable. However, we feel that the unique data collected under recent movers allows us to explore the character of residential self-selection processes and their impact on travel behaviour in more detail and derive innovative insights.

2.3. Measuring travel attitudes and reasons for location choice

Travel attitudes were tapped using a number of statements, with which respondents expressed their agreement (see Table 3) on a 5 point scale, ranging from totally disagree to totally agree. Factor analysis with varimax rotation was used to reduce the original 12 items to three factors, which can be interpreted as positive attitudes toward car, public transport and slow modes respectively (Table 3). The total explained variance of the original items is 60.7%. For each factor, factor scores were calculated in SPSS, using the regression method. As these scores

Table 3
Factor loadings of travel attitude factors.

	Factor 1 Pro slow mode	Factor 2 Pro car	Factor 3 Pro public transport
'I like cycling'	0.805		
'I like walking'	0.637		
'If possible I rather walk than drive'	0.742		
'If possible I rather cycle than drive'	0.799		
'The government should invest more in walking cycling infrastructure'	0.598		
'I Like driving'		0.618	
'I need a car is to participate in my activities'		0.748	
'Owning a car allows me to do more'		0.873	
'Owning a car gives me freedom'		0.871	
'I like to use public transport'			0.829
'If possible I rather use public transport than drive'			0.687
'Public transport is unreliable'			-0.718
Percentage explained variance	22.3%	22.0%	14.0%
Cronbach's alfa	0.768	0.831	0.587

(Only factor loadings > 0.3 displayed.)

Table 4
Items used in indicators of reasons for location choice.

	Cronbach's alpha
Walking	0.665
- There are shops on walking distance	
- There are schools on walking distance	
- The residential environment is pedestrian friendly	
Cycling	
- The environment is cycling friendly	
Car	0.772
- The residential environment is car friendly	
- Short distance to highways	
- There number of parking lots	
Train	
- There is a train station on short distance	
Bus/tram	
- There are bus or tram stops on short distance	

are standardized, both positive and negative factor scores, indicating attitudes toward travel modes, may occur.

While attitudes represent a base orientation toward travel, they need not be the primary reason of location choice, as discussed before. Respondents indicated to what extent (on a 1 to 5 scale) various travel related reasons influenced their choice of the residential location. Based on these items we constructed indicators of whether location choice was driven by car travel, active travel or public transport conditions. Table 4 displays which items are included in each indicator. Indicator scores were obtained by averaging the scores over the items per travel mode (if more than one), which were measured on a 1–5 scale ranging from "not at all influencing location choice" to "very much influencing location choice". As a result composite indicators per travel mode are also expressed on a 1–5 scale.

2.4. Modelling approach

To assess the impact of travel attitudes and reasons for location choice on travel behaviour, we follow the statistical control approach suggested by Mokhtarian and Cao (2008). According to this approach, the typical assumption is that BE is an important reason of travel behaviour (TB), in addition to control variables X:

$$TB = f_1(BE, X) + \varepsilon \quad (1)$$

However, outcomes (such as a coefficient indicating the impact of BE on TB) will be biased if an omitted variable (such as an attitude) influences BE (e.g. through residential location choice) and thereby TB. In this case observed explanatory variables (BE) are correlated with the unobserved variables (ϵ) via the attitude (AT):

$$TB = f_1(BE(AT), X) + \varepsilon(AT) \quad (2)$$

In this case the impact of BE is likely to be overestimated. Mokhtarian and Cao (2008) discuss various approaches to circumvent this issue, such as direct questioning, statistical control, instrumental variables, sample selection models and joint modelling residential location choice and TB. For a detailed review of these approaches and their pros and cons we refer to Mokhtarian and Cao (2008). In our study we apply the statistical control approach, given that we have information about movers' attitudes toward travel by various modes, which may influence both their residential location and their travel behaviour. In a statistical control approach, TB is modelled as a function of BE characteristics (BE), attitudes toward TB (AT) and additional explanatory variables (X) as follows:

$$TB = f_2(BE, AT, X) + \xi \quad (3)$$

This would eliminate correlations between BE and ε, and thereby biases in the estimation. If adding AT to the equation eliminates the effect of BE, the interpretation is that the effect of BE was due to predispositional attitudes (thus self-selection). If BE remains significant in the explanation of TB, it is supposed to exert also some influence of its own (i.e. a true BE effect).

