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Hamersma, M, Heinen, E orcid.org/0000-0001-8428-5709, Tillema, T et al. (1 more author) (2017) New highway development in the Netherlands: A residents' perspective. Transportation Research Part D: Transport and Environment, 51. pp. 326-339. ISSN 1361-9209

https://doi.org/10.1016/j.trd.2017.01.006

New highway development in the Netherlands: A residents' perspective

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Abstract

This study investigates the impacts of new highway development from a residents' perspective. Data were collected by questionnaire in two residential areas, Son and Uden, both situated along the new A50 highway in the Netherlands. The objectives of this study are: 1) to analyse the extent to which highway development has impacted the residents' self-reported residential satisfaction through the use of Structural Equation Modeling, and 2) to explore residential self-selection, by comparing characteristics of the original population with those who have relocated into the area during and after highway development using Multinomial Logistic Regression.

The results indicate that a small majority of the residents perceived an increase in residential satisfaction due to the highway development. Living in the sampled area in Son (compared to Uden), living on close proximity to the A50 highway, having a low preference for car accessibility, and a strong preference for environmental quality were negatively associated with the change in residential satisfaction, mostly via a negative association with the perceived change in liveability or accessibility. The findings of our second analysis show that residents who had relocated into the area after the highway development have a slightly more 'highway-oriented' profile than the original population, i.e. a marginally higher preference for car accessibility and lower preference for environmental quality.

The study sheds light on the importance of accounting for the perceptions of the wider residential population and reveals how the impacts of new highway development differ between and within residential areas.

Keywords: *Highway development, residential satisfaction, residential self-selection, perception, residents.*

1 Introduction

The car is still one of the most dominant modes of transport in our society. To perpetuate this trend, governments dedicate considerable investment to improve their national and regional road infrastructure networks. In the Netherlands alone, a highly densely populated country with a relatively mature road infrastructure network (Arts, 2007), the Dutch national government invested approximately Euros €2.4 billion in their main road i.e. highway infrastructure in 2015 in order to ensure, among other things, "accessibility and liveability" (Ministry of Infrastructure and the Environment, 2016).

At the local residential level, however, the effects of road investments are often considered to be controversial. Along with the positive effect of increased accessibility or liveability, road development may also involve negative effects, such as undesired landscape changes and (increases in) noise, air pollution and barrier effects caused by obstructed views or reduced access to places in the residential area due to fragmentation (Arts, 2004). Given that new road infrastructure can generate both positive and negative effects in residential areas means that it is incumbent upon decision-makers to take a range of complex issues into account when investing in road infrastructure (Tillema et al., 2012).

Effects of road infrastructure development at the residential level have received scientific attention in the house price literature. In general, studies indicate that both positive and negative effects of infrastructure investment are capitalised in house prices, with variations in the magnitude of both effects (Levkovich et al., 2016; Theebe, 2004; Boarnet and Chalermpong, 2003; Reibel et al., 2008; Kang & Cervero, 2009). A recent work by Levkovich et al. (2016) aimed to monetize the impacts of the development of e.g., the new highway A50 in the Netherlands, on house price using a repeated sales analysis. Their study shows that, although increased exposure to negative impacts has a downward effect on house price, the positive effect of increased accessibility outweighs the negative effects, suggesting that residents are willing to pay to live close to highways.

Although house price studies provide insights into the general effects of highway development on residential areas over the long-term, they may not always give a complete picture of the implications for residents (Tillema et al., 2012). For example, some residential groups may evaluate highway development in a more positive light than others, depending on their characteristics and preferences. In addition, despite that the development of (road) infrastructure may have created a selective inflow of people who prefer (road) accessibility and who are less sensitive to potential negative effects such as noise and air pollution (Van Wee, 2009; Cao et al., 2009), the original population already living in the area may have different preferences and may evaluate road development in a negative light. We argue that, by gaining further insights into how infrastructure investment is perceived from a residents' point of view, decision-makers will be better prepared to evaluate their policy aims to improve accessibility and liveability.

This study aims to contribute to the knowledge on road infrastructure development by analysing the effects brought to bear by the new Dutch highway A50 from a residents' perspective. Firstly, we evaluate the impacts of new highway development on the original population by studying the perceived change(s) in self-reported residential satisfaction. Residential satisfaction is seen as an important proxy for residential wellbeing and quality of life; as an indicator, it represents the match between actual and preferred housing conditions

that may have changed due to the highway development (Lu, 1999; Speare, 1974; Hamersma et al., 2015). Specifically, we study how perceived changes in residential satisfaction are associated with original residents' geographical locations as well as residential preferences. Following the literature (Hamersma et al., 2015; Kroesen et al., 2010), we take account of both potential positive and negative effects of highway development on residents and hypothesise that both aspects mainly influence residential satisfaction via their relationship with perceived changes in liveability or accessibility as a consequence of highway development. Analysts frequently use Structural Equation Modeling (SEM) to investigate mediating types of relationships, and for this reason we have selected SEM as an appropriate and fruitful analytical tool. Secondly, we explore differences between the original population and residents who had arrived during or after the highway development as an indicator for (long-term) residential self-selection. Using Multinomial Logistic Regression (MLR), we compare the groups in terms of geographical location and residential preference(s). The analyses are based on questionnaire data collected from two Dutch villages along the A50, Uden and Son, which also provides us with the opportunity to 1) study potential differences between both areas, and 2) compare some of the results with Levkovich et al. (2016) who studied house prices in the same research area.

The article is structured thusly; we next discuss the literature on potential effects of highway development on residential satisfaction and residential self-selection. Thereafter, in Section 3 we discuss our research methodology, and carry on with results, discussion and conclusions in sections 4 and 5.

2 Literature review: The impact of highway development from a residents' perspective

Following our research aims, we begin with a discussion of the existing literature on two aspects, first, the influence of highway development on residential satisfaction and thereafter, the idea of residential self-selection.

2.1 Highway investments and (changes in) residential satisfaction

Residential satisfaction is found to be influenced by aspects of the house, the environment, and the person (Tillema et al., 2012; Buys & Miller, 2012; Lu, 1999). Highway development may impact on the environment and, if proximity pertains, also on residential satisfaction. On the one hand, it may increase residential satisfaction by improving accessibility or liveability, the former when a new lane is provided, and the latter through improving environmental attractiveness. On the other hand, residential satisfaction may decrease if highway development involves a deterioration of liveability through undesired changes in the immediate residential environment or an increase in nuisance, such as noise, air pollution and barrier effects (Tillema et al., 2012). Studies indicate that negative effects of roads mainly occur within 300 metres of highways, whereas positive gains due to accessibility tend to spread across a wider area (Tillema et al., 2012; Nelson, 1982; Eliasson, 2005; Wilhemsson, 2000).