In a similar vein, it might be argued that the reason for location choice (RL) may influence TB directly, as it can be interpreted as an indicator of the propensity to display a particular behaviour. However, the reason for location choice may influence TB also via its impact on residential location and thus BE. To account for this, we extend Eq. (3) to:

$$TB = f_2(BE, AT, RL, X) + \xi \quad (4)$$

RL may now (partly) eliminate the effect BE, implying a different and more intended form of self-selection. In particular, it would imply that travel options associated with a residence are a concrete reason for choosing the residence. In addition, RL may (partly) eliminate the effect of AT, which would imply that a more general attitude toward a travel mode is converted into a criterion with respect to travel options in the process of residential location choice.

3. Results

This section discussed the empirical outcomes of our study. We first (Section 3.1) provide descriptives of travel behaviour, attitude toward travel mode and reasons for location choice for the three study areas and draw conclusions about the degree of congruence with residential location. Also, we discuss to what extent travel attitude and reasons for location choice are associated. Next, we analyse the implications of travel attitude and reasons for location choice for travel behaviour by Poisson regression models, which are described in Section 3.2.

3.1. Travel behaviour, attitudes and reasons for location choice

Travel mode use in the three different locations (Table 5) shows some remarkable differences. Car use frequency in Voorhout is about 1.5 times higher than in The Hague areas, which is in line with the presence of car infrastructure, such as the A44 motorway. Train frequency does not significantly differ between the locations, probably due to the good rail accessibility in all locations, which are selected as TOD locations for this reason. Use of bus and tram is highest by far in Moerwijk, due to the high access to busses and trams in this area. Cycling frequency is highest in Voorhout and lowest in the urban locations of CS and Moerwijk. This may look contradictory, given the lower density in Voorhout, but it should be kept in mind that many facilities are on cycling distance in a smaller village such as Voorhout, and bicycle faces more competition from travel modes such as bus, tram and walking in The Hague. Hence, differences in travel mode use between locations are in line with expectations.

Comparing the mean scores on each travel attitude factor by location (Table 3), it is found that recent movers in Voorhout have a significantly more positive attitude toward car use, which is in line with the better car accessibility of this location. Inhabitants of the Hague CS environment have the most positive attitude toward active travel, which is consistent with the positive conditions for walking and cycling in that area. Those around The Hague Moerwijk are least positive toward active travel. This implies a mismatch between travel attitudes and travel conditions, since higher densities and land use mix in Moerwijk should be conducive to active travel. Significant differences are also found in public transport attitude, with the most positive attitude found in Moerwijk. This is in line with the high shares of bus and tram use in this area.

The indicator scores of reasons for location choice per location are displayed in Table 5. It is found that in Voorhout, car conditions are a relatively more important location factor. Access to train is most relevant around the CS area, which is understandable from the best train facilities offered there. Access to bus and tram is most important as a location factor for those residing around Moerwijk, again understandable from the best bus and tram facilities offered there. Good conditions for cycling are most prominent as a location factor around Moerwijk, and least important around CS. The latter is not in line with the high access of services and facilities by bicycle in the CS area. A possible explanation is that the high traffic density in general (also pedestrians and cars/busses) make cycling less attractive. Walkability is a more important reason for location choice in Voorhout than in the central locations in The Hague. This is unexpected since one would expect walking conditions to be better in The Hague CS and Moerwijk, with higher densities and more mixed land use.

Taken together, the findings regarding attitudes and location choice motivations suggest two relevant notions. First, the fit between residential locations and travel attitudes is far from perfect. Although the mean scores of attitudes differ between locations significantly and in mostly logical ways, eta scores are low, and considerable variance exists within locations. This indicates that, for instance, Voorhout not only hosts those

Table 5
Travel behaviour, travel attitudes and reasons for location choice by location.