Some studies investigate relationships between proximity to highways or other infrastructure and residential satisfaction levels, although not in the context of *highway development*. Such

studies generally find no strong associations between residential satisfaction and resident proximity to the infrastructure, e.g., distance to the (highway), exposure to noise, or air pollution (Hamersma et al., 2014; Morris, 2013; Van Praag & Baarsma, 2005; Kroesen et al., 2010). In contrast, studies which include *perceptions* of (highway) accessibility and nuisances seem to find effects relating to residential satisfaction. For instance, Hamersma et al. (2014) find that perceived highway nuisances has a negative effect on residential satisfaction for those living close to highways; in a follow-up study, the authors verify that actual highway proximity was one of the factors influencing the perception of those nuisances (Hamersma et al., 2015). Also studies which include other measures of traffic nuisance or accessibility, such as perceived access to work and shops, find significant impacts on residential satisfaction (Buys & Miller, 2012; Hur & Morrow-Jones, 2007). When analysing the effects of highway development on residential satisfaction, it may therefore be important for researchers to enquire into possible differences between the actual changes in accessibility and liveability, and the ways those changes are *perceived* by residents.

Differences in residential preferences may moreover be vital towards understanding the perceived impacts of highway development. Studies confirm that people are more satisfied in residential areas that match their own residential preferences (Schwanen et al., 2004; Barcus, 2004). The studies of Hamersma et al. (2014; 2015) show that individuals who prefer a highway location are more satisfied with their residential location and also have lower highway nuisance perceptions when living close to highways. In their study on residential satisfaction close to airports, Kroesen et al. (2010) find that frequent flyers, who are likely to be strongly interested in flying, more than non-users and thus have a higher preference for living close to airports, are more satisfied with their residential location, and report lower perceptions of aircraft noise annoyance. Along the same line, changes in liveability due to highway development may be more negatively perceived by people with stronger preferences for clean and safe environments. For example, several studies indicate that people who are sensitive to nuisances such as noise, generally have a higher negative perception of nuisance (Fields, 1993; Kroesen et al., 2007; Nijland et al., 2007), and a lower residential satisfaction in high noise exposure areas (Nijland et al., 2007). We argue therefore that, through the inclusion of specific residential preferences, residents may perceive the impacts of highway development on residential satisfaction differently.

In our literature survey we have brought to the fore the recent literature which discusses how impacts of highway development on residential satisfaction may best be measured with regard to how liveability and accessibility changes are *perceived*. In this context we examine the extent to which perceptions of changes in liveability and accessibility function as mediators for understanding the connections between residents' geographical location, their residential preferences, and changes, if any, in residential satisfaction as a consequence of highway development.

2.2 Highway development and residential self-selection

One could also argue that highway infrastructure development triggers a process of residential self-selection. A study by Thanos et al. (2014) suggests that households 'sort' across neighbourhoods in accordance with their attitudes about environmental issues, and in relation to key social factors such as income, travel costs and budget constraints. In other

words, people are likely to select neighbourhoods which mirror their own lifestyles and personal preferences (Van Dijck et al., 2011). The topic of residential self-selection is often investigated in the search for the 'true' relationship between characteristics of residential areas and individuals' (travel) behaviour while also aiming to identify the selective characteristics and preferences of people already living in those areas (Cao et al., 2009).

Highway development makes it easier to reach places in a regional context, and by doing so, may trigger an inflow of people who prefer good road accessibility. Studies generally indicate that, although people also seem to attribute and change their travel behaviour based on characteristics of the neighbourhood in which they live, at least a part of the variation in travel behaviour between neighbourhoods is caused by self-selection of people with specific travel preferences *into* a certain neighbourhood (Cao et al., 2009; Van Wee, 2009; Silva, 2014; Cao et al., 2007). For example, using data of residents in several neighbourhoods in Northern California, Cao et al. (2007) argue that neighbourhood preferences and travel-related attitudes exert a direct influence on the choice for a certain neighbourhood. Similarly, the study of Silva (2014) finds evidence for both residential self-selection and neighbourhood characteristics to explain travel behaviour among residents in the Lisbon Metropolitan Area. Following this logic, let us assume that residents who have relocated into an area after a highway has been built have a more car-oriented profile, on average, than the original population of that area.

Although the advantages of highway proximity are likely to appeal to people with a preference for car accessibility, the negative environmental effects of a highway could also be a source of concern and worry. More specifically, people who are more sensitive to environmental qualities may decide to move or choose not to live near highways. A few studies have investigated the tendency of residential self-selection based on the environmental consequences of infrastructure, but found mixed results. For example, the study of Nijland et al. (2007) examines the extent to which people self-select into higher and lower noise exposure areas due to noise sensitivity, but find no significant differences. They point up the potential effects of low house prices and other residential characteristics, which could be valued as more important. Other studies, however, unearth evidence to support the notion that people (at least partly) seem to self-select into residences based on sensitivity to noise (Thanos et al., 2014; Boes et al., 2013; Arsenio et al., 2006). Along this same line are studies emphasising the relevance of accounting for self-selection by also examining the causality between proximity to air pollution and health (Neidell, 2004). Residents who relocated into an area after highway development may therefore have a lower preference for environmental quality than the original population of that area may have had.

To conclude, various studies give indications for residential self-selection based on accessibility or environmental characteristics of an area. We suggest that the people who disliked the new highway development in their proximal location may have moved and thereafter been replaced by people with generally positive attitudes about the highway. In the present study we seek evidence for residential self-selection by analysing the extent to which the residents who arrived later to the area have different geographical location characteristics and preferences for car accessibility and environmental quality compared to the original population.

3 Research Design

3.1 Research setting

We study the effects of the development of the four-lane A50 highway extension (two lanes in each direction) in the Netherlands (Fig. 1) to connect the cities of Eindhoven and Oss, which was completed between 2001 and 2006. This part of the A50 was built in order to replace the N265, the main road between both cities until 2001. The previous N265 consisted of two lanes (one in each direction) and crossed through several towns along the route. Over the years, the N265 had become a congested road that began to generate increasingly negative effects on liveability. The A50 highway project was designed to ameliorate negative externalities by improving accessibility as well liveability and safety through the reduction of traffic along the N265 (David-Dentener, 2004; Arts, 1998). Fig. 1 depicts the A50 highway between Eindhoven and Oss and its connection to the A50 towards Nijmegen. The A50 route is shown in orange and the former N265 is indicated by a black dashed line.

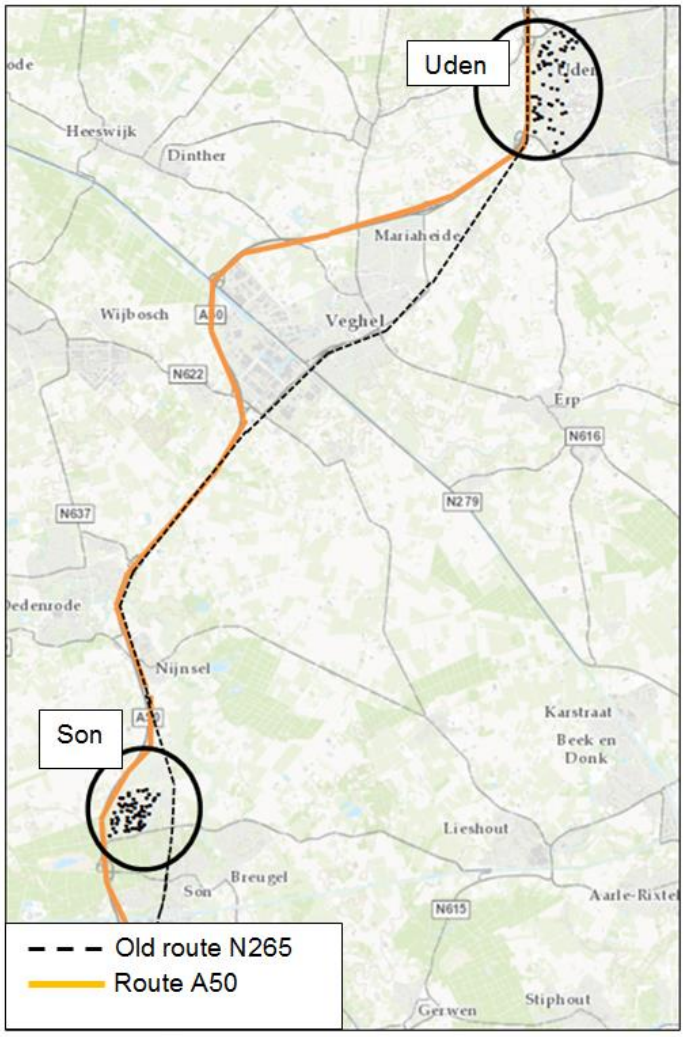

Figure 1 Route of the newly developed highway.

In this study we focus on two residential areas along the A50: Uden and Son. At the time of our sampling, there were respectively, approximately 35,275 and 10,785 inhabitants in each

town (Statistics Netherlands, 2011). In Uden the A50 was built along the same trajectory as the N265, but in Son the A50 was constructed along a new route west of the town. Two construction alternatives were set out for Son, one close to a residential area and the other crossing a natural area; the former was chosen because the latter (nature) was likely to suffer overly from damaging impacts brought about by the construction. In Son especially, a high level of aversion to the new highway project was also reported (David-Dentener, 2004; Arts, 1998). The A50 highway in both sampled locations was completed in 2004. Given that the trade-offs between positive and negative effects of highway development are particularly influential in close proximity to it (Tillema et al., 2012), we therefore focus only on residential areas within one kilometre of the new highway.

3.2 Data collection

We use data from a questionnaire sent in May 2011 to Son and Uden residents who live in proximity of the new highway A50. We are aware that the survey takes place approximately seven years after completion of the A50, and that residents who had been most annoyed by the highway may have already moved. However, the time lag means that our dataset also consists of a significant group of residents who relocated during or after the development of the highway. We seized the perfect opportunity to study potential differences between new inflows and the original population. In total 1,000 respondents (500 in each location) all living within one kilometre of the new highway have been sampled. To assure consistency in the distribution process, the questionnaire was distributed to the first house(s) of each selected postal code area (Hamersma et al., 2016). Data were collected on people's perceptions and opinions about highway development, their residential preferences, in addition to a variety of background characteristics: socio-demographics, length of residence, and 6-digit postal code (allowing us to calculate distance to new highway). In order to reduce potential response bias due to support or opposition of the project, the questions about highway development were embedded in an elaborate questionnaire which did not focus solely on the highway, but on the general residential experience (see also Van Praag and Baarsma, 2005) In total, we received 302 useful questionnaires, giving us a response of 30% (respectively, 39% for Son and 21% for Uden). The high response in Son –the area with more initial protest against highway development- may suggest a higher participation of residents with a more negative attitude. Nevertheless, the response rate was not higher in the area closest to the highway, which reduces this possibility.

3.3 Methodology

To investigate the influence of the A50 highway development on residents, we conduct two analyses: we evaluate the change in residential satisfaction among the original population, and make a comparison between characteristics of the original population and the population that arrived during and after highway development (as indicators for residential self-selection). Below we elaborate on the conceptualisation and statistical analysis for our two-part study.

3.3.1 The perceived change in residential satisfaction

Conceptualisation

In the first analysis depicted graphically in Fig. 2, we study the extent to which residents already living in the area prior to the development of the A50 have expressed changes in their residential satisfaction as a consequence of the highway development. Following the literature, we assume that residents' geographical location and residential preferences are associated with the change in residential satisfaction due to highway development via their influence on either the perceived change in liveability or accessibility (Hamersma et al., 2015; Kroesen et al., 2010). A preference for good environmental quality is assumed to mainly have a negative relationship with perceived liveability change, and via that influence, the change in residential satisfaction. Similarly, a preference for car accessibility is assumed to be mostly positively associated with the perceived change in accessibility. Highway proximity is mainly expected to influence the change in residential satisfaction via a negative relationship with the perceived change in liveability but it is less expected to relate to the perceived change in accessibility; changes in perceived accessibility are likely to be limited within one kilometre distance of the highway (Tillema et al., 2012). In addition, we expect a higher percentage of positive change in liveability in Uden due to the familiarity of dwelling close to a road, and awareness of the previous liveability issues of the N265 – for which mitigation measures were taken (e.g., noise barriers) when the provincial road was rebuilt into a highway – unlike Son, where the highway was built in a 'pristine' area. We also assume a more robust change in accessibility in Uden. In our same research context, the study of Levkovich et al. (2016) finds a higher reduction in travel time to other areas due to the highway development (in Uden more so than for Son).