Description	Voorhout Suburban train station	The Hague CS Central urban train station	The Hague Moerwijk Urban bus/tram oriented	*p*-Value	Eta
Travel behaviour					
- Car days/week	4.24	2.01	1.96	0.000	0.290
- Train days/week	1.76	1.97	1.33	0.057	0.134
- Bus/Tram days/week	0.34	1.34	2.69	0.000	0.090
- Cycling days/week	3.75	3.10	3.30	0.215	0.098
Travel attitude (mean)					
- Pro car	0.32	−0.09	−0.19	0.004	0.164
- Pro walk/cycle	−0.02	0.12	−0.27	0.023	0.149
- Pro PT	−0.27	0.05	0.09	0.023	0.138
Travel attitude (% in lowest/%in highest quintile of the total sample)					
- Pro car		22.6%/20.9%	21.3%/13.0%		
- Pro walk/cycle	10.5%/23.3%	13.8%/19.7%	28.7%/20.4%		
- Pro PT	23.3%/22.1%	18.0%/20.9%	17.6%/23.1%		
	30.2%/12.8%				
Importance of reasons for location choice (on 1 to 5 scale)					
- Walking conditions	3.46	3.09	3.42	0.000	0.194
- Car conditions	3.34	2.88	3.04	0.004	0.153
- Train conditions	3.67	4.16	3.71	0.000	0.195
- Bus/tram conditions	2.91	3.13	3.77	0.000	0.231
- Cycling conditions	3.50	3.17	3.76	0.000	0.205
Reasons for location choice (% in lowest/%in highest quintile of the total sample)					
- Walking conditions		21.6%/17.6%	12.9%/28.4%		
- Car conditions	16.9%/38.2%	23.3%/23.7%	18.9%/24.6%		
- Train conditions	9.3%/31.4%	8.7%/49.8%	19.0%/35.7%		
- Bus/tram conditions	18.9%/33.3%	18.1%/19.2%	10.3%/39.7%		
- Cycling conditions	16.7%/14.4%	13.1%/14.6%	7.2%/40.0%		
	5.6%/18.9%				

with the strongest car attitude, but also people with a negative car attitude. Likewise, a place like The Hague CS with excellent public transport options hosts people with a very positive car attitude as well as people with a negative attitude toward public transport. The imperfect match between travel attitudes and locations is in line with earlier findings in the literature, and may be explained by financial and housing market constraints, as well as the prevalence of non-travel related reasons, as discussed before.

Similarly, with respect to transport related reasons for location choice, we observe significant variation within locations, suggesting that some households have unexpected reasons for living in particular places. In fact, each location includes respondents rating access to particular travel modes among the 20% least and 20% most important of all respondents (Table 4). For instance, some living in The Hague CS area mention positive conditions for car use as a reason for living there. On the other hand, some living in Voorhout have chosen to live there because of the good conditions for using the bus. Such inconsistent travel related reasons for location choice may be partly due to prevalence of other, non-travel related reasons. In addition, even with similar strength of travel mode conditions as a locational factor (e.g. access to PT), households end up in different locations, because they may hold different perceptions of what constitutes a 'good' location in terms of the preferred travel mode. For instance, walking distance and risk of accidents may be defined differently by different individuals, based on physical condition or gender.

Table 6
Correlations between travel attitudes and reasons for location choice.

		Attitude toward travel modes		
		Pro car	Pro walk/cycle	Pro PT
Reasons for location choice	Walking conditions	0.001	0.148**	0.010
	Car conditions	0.397**	−0.044	0.025
	Train conditions	−0.163**	0.268**	0.208**
	Bus/tram conditions	−0.198**	0.033	0.207**
	Cycling conditions	−0.099**	0.309**	0.065

** $p = 0.05$.

A second notion is that that attitudes toward travel modes and mode related location factors correlate significantly, but not highly (Table 6). The strongest correlation between attitude and motivation for location choice is found for car and is 0.397. This implies that travel attitudes and reasons for location choice may not be consistent. For instance, some with a positive attitude toward car travel mention car accessibility as unimportant for their location choice, and some with a negative attitude toward car travel mention it as an important factor in their locational decision. These findings suggest at least that travel attitudes are not translated into underlying reasons for location choice in a direct way, as assumed in existing approaches to analysing RSS. A possible explanation may be that constraints with respect to access to or feasibility of transport options prohibit residential choices that are in line with one's preferences. For instance, even without liking driving, a car may be the only way to get to one's job and drop off one's child, so that one opts for a residential location with good car accessibility. However, more research is needed to unravel the exact reasons for discrepancies between travel attitudes and reasons for location choice in residential location choice.

3.2. Modelling self-selection effects

Given that attitudes toward travel modes and reasons for location choice are only weakly related, and both show only a limited congruence with residential area type, this section addresses the implications

for travel behaviour. Following the modelling approach outlined in Section 2.4, the frequencies of using car, train, bus/tram and bicycle were modelled as a function of socio-demographic variables, locational characteristics (living in Voorhout, The Hague CS or Moerwijk), attitudes toward travel modes and reasons for choosing the current residential location. Since we are modelling count data, which is not necessarily normally distributed, we use Poisson regression models. In a stepwise procedure, attitudes and location choice reasons were added stepwise, to get an indication of residential self-selection from a travel mode perspective. In particular, it is examined whether RSS occurs based on attitudes and travel related reasons for location choice, and to what extent they exert overlapping or independent effects. Models are presented in Table 7.