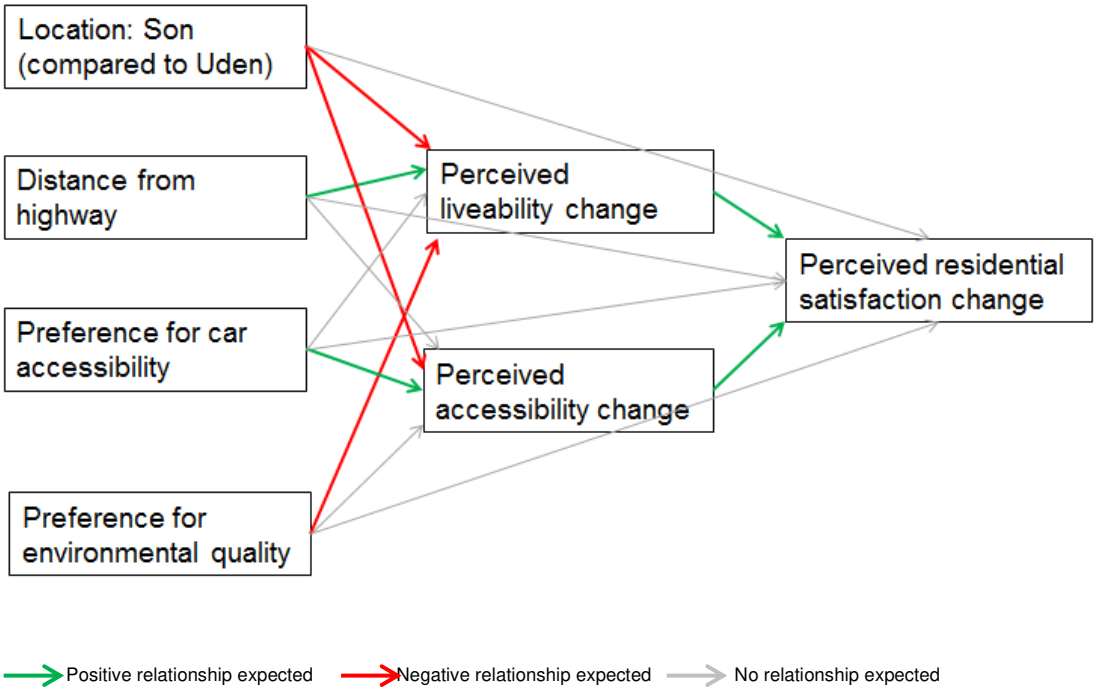

Figure 2 Expected relationship changes in residential satisfaction (main variables).

Variables and statistical analysis

We perform a Structural Equation Model (SEM) using LISREL to study the aforementioned relationships and to better understand changes, if any, in residential satisfaction; this method allows us to analyse the potential mediating role of the perceived changes in liveability and accessibility. A Structural Equation Model includes both endogenous dependent and exogenous independent variables (Hair et al., 2006). Following our conceptualisation, the model consists of three dependent (endogenous) variables: the perceived change in residential satisfaction, liveability, and accessibility. All three are self-reported measures, which means that residents are asked to reflect back on how they perceived the impact of highway development. All of the endogenous variables are measured on a 7-point scale, ranging from a perceived strong deterioration (1), to a strong improvement (7).

For the independent (exogenous) variables, we use residential preferences; i.e. preference for environmental quality and car accessibility; and geographical location, i.e. highway proximity and the residential area. The preference for environmental quality is calculated by taking the average of two variables: a residents' preference for clean areas and quiet areas, measured on a scale of 'very low' (1) to 'very high' (7). Both variables are averaged because of the high correlation between the two (0.6). Preference for car accessibility is measured on a scale from 1 ('very low') to 7 ('very high'). With regard to geographical location, we calculate the straight-line distance between the resident's 6 digit postal code and the new highway. Finally, to study potential differences between both residential areas, we include a dummy: with '1' for Son and '0' for Uden. We also add interaction effects between residential areas and, respectively, distance to the highway, preference for car accessibility, and environmental quality (based on centered predictor variables), in order that we may detect possible differences in the strength of those relationships for the different residential areas.[1] We suggest that the independent variables could influence the change in residential satisfaction directly or indirectly via their effect on the endogenous variables' perceived change in liveability and/or accessibility.

All variables in our data are directly observable and are not latent constructs. Our results are therefore based on the estimation of a series of simultaneously-estimated regression equations (Van Acker & Witlox, 2010). We first estimate a full model in which all exogenous variables are related to all endogenous variables. After that, the insignificant links are removed. In assessing the model fit, we next focus on the Root Mean Square Error of Approximation (RMSEA) and the Comparative Fit Index (CFI) (Ullman & Bentler, 2003).

3.3.2 Exploring residential self-selection

Conceptualisation

In the second analysis, shown in Fig. 3, we explore potential residential self-selection due to highway development by analysing differences in the characteristics of residents in relation to their time of relocation into the area. On basis of the literature discussed in Section 2 (Van Wee, 2009; Nijland et al., 2007; Cao et al., 2009; Thanos et al., 2014), we may assume that residents who arrived later in the area have a higher preference for car accessibility and a

[1] We also estimated a multiple group analysis in LISREL in order to compare the robustness of the relationships between the Son and Uden residential areas. Results are largely in line with the interaction effects found.

lower preference for environmental quality. Regarding highway proximity we can expect that there have been relatively more relocations in close proximity to the new highway where negative changes in liveability are likely to have been strongest (Eliasson, 2005; Wilhemsson, 2000). Furthermore, we explore differences between the two residential areas by analysing if there was a higher number of relocations in Son than in Uden due to a more negative attitude against highway development in Son.

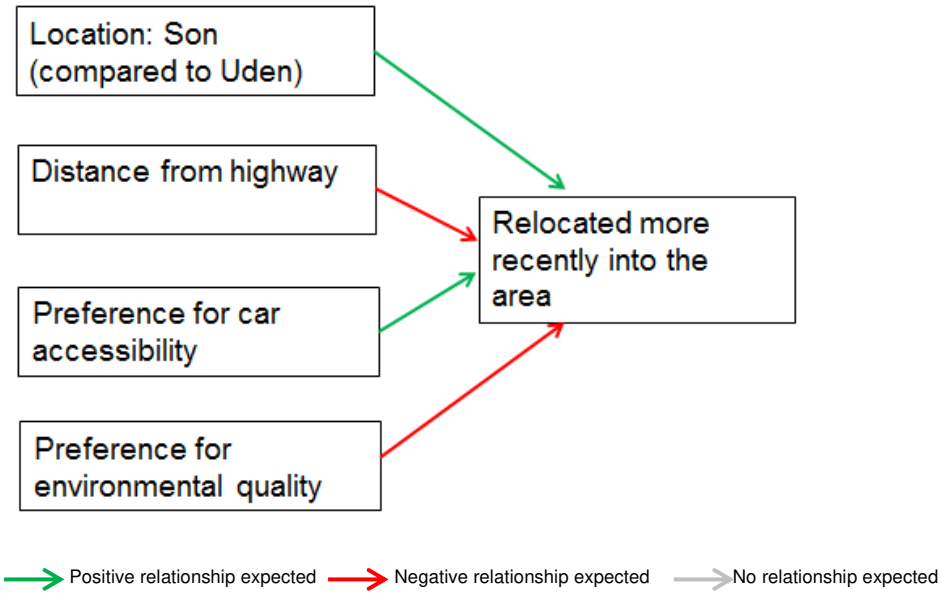

Figure 3 Expected relationships analysis at the time of relocation (main variables).

Variables and statistical analysis

We make use of Multinomial Logistic Regression (MLR) to estimate the likelihood in time of relocation into the area, and compare three groups: the group who arrived *after* the highway was built (after 2004) and the group who arrived just before or *during* the construction period (between 2000 and 2004), were compared with residents who had already lived in the area for a longer time (before 2000). We also identify the group that arrived during highway development so that we may also explore potential anticipation effects in regard to future highway development. The study of Levkovich et al. (2016) in the same research area indicates that house prices seemed to rise already in anticipation, of i.e. during infrastructure development. This may also be reflected in a more highway-oriented profile for this group of residents.

The independent variables in the study largely correspond with those included in our first analysis. We have added preference for environmental quality, car accessibility, highway proximity, and a dummy for the residential area as well as interaction variables with residential area. In addition, we controlled for age, having children, income, and house ownership. The likelihood of moving is often found to be lower for older people, people with children, lower income earners, and house owners (Coulombel, 2010; Hamersma et al., 2015).

Table 1 Descriptive statistics for A50 analysis.

		Son	Uden	Total
Perceived change in residential satisfaction due to highway development* (1=strong deterioration; 7=strong improvement)	1	6.0%	0.0%	3.7%
	2	8.7%	1.1%	5.8%
	3	14.1%	2.1%	9.5%
	4	22.8%	27.7%	24.7%
	5	10.7%	18.1%[a]	13.6%
	6	28.2%	36.2%[a]	31.3%
	7	9.4%	14.9%	11.5%
Perceived change in accessibility due to highway development* (1=strong deterioration; 7=strong improvement)	1	3.9%	0.0%	2.4%
	2	1.9%	2.1%	2.0%
	3	1.9%	2.1%	2.0%
	4	9.7%	14.9%	11.7%
	5	18.2%	12.8%	16.1%
	6	34.4%	37.2%	35.5%
	7	29.9%	30.9%	30.2%
Perceived change in liveability due to highway development* (1=strong deterioration; 7=strong improvement)	1	16.2%[a]	5.3%	12.1%
	2	14.9%	8.5%	12.5%
	3	14.9%	7.4%	12.1%
	4	32.5%	51.1%[a]	39.5%
	5	9.1%	13.8%	10.9%
	6	7.8%	9.6%	8.5%
	7	4.5%	4.3%	4.4%
Moment of moving into the area**	Moved in before 2000 (original population before highway construction)	62.0%	60.9%	61.6%
	Moved in between 2000 and 2004 (anticipation period, during highway construction)	13.9%	11.3%	12.9%
	Moved in after 2004 (after highway construction)	24.1%	27.8%	25.5%
Distance from highway**	Metres	464.5[a]	389.7	435.6
Preference for environmental quality** (1=very low; 7=very high)	1	1.1%	0.9%	1.0%
	2	0.5%	0.9%	0.7%
	3	2.2%	5.3%	3.3%
	4	7.0%	23.9%[a]	13.4%
	5	18.8%	25.7%[a]	21.4%
	6	42.5%[a]	28.3%	37.1%
	7	28.0%[a]	15.0%	23.1%
Preference for car accessibility** (1=very low; 7=very high)	1	1.1%	2.7%	1.7%
	2	1.6%	1.8%	1.7%
	3	3.2%	0.9%	2.3%
	4	10.2%	10.6%	10.4%
	5	19.9%	23.0%	21.1%
	6	35.5%	36.3%	35.8%
	7	28.5%	24.8%	27.1%
Owned house**	Yes	95.2%	84.3%	91.1%
Age**	Years	59.7	57.1	58.7
Children in the household**	Yes	33.2%	33.0%	33.1%
Income above €3000 Euros (after tax) per month**	Yes	43.3%	27%[a]	37.1%

*Based on respondents who moved into the area before or during the highway construction only, N=225.
**Based on all respondents, N=302.
[a]Significantly higher than reference category.

4 Results

4.1 Descriptive analyses

Table 1 shows that, on average, 61% of the respondents in our dataset relocated to the areas before, 13% during, and 26% after highway development. At first glance, no considerable percentage difference between Son and Uden is apparent. Overall, the majority of respondents who already lived in the area before the new highway experienced a positive influence of the highway development on residential satisfaction (56%). About 25% reported no change in residential satisfaction, and the remaining 19% experienced a decrease in satisfaction. Table 1 also shows differences between the two locations: in Son, a higher percentage of residents indicated a decrease in residential satisfaction, which seems in line with the more negative attitude in Son against the new highway (David-Deventer, 2004; Arts, 1998) prior to project execution. However, also in Son a higher number of respondents experienced an increase - rather than a decrease - in satisfaction. As might be expected, in both locations the majority of residents experienced an increase in accessibility from the highway development.

The results are more mixed however, with respect to the perceived change in liveability. A considerable group of residents reported a liveability decrease, especially in Son. In interpreting the percentages, one should be aware that the evaluation may have been somewhat more negative just after highway construction, since residents with the most negative perceptions could have left in the last seven years. Furthermore, it is important to mention that we have focused on the residential area in Son in close proximity (1 km) to the new A50 highway. The people of Son who lived close to the N265, which was downgraded as a consequence of new highway development, might have been more supportive of the project.

When asked what motivated the change in their residential satisfaction, 131 residents replied to the open-ended question. Most residents in both locations responded that they experienced better accessibility. Regional economic improvement was also reported several times as a reason to positively evaluate the highway development in both Son and Uden. Furthermore, in Son, several residents mentioned the alleviation of the city centre, which had been traversed by the busy N265, as a reason for residential satisfaction increase. Motivations for a decrease in satisfaction were mainly given by respondents living in Son. Most respondents who experienced negative impacts mention (in order of frequency) an increase in noise nuisance, a decrease in access to greenery (especially in Son), increased air pollution, and deterioration of view. In addition, some residents in Son who had arrived just before the highway construction replied that they felt misled by government, as they were unaware of the road plans at the time that they decided to buy their house. In Son some residents explicitly mentioned that, in their opinion, the wrong alternative route was chosen. As mentioned in the case description, the selected alternative was the route passing close by the residential area where we sampled (the second alternative would have incurred an unacceptable level of nature impacts). In Uden some respondents mentioned regret at the loss of several farms in the area due to the highway construction.

4.2 Highway development and the change in residential satisfaction

Table 2 presents the estimation results of our final Structural Equation Model to elaborate the change(s) in residential satisfaction after exclusion of insignificant links. Indirect effects are effects via another endogenous variable, whereas direct effects are direct relationships of independent exogenous variables with the endogenous variables, and total effects are the sum of direct and indirect effects. The final model has an RMSEA of 0.036 and CFI of 0.997. Values below 0.100 for RMSEA and above 0.900 for CFI indicate a good fit (Hair et al., 2006). Below we elaborate on the estimated relationships. First we discuss the included independent exogenous variables, and thereafter we assess the overall importance of the variables in the model.