For car use frequency, we find that factors such as age, household composition and gender do not significantly influence car use. A positive effect is found for income, which disappears however after adding

Table 7
Poisson regression models of trip frequency.

	CAR						TRAIN					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.
Constant	−0.738	0.005	−0.386	0.144	−0.050	0.870	0.213	0.423	−0.206	0.473	−0.744	0.057
Location												
The Hague CS	−0.373	0.000	−0.262	0.001	−0.314	0.000	−0.113	0.343	−0.272	0.023	−0.394	0.001
The Hague MW	−0.231	0.021	−0.199	0.047	−0.211	0.037	−0.385	0.010	−0.452	0.003	−0.366	0.020
Personal characteristics												
Male	0.064	0.358	−0.008	0.908	−0.028	0.690	0.183	0.040	0.232	0.009	0.177	0.048
Income middle	0.094	0.299	0.106	0.243	0.024	0.798	0.017	0.883	0.055	0.632	0.056	0.630
Income high	0.192	0.039	0.166	0.072	0.112	0.235	0.226	0.075	0.311	0.017	0.287	0.028
Has drivers license	0.217	0.233	0.070	0.702	0.106	0.565	−0.101	0.485	0.134	0.378	−0.023	0.878
Has partner	−0.176	0.038	−0.080	0.343	−0.075	0.381	0.146	0.188	0.078	0.492	0.063	0.584
Has children	0.033	0.694	0.018	0.834	0.034	0.695	0.035	0.786	0.013	0.921	0.100	0.444
Has a car	2.253	0.000	1.735	0.000	1.513	0.000	−0.605	0.000	−0.276	0.025	−0.077	0.586
Has a bicycle	−0.354	0.009	−0.344	0.016	−0.279	0.053	0.329	0.098	0.221	0.281	0.171	0.422
Age < 25	0.013	0.926	−0.057	0.688	−0.026	0.857	0.564	0.001	0.809	0.000	0.507	0.004
Age 26–35	0.106	0.224	0.057	0.521	0.047	0.615	0.449	0.001	0.601	0.000	0.333	0.017
Age 36–50	0.142	0.128	0.174	0.063	0.208	0.032	0.224	0.118	0.258	0.075	0.112	0.453
Travel attitudes												
Pro car			0.396	0.000	0.323	0.000			−0.261	0.000	−0.144	0.011
Pro walking & cycling			−0.165	0.000	−0.101	0.014			0.156	0.002	0.068	0.201
Pro PT			−0.182	0.000	−0.140	0.000			0.235	0.000	0.130	0.004
Reason for location choice												
Walking					−0.034	0.053					−0.021	0.382
Car use					0.070	0.000					−0.049	0.010
Train					−0.088	0.009					0.445	0.000
Tram/bus					0.016	0.622					−0.027	0.487
Cycling					−0.066	0.103					−0.084	0.093
−2 * LL	−660.61		−608.355		−594.952		−642.271		−614.138		−573.439	
Chi-square	0.000		0.000		0.000		0.000		0.000		0.000	