We find that people living in close proximity of the highway reported a significantly negative association with the change in liveability (and via that, negatively influences the change in residential satisfaction). No significant relationship between highway proximity and perceived accessibility change is found, which might be explained by the notion that accessibility gains are relatively constant within a short distance of the highway (Tillema et al., 2012). However, we do also find a direct positive relationship between distance from the highway and change in residential satisfaction, irrespective of mediating variables. In other words, the highway

development seems to have additional impacts relating to highway proximity, which could not all be covered by a change in perceived accessibility or liveability.

Having a preference for environmental quality is found to influence the change in residential satisfaction via its negative relationship with both the perceived change in accessibility change and liveability. The negative association with perceived accessibility change is surprising, but is potentially caused by a negative attitude of this group towards car transport in general. Similarly, we find that people with a higher preference for good car accessibility reported a higher perceived change in accessibility as well as a higher perceived liveability change, and as such, indirectly experienced a more positive change in residential satisfaction due to the highway development.

We also encountered significant differences in the change in residential satisfaction between the two locations of Son and Uden. In line with expectations, residents in Son reported a more negative change in liveability due to the highway development compared to residents in Uden. Surprisingly, although the study of Levkovich et al. (2016) suggests that travel time to other areas seems to have reduced more in Uden than in Son due to highway development, no differences between the two locations are found with regard to perceived accessibility change. However, our results indicate that residents in Son who lived closer to the highway perceived a slightly weaker perceived change in accessibility than residents in Uden. This may be due to (perceived) fragmentation (Arts, 2004) by sampled residents in Son caused by the construction of the highway on a trajectory close to their homes. Furthermore, we observe a directly negative association with the change in residential satisfaction for Son, independent of the perceived change in liveability or accessibility. The observation could be related to an overall more negative attitude towards highway development in the sampled residential area in Son compared to Uden (David-Dentener, 2004; Arts, 1998).

On the basis of the total effects (the sum of indirect and direct effects) of the improved model, we observe that perceptions of accessibility and liveability change(s) appear to be most important and of comparable strength in explaining the change in residential satisfaction. Nevertheless, the included mediating variables were not able to fully account for the relationships between exogenous variables and change in residential satisfaction: residents in Son and residents living in close proximity to the new highway expressed a significantly direct negative association with residential satisfaction, independent of the perceived change in liveability or accessibility. Fig. 4 graphically depicts the significant relationships.

Table 2 Results for final Structural Equation Model on change in residential satisfaction.

	Perceived accessibility change	Perceived liveability change	Residential satisfaction change		
	Direct/Total effect (St.B)	Direct/Total effect (St.B)	Direct effect (St.B)	Indirect effect (St.B)	Total effect (St.B)
Perceived accessibility change			0.523***		0.523***
Perceived liveability change			0.483***		0.438***
Preference for environmental quality	-0.191*	-0.179*	-	-0.177**	-0.177**
Preference for car accessibility	0.364***	0.268**	-	0.309***	0.309***
Distance from highway	-0.019	0.193**	0.166***	0.071	0.237***
Location: Son (ref: Uden)	0.041	-0.249***	-0.255***	-0.096	-0.351***
Preference for environmental quality x Son	-	-	-	-	-
Preference for car accessibility x Son	-	-	-	-	-
Distance from highway x Son	0.148*	-	-	0.056*	0.056*

N=225; Chisq=5.323; RMSEA<0.036; CFI=0.997; SRMR=0.024.
St.B.=Standardized Beta.
*** p<0.01, ** p<0.05, * p<0.1.
- Not included in final model, because not significant.

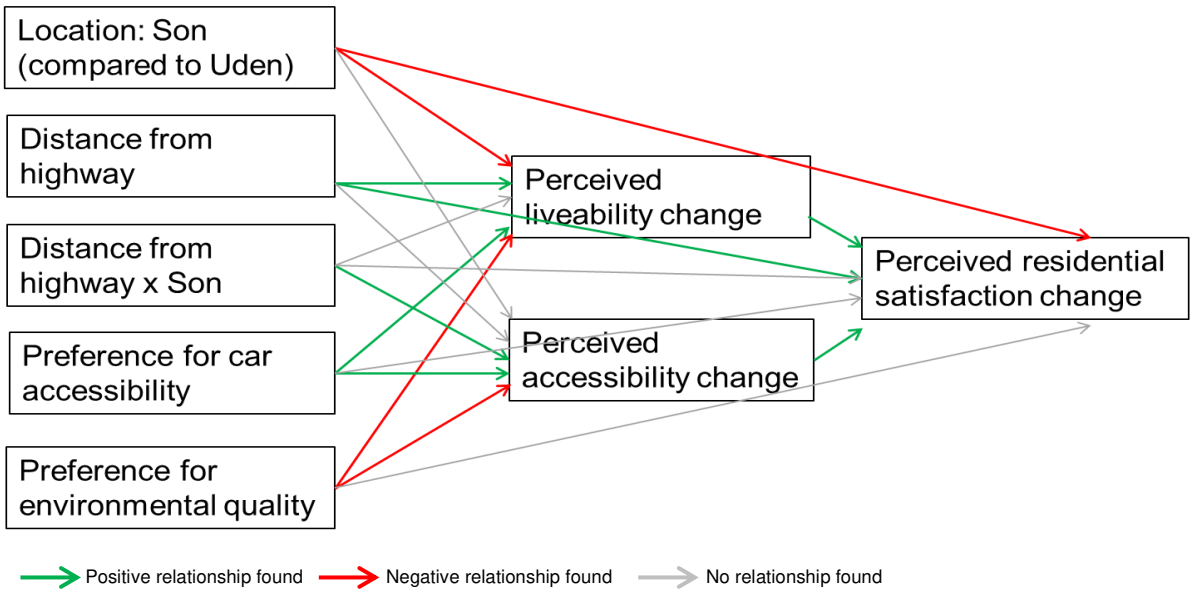

Figure 4 Significant relationships with change in residential satisfaction.

4.3 Highway development and potential residential self-selection

Table 3 presents the estimation results of the Multinomial Logistic Regression to explore differences between the original population and, respectively, the residents arriving during and after highway development.