	Bus/tram						Cycling					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.	Coeff.	Sign.
Constant	−0.033	0.910	−0.232	0.453	−0.765	0.039	−1.344	0.004	−1.184	0.012	−1.737	0.000
Location												
The Hague CS	1.250	0.000	1.161	0.000	1.186	0.000	−0.193	0.011	−0.191	0.014	−0.160	0.043
The Hague MW	1.672	0.000	1.541	0.000	1.398	0.000	0.044	0.607	0.089	0.305	0.059	0.519
Personal characteristics												
Male	−0.126	0.219	−0.110	0.287	−0.088	0.402	−0.070	0.247	−0.077	0.208	−0.061	0.324
Income middle	−0.085	0.469	−0.072	0.547	−0.094	0.437	−0.109	0.126	−0.086	0.230	−0.085	0.237
Income high	0.118	0.430	0.223	0.143	0.184	0.233	−0.242	0.003	−0.245	0.003	−0.283	0.001
Has drivers license	−0.137	0.323	0.048	0.747	0.015	0.919	0.281	0.016	0.207	0.081	0.222	0.062
Has partner	0.051	0.646	−0.003	0.980	0.048	0.675	−0.018	0.802	−0.001	0.991	−0.021	0.776
Has children	0.189	0.192	0.056	0.718	0.051	0.746	0.067	0.411	0.085	0.297	0.088	0.284
Has a car	−0.422	0.000	−0.415	0.001	−0.500	0.001	−0.247	0.001	−0.164	0.063	−0.145	0.144
Has a bicycle	−0.499	0.000	−0.367	0.012	−0.341	0.025	2.894	0.000	2.572	0.000	2.545	0.000
Age < 25	−0.086	0.591	−0.122	0.463	−0.144	0.418	−0.210	0.061	−0.094	0.412	−0.137	0.242
Age 26–35	−0.229	0.069	−0.259	0.043	−0.165	0.222	−0.164	0.029	−0.048	0.531	−0.046	0.573
Age 36–50	−0.189	0.185	−0.277	0.061	−0.240	0.117	0.001	0.993	0.057	0.493	0.039	0.650
Travel attitudes												
Pro car			−0.041	0.498	−0.027	0.672			−0.023	0.528	−0.011	0.777
Pro walking &cycling			−0.141	0.003	−0.143	0.006			0.290	0.000	0.228	0.000
Pro PT			0.176	0.000	0.147	0.000			−0.096	0.003	−0.113	0.001
Reason for location choice												
Walking					−0.010	0.714					−0.003	0.827
Car use					0.022	0.276					0.005	0.696
Train					−0.076	0.143					0.055	0.093
Tram/bus					0.201	0.000					−0.020	0.467
Cycling					0.021	0.707					0.117	0.001
−2 * LL	−568.299		−548.583		−536.664		−826.416		−787.139		−775.600	
Chi-square	0.000		0.000		0.000		0.000		0.000		0.000	

attitudinal variables. Car ownership logically has a strong positive effect, which remains present after adding attitudinal variables and reasons for location choice. Apparently, car ownership can be regarded as an influence by itself, and not as a proxy variable of attitude or residential location. With respect to the effect of residential location, it is found that respondents living near CS or in Moerwijk use the car less often the inhabitants of Voorhout, controlled for car ownership. This confirms the hypothesis that less favourable driving conditions and availability of more attractive alternatives reduce the amount of driving. After adding the attitudinal variables, the locational effects remain strongly significant and reduce little in effect size, suggesting that self-selection based on attitudes plays a limited role. Travel attitudes, however, also have a strong and significant effect on car use. A positive attitude toward car increases car use frequency, whereas positive attitudes toward public transport and active travel logically diminish the frequency. This suggests that attitudes exert an autonomous influence on travel choices, and are only to a limited extent translated into locational decisions in the context of car use in the geographical context of this study. Adding location choice reasons to the model, it is found that if car accessibility was a stronger reason for location choice, the car will be used more, but less so if train accessibility was an important reason for location choice. It is noted that after adding reasons for location choice, the effects of residential location and travel attitude remain unaffected. This suggests that if the relocation was at least partly aimed at creating favourable conditions for car use, this has an additional effect on car use, over and above the effect of location and travel attitude. The relative modest improvement in model fit suggests, however, that the effect of travel attitude is larger where car use is concerned.

For train use frequency, the base model suggests that age has a significant effect on train use frequency. In particular, those younger than 25 and aged 26–35 will use the train more frequently. Also, males use the train more frequently. Logically, those owning a car use the train less frequently. Inhabitants of Moerwijk use the train less often. Adding attitudinal variables reveals that those with a positive attitude to public transport will use the train more, as expected. However, also those with a positive attitude to active travel use the train more, which may be related to their willingness to use active access and egress modes. Logically, those with a positive car attitude use the train less. Remarkably, after adding the attitudinal variables, location (living in The Hague CS) has a negative effect on train frequency. The negative effect sizes of living around CS (although not significant) and Moerwijk increase. This suggests that the correlation between location and travel attitudes, displayed in Table 6, needs to be controlled for to obtain valid estimates of the effect of location, and that residential self-selection is at play to a certain extent. Adding the reasons for location choice reveals that those for whom access to train was an important reason for their location choice use the train more often, whereas those who considered car accessibility an important reason will logically use the train less. It is found that positive attitudes toward active travel are not significant anymore after adding the reasons for location choice. This suggests that a considerable share of those with a positive attitude to active travel consider access to train as a reason for location choice. The strong increase in model fit suggests that deliberately choosing to live near railway facilities is an important factor for train use frequency, whereas for car use travel attitudes appeared to exert a relatively larger effect. Finally, adding the reasons for location choice results in a larger negative effect of living near CS. This suggests that in CS, especially those relocating because of better access to the train will use it, and not those relocating for other reasons.

For bus and tram frequency, the estimations suggest that socio-demographics do not play a significant role in bus/tram frequency. Car ownership and bicycle ownership have a negative effect on bus/tram frequency, implying that walking/cycling and bus/tram can be considered competitive travel modes. Living in The Hague areas (CS and Moerwijk) has a positive effect on using tram and bus, which is easily understood from the higher level of service in these locations. Adding the attitudinal variables indicates that car attitude does not influence bus/tram frequency, but a positive attitude toward active travel diminishes bus/tram frequency, again indicating competition between these active modes and bus/tram. Logically, a positive attitude toward public transport increases bus/tram frequency. The location variables remain strongly significant. Finally, adding reasons for location choice, it is found that if access to bus/tram was more important as a reason for location choice, bus/tram is used more frequently. Location variables and travel attitudes remain very significant. The modest increase in model fit suggests that travel attitudes exert a stronger effect on frequency of bus/tram use than reasons for location choice. Altogether these findings suggest that self-selection has a limited effect on using bus and tram, and that travel attitudes and location choice reasons exert independent effects of the frequency of using bus and tram.

For cycling, the base model suggests that with a higher income, respondents are less inclined to use bicycle. Also, car ownership and bicycle ownership have expected effects on bicycle use. A significant locational effect is found for the Hague CS, suggesting that this environment is less conducive for cycling. Adding attitudinal variables, it is found that a positive attitude to active travel is associated with more frequent bicycle use, whereas a positive public transport attitude leads to a lower cycling frequency, confirming the competition between these travel modes. Adding attitudes does not affect the significance and effect size of living around CS. Adding reasons for location choice, we find that cycling accessibility being a reason for location choice has a significant impact up and above the locational and attitudinal factors. The effect of travel attitudes is not strongly affected, suggesting that travel attitudes and reasons for location choice exert independent effects. The increase in model fit suggests that the effect of attitudes is relatively stronger.

4. Conclusions and discussion

In this paper we have investigated to what extent locational factors (access to train and bus/tram, accessibility by car and conditions for walking and cycling), travel attitudes and reasons for location choice influence the use of various travel modes within two years after relocation. A main reason for doing so is the hypothesis that apart from travel attitudes, the reason for residential location choice gives an additional, and more direct, indication of the occurrence of self-selection. In addition, comparing travel attitudes and reasons for location choice gives an indication of the validity of travel attitudes as indicators of self-selection processes.

We investigated attitudes, reasons for location choice and travel behaviour using a data set collected under recent movers to TOD locations in the Netherlands. A drawback of this data set is that given the low response rate (in particular in Moerwijk) and the fact that statistics of the sampling frame are lacking, we cannot safely assume that our sample is representative and the results are generalizable. However, we feel that the unique data collected under recent movers allows us to explore the character of residential self-selection processes and their impact on travel behaviour in more detail and derive innovative insights.

An important conclusion, which confirms earlier findings by Schwanen and Mokhtarian (2004) and De Vos et al. (2012) is that attitudes toward travel modes and residential location type are associated only to a limited extent. For instance, public transport oriented environments will host also people with a positive attitude toward car, and car oriented locations also have inhabitants with a preference for public transport. This can be at least partly explained by the reasons people have to choose their residential location. These reasons include many non-travel related factors such as dwelling and neighbourhood qualities. However, also reasons for location choice are not consistently linked to locations. For instance, some choose to live in inner city locations for reasons of car accessibility. Such inconsistencies may be due to differences in perceptions or trade-offs with other locational factors. Finally, it is found that travel attitudes and reasons for location choice

are only weakly correlated, suggesting that travel attitudes are not directly translated into reasons for residential location choice.