We detect differences between the original population and residents who arrived after the highway project, but not for the people who relocated during the anticipation period. Although we find no indications for a relationship between highway proximity and the time (moment) of relocation to the area, our results show that people who relocated into the area after the highway construction have a slightly higher preference for car accessibility and a lower preference for environmental quality compared to the original population. Nevertheless, the differences in preferences of both groups appear to be quite small; this may partly be due to the relatively small sample used for the analysis, but could also be explained in other ways. First, the people with the strongest mismatch in preferences due to the new highway development might have already left the area. Second, the original population might have adjusted their preferences somewhat to the new situation, which may suggest an impact of the built environment on behaviour (Cao, 2007; Bohte, 2010; Silva, 2014). In addition, the fact that we do not find an increased highway-oriented profile for people who had relocated during the highway development may also be influenced by a prior underestimation of the negative effects of the highway development by the residents who chose to move into the area during the anticipation period (Levkovich et al., 2016).

Furthermore, although no general differences between Son and Uden are found with regard to the time of relocation into the area, some interaction effects are (almost) significant. The interaction effect between Son and distance to highway indicates that there were relatively more residential relocations in Son in closer proximity to the A50 highway as a consequence of its construction, compared to Uden. Moreover, although 'just under significant at the 10% level,' the interaction effect between Son and the preference for environmental quality

suggests a stronger difference in preferred environmental quality between the original population and residents arriving after highway development in Son. Both findings imply that, in Son, differences between the original population and the arrivals post-highway development, are larger.

In sum, although anticipation effects were not revealed, we do find small differences between residents who arrived before and after the A50 highway development. This gives us first indications for residential self-selection into a more highway-oriented population over the long-term. Fig. 5 presents a graphical overview of the significant relationships.

Table 3 Results for MLR on time of arrival into the area.

Ref: Relocated into area before 2000 (=0)	**Unst. B**	**Wald**	**Exp**	**95% Conf. interval**	
				Lower	**Upper**
Arrived in area between 2000 and 2004 (=1)					
Intercept	4.397	7.202			
Preference for environmental quality	0.400	2.353	1.492	0.895	2.489
Preference for car accessibility	-0.158	1.013	0.854	0.628	1.161
Distance from highway	0.000	0.099	1.000	0.997	1.002
Location: Son	0.284	0.297	1.328	0.479	3.684
Preference for environmental quality x Son	0.469	0.936	1.599	0.618	4.137
Preference for car accessibility x Son	-0.511	2.371	0.600	0.313	1.149
Distance from highway x Son	0.001	0.436	1.001	0.997	1.006
Owned house	-1.562**	3.031	0.247	0.051	1.192
Age	-0.090***	13.211	0.919	0.878	0.962
Children in household	0.075	0.092	1.186	0.395	3.557
Income above €3000 (Euros)	-0.391	0.572	0.708	0.289	1.734
Arrived in area after 2004 (=2)					
Intercept	8.951***	37.413			
Preference for environmental quality	-0.317*	3.076	0.728	0.511	1.038
Preference for car accessibility	0.280*	2.873	1.323	0.957	1.828
Distance from highway	-0.001	0.862	0.999	0.997	1.001
Location: Son	0.515	1.636	1.674	0.760	3.689
Preference for environmental quality x Son	-0.471	1.732	0.625	0.310	1.259
Preference for car accessibility x Son	-0.300	0.757	0.741	0.377	1.457
Distance from highway x Son	-0.005**	5.933	0.995	0.992	0.999
Owned house	-1.927***	7.972	0.146	0.038	0.555
Age	-0.143***	47.142	0.867	0.832	0.903
Children in household	-0.555	1.368	0.574	0.227	1.455
Income above €3000 (Euros)	0.039	0.010	1.040	0.478	2.263
N=302; Nagelkerke Rsq=0.495					

Unst.B.=Unstandardized Beta.
*** p<0.01, ** p<0.05, * p<0.1.

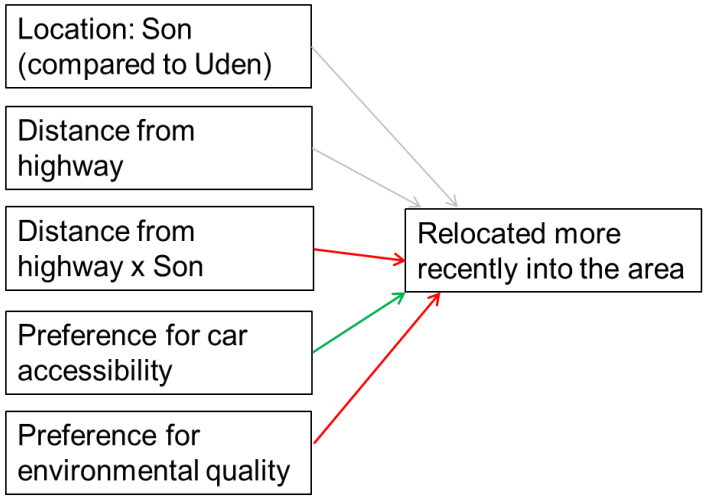

Figure 5 Observed relationships with time of arrival in the area.

5 Discussion and Conclusions

Although several authors have studied highway development from the perspective of house price, fewer specific insights into highway development effects are available from a residents' perspective. In this paper we have analysed the impact of the development of a new highway on residents using questionnaire data collected from residents living in close proximity to highway A50 in two residential areas in the Netherlands, Uden and Son. We: 1) analysed the extent to which residents perceived this highway development has influenced residential satisfaction, and 2) explored differences between the original population and residents who arrived during or after highway development who might have other characteristics influenced (potentially) by residential self-selection as a consequence of highway development. Our analyses report variations in the perceived effects of highway development on residential satisfaction among different residential groups, and provide (first) indications for differences between the original and recently relocated population potentially due to residential self-selection. Let us next elaborate our main findings.

With regard to our first aim, a small majority of residents experienced a positive effect of the A50 highway on their residential satisfaction in both residential areas seven years after its development. Especially in Son this presents a more positive perspective than might have been expected, given the protest against the new highway prior to its development. This positive finding may indicate a potential difference between the more 'silent' majority of residents and the active minority who opposed the highway development (Hamersma et al., 2016). However, other reasons can also be considered, such as an overestimation of potential negative effects prior to highway development (Kahneman and Tversky, 1979); habituation to negative effects or relocation of residents with the most negative perceptions. Nevertheless, the group of residents who experienced negative perceptions on residential satisfaction was still approximately 20% seven years after the A50 highway development. As such, our results also reveal that the overall effects on residential satisfaction are somewhat less positive for at least some groups of residents than suggested in Levkovich et al. (2016) who indicated an overall increase in house price in the same research area. The implication here is that house price analyses may not entirely reflect the full range of perceived impacts of highway development on original residential populations.

Our study shows that the perceived changes in residential satisfaction are best explained by perceived changes in accessibility and liveability. That perceptions are important is in line with other studies (Buys and Miller, 2012; Hur and Morrow-Jones, 2008; Hamersma et al., 2014). Our results indicate that residents in close(r) proximity to the new highway, with a lower preference for car accessibility and higher preference for environmental quality, perceived a more negative change in residential satisfaction – mostly via a negative mediation with perceived accessibility and/or liveability change. Nevertheless, also a direct relationships between highway proximity and the change in residential satisfaction was found, irrespective of mediating variables. This finding indicates that, although being the main explanatory variables, the perceived change(s) in accessibility and liveability were not able to account for all the perceived effects caused by the highway development on close proximity of the project.