With respect to the effect of the BE on travel behaviour, these findings have some implications. First, the finding that attitudes are only to a limited extent 'translated' into location choices suggests that self-selection will be limited by definition, and that the BE exerts considerable 'autonomous' influence on travel behaviour. E.g., a car enthusiast ending up in a place with good access to public transport may in the end be tempted to use public transport and learn to appreciate it, eventually changing his/her attitude toward this travel mode. Second, travel related residential preferences may be regarded as a more direct indicator of self-selection in the context of travel behaviour than attitudes toward travel modes. Nevertheless, it cannot be regarded as an absolute indicator, given differences in perception, trade-offs with other locational factors and constrained choice sets.

Since the effects of location on travel are only to a limited extent affected by adding travel attitudes and reasons for location choice to the models, the RSS effect seems to be limited in our case. Our model results suggest also that travel conditions being a reason for residential location has an additional and independent effect up and above the effects of location and attitude. Thus, the self-selection effect based on travel attitudes usually found in other studies, is composed of the effects of travel attitude of those relocating for both travel and non-travel reasons. This implies that 'true' self-selection (i.e. selecting a place for travel reasons) applies to fewer people than assumed in earlier conceptualisations, but is then likely to exert a stronger effect on travel behaviour. In some cases (e.g. train use among residents of the CS area), such true self-selection seems actually a prerequisite for locational conditions to influence travel behaviour.

Another implication of our analyses is that effects of location, attitude and location choice reasons may play out differently for different modes. For car, bus/tram and bicycle, we find clear and almost independent effects of location, attitude and reason for location choice. Apparently, there is not a strong sorting mechanism by which car enthusiasts end up in car oriented places, those preferring public transport in public transport oriented places and those with active travel preferences in places with the best walking and cycling conditions. As a result, residential selection for these modes is limited and location and attitude exert independent influences. In all cases, however, if the location was chosen for its travel conditions, this adds to the effect of the locational conditions (or diminishes negative effects). A somewhat divergent image appears for train use. In particular, we find that taking into account reasons for location choice moderates the effect of location and attitude, in the sense that movers into the CS area will use train more often if train use was a reason for their location choice. Also in terms of effect size, it appears that the extent to which conditions for using the travel mode influenced location choice is largest for the train (followed by cycling).

Also in other respects, it is found that asymmetrical relationships between travel modes appear. The effects of attitudes suggest, for instance, that those with a positive attitude toward active travel will use the train more, but bus and tram less, suggesting competition between slow modes and bus/tram. According to the models, car competes with train but also with active travel and public transport in general.

The above results have various planning implications. Our study suggests that access to train and bus/tram indeed helps to increase the use of these travel modes, and allows individuals to travel in line with their travel attitudes. However, access to PT and cycling conditions are only one reason for people to reside in TODs or cycling friendly environments. Thus, if one aims to increase PT use or cycling by land use planning, one should take into account other housing preferences of PT and cycling adepts as well. For instance, housing should be suited to the life cycle, housing style, preference for amenities etc. of those most likely to use PT or cycle. Another implication is that, since attitudes toward travel modes and reasons for location choice exert an independent effect, awareness of travel options may play a significant role for travel behaviour after relocation. This suggests that 'soft policies' such as providing information about travel options to recent movers, may help to increase the use of PT and active travel modes among new residents of TODs. Finally, the fact that significant differences in travel behaviour are observed between the spatial locations in this study confirms that BE exerts an independent effect on travel behaviour. Hence, developing TODs in the Dutch context is likely to increase PT use, although this effect can be increased by catering for the needs of PT oriented households, also with respect to non-travel related housing preferences.

A caveat is in place with respect to our findings. Our data was collected in a rather specific setting of three TOD locations, offering good access to rail transit by definition. It is uncertain how relationships found in our models would play out if a wider range of locations were included, such as low density rural areas. Given the only partial associations between attitude toward travel modes, reasons for relocation and travel behaviour, it is likely that car dependent areas will be populated not only by those who prefer to travel by car, but also by those who favour public transport or active travel modes. Housing market restrictions, or prevalence of other housing considerations over travel related considerations may lead these groups to live in car dependent areas. The impacts on their behaviour will depend on the extent to which they can organize their activities based on PT or active travel modes and on the extent to which their preference for car travel might change in their new environment. The conclusion that self-selection plays a limited role should be tested again in such a design.

Also, using a sample that is skewed toward higher education and income groups in an area in the Netherlands with a large variety of residential milieus suggests that constraints with respect to residential location may be limited. Repeating similar analyses among different social strata and in different spatial settings may lead to different conclusions regarding the effect of built environment on travel and self-selection effects.

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