With regard to our second aim, although we found no significant different preferences between the original population and people who relocated into the area *during* the construction of the highway, we did observe a slightly higher preference for car accessibility

and lower preference for environmental quality in residents who relocated into the area *after* the A50 highway construction. This finding suggests a process of residential self-selection towards a population with a somewhat more highway oriented profile and thus corroborates with studies who suggest that people base their location choices at least partly on travel preferences or their sensitivity to environmental quality (Van Wee, 2009; Cao et al., 2009; Arsenio, 2006; Thanos et al., 2014; Boes et al., 2013), although differences between both groups appeared small.

Furthermore, we have found specific differences between the two residential areas. We observe a more negative change in perceived liveability and residential satisfaction, and a higher number of re-locators in close proximity to the new highway in Son, compared to Uden. This might be explained by the fact that residents in Uden had already become accustomed to living close to a busy road compared to the Son population, and had also experienced negative effects from the prior build of the N265. The aforementioned specific findings illustrate that the characteristics of residential areas indeed play a role in the clarification of highway development effects.

Although acknowledging the fact that studying additional cases might be worthwhile, the insights of the present case study contribute to existing literature in at least three ways. First, the fact that our findings with regard to the impacts on self-reported residential satisfaction change deviate from the findings regarding the change in house prices in the same research area (Levkovich et al., 2016) underlines the importance to take account of residents' perceptions when aiming to better understand the implications of highway projects on residents. Second, the findings of the study stress the importance of having a broader perspective accounting for both accessibility and liveability impacts in understanding the implications of highway projects, the latter going beyond noise and air pollution only. This also places NIMBY opposition in a broader societal context and underlines the importance of including opinions of the wider community in order to draw more general conclusions on the impact of highway development. Third, the present study contributes to the broader branch of research on self-selection mostly looking at self-selection in either the context travel behaviour (Cao et al., 2009; Naes, 2009; Nijland et al., 2007) or environmental nuisances (Nijland et al., 2007; Thanos et al., 2014; Boes et al., 2013; Arsenio et al., 2006), by showing how highway development could trigger self-selection both with regard to car accessibility as well as environmental quality. The fact that we only find small differences between the original population and new residents may be influenced by data limitations. Nevertheless, it may also suggest that 1) people who were most negative about the highway development have already left and thus the original population is a selection of people 'bearing' highway development, or 2) the original population has changed their preferences as consequences of highway development towards a more highway oriented profile. This might imply that highway development simultaneously triggers a process of self-selection as well as a change in the original population, which has also been suggested by other studies (see e.g. Cao et al., 2007; Silva, 2014).

The present study highlights several aspects which could be investigated in future research. Our study has focused on highway development in a relatively highly densely populated country with well-developed infrastructure – i.e. the Netherlands. However, it may be worthwhile to study the extent to which the results differ in countries with less-developed infrastructure networks. Along the same lines, it might be of added value to study differences between the impact on different residential areas or residential groups, or to further

differentiate among other types of highway projects, so that we may broaden our understanding of the implications of highway developments for residents. In addition, the present study stresses the importance of accounting for perceived environmental changes in understanding the impact of highway development on residential satisfaction, but the authors have also shown that, despite their importance, our included measures of perceived accessibility and liveability change were not able to fully mediate all the relationships in the model. An extension of the present research would be a qualitative study enquiring into why residential satisfaction became more negative at closer proximity to the A50 highway and in Son than was expected based on perceived changes in accessibility and liveability. Furthermore, the authors have investigated the effects of highway development by asking residents about their perceived changes in residential satisfaction seven years after the highway development was completed. By using a self-reported measure and ask people to reflect back in time it was possible to directly grasp people's perception about changes due to the project. Nevertheless, self-reported residential satisfaction change might also be influenced by factors such as a resident's (lack of) memory, present mood and (political) support for the project (Coglianeze, 2003; McDonald, 2008; Cao et al., 2009) and might therefore not totally reflect the 'true' change in residential satisfaction. To better understand how residential satisfaction has developed over time, it might also be interesting to conduct quasi-experimental studies on the changes in residents' satisfaction on different other moments in time, such as just before and after highway development. Finally, related to that, the authors have also explored differences between the original population and residents who had recently relocated into the area as an indicator for residential self-selection, but our dataset did not allow us to draw firm conclusions due to its limitations. Following other studies into the role of residential self-selection (e.g. Cao et al., 2009; Nijland et al., 2007; Van Dijck et al., 2011), we suggest that our results can be further elaborated by for example, 1) studying the reasons for moving or relocating into the area by a qualitative study design, 2) including a control case to better estimate the effect of highway development, or 3) using a longitudinal design taking measurements before and after highway development and analyse a potential change in preferences among the original population while taking account of preferences of the newly arrived population. In this way the role of self-selection as a consequence of highway development could be further understood.

The findings of this study suggest different implications for highway infrastructure planning. For example, our research paints a fairly positive picture of the effects of highway development on residential satisfaction, more than one might have expected based on the initial opposition in Son (Arts 1998, David-Dentener 2004). The implication here is that the broader residential community seems to trade-off negative environmental changes with positive accessibility gains of highway development, and may not always reflect the opinions of the group actively giving voice against highway development. Nevertheless, there was a group of residents who were less-than-satisfied with the highway development. In addition, a significant group of respondents felt that liveability decreased because of the highway development, indicating that, despite current efforts to mitigate and compensate impacts of highway development, additional efforts could still have been taken, especially in areas closest to the highway development were effects appeared to be clearly the most negative. Furthermore, our analysis showed a difference in characteristics between the original population and more recently-relocated residents, which may be a sign of residential self-selection due to highway development. Although there may of course be many other reasons why people choose to live in a specific residential area other than highway proximity, it may

be valuable to account for differences between the planning of new development and redevelopment projects. In new developments, stronger negative impacts may be perceived, since self-selection based on highway development has not yet occurred. Overall, our findings suggest clear differences within the broader residential population in their perceptions towards highway development. It might therefore be worthwhile to consider whether and when it is valuable to collect the values and preferences of residents much more widely, for example via written, electronic and verbal assessments (Stolp, 2002). By doing so, decision-makers could facilitate increased understanding of why and when liveability and accessibility perceptions are (not) perceived as such. We think that, in this way, higher residential satisfaction of living close to highways can be reached over the long-term.

Acknowledgements

This research is funded by Rijkswaterstaat, Dutch Ministry of Infrastructure and the Environment.

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