Explaining residential moving intentions:

the case of highway locations

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SAMENVATTING

Mensen die nabij snelwegen wonen, kunnen worden beïnvloed door zowel positieve (bereikbaarheid) als negatieve (geluid, luchtverontreiniging, barrière-effecten) snelweg externaliteiten; beide worden (mogelijk) afgewogen met andere woonkenmerken in verhuisintenties. Aan de hand van in 2011 verzamelde enquête data op een zevental snelweglocaties (<1000 meter afstand) in Nederland testen we een theoretisch framework wat de verhuisintentie op snelweglocaties beschrijft. Hierbij maken we gebruik van Structural Equation Modeling (SEM). Het doel van de analyse is tweeledig. Ten eerste onderzoeken we hoe snelweg externaliteiten de verhuisintentie beïnvloeden. Dit kan zijn direct of enkel indirect via de woontevredenheid. Een directe relatie zou daarbij betekenen dat bereikbaarheid dan wel hinder direct de verhuisintentie beïnvloeden, ongeacht de tevredenheid met de woonomgeving in het algemeen. Bij een indirect effect beïnvloeden beide enkel de verhuisintentie via een effect op de woontevredenheid. Het tweede doel is te kijken hoe negatieve externe effecten worden afgewogen met bereikbaarheid en overige woonkenmerken. Beide kunnen het effect van negatieve externe effecten op verhuisintenties compenseren (er tegenop wegen) dan wel waargenomen negatieve effecten direct beïnvloeden. Inzicht in deze doelen is relevant voor beleid in het nadenken over mitigatie voor negatieve effecten, om daarmee de leefbaarheid te verbeteren alsmede bewonersprotest te verminderen.

De resultaten laten zien dat verhuisintenties in de geanalyseerde snelweglocaties niet veel afwijken van andere gebieden in Nederland. Positieve en negatieve snelweg externaliteiten beïnvloeden verhuisintenties enkel indirect via de woontevredenheid. Hierin zijn negatieve externe (met name geluids-) effecten belangrijker dan bereikbaarheid, hoewel een lage filefrequentie (via de woontevredenheid) de verhuisintentie vrij sterk verminderd. Een aantrekkelijk bebouwde en verkeersveilige woonomgeving zijn minstens zo belangrijk als negatieve externe effecten in de verklaring van verhuisintenties. Mensen die tevreden zijn over de net genoemde woonkenmerken hebben daarnaast ook een direct lagere hinderbeleving. Een hoger bereikbaarheidsniveau (dichterbij een toerit, minder vaak in de file of meer tevreden over bereikbaarheid) lijkt de beleving van geluid, lucht en barrière-effecten niet direct te verminderen. Wel ervaren mensen die bewust hebben gekozen voor een snelweglocatie (waarschijnlijk omdat respondent of partner de snelweg gebruikt) minder hinder.

Praktisch gezien geeft het feit dat verhuisintenties relatief laag zijn aan dat negatieve snelweg externaliteiten de verhuisintentie niet lijken te domineren. Inrichting van de woonomgeving lijkt hierbij een belangrijke rol te spelen, zowel wanneer we het hebben over het verminderen van stress rond negatieve effecten als wel het compenseren voor negatieve externaliteiten. Investeringen in bereikbaarheidsverbetering (vermindering files) kunnen bijdragen aan een lagere verhuisintentie en daarmee compenseren voor negatieve effecten, maar verminderen niet direct de hinderbeleving.

1.INTRODUCTION

Highways have a controversial impact on society. They are associated with economic prosperity as they make it possible to reach activities in a regional context. However they also cause negative environmental effects (noises, air pollution and barrier-effects). The duality between positive (i.e. accessibility gains) and negative externalities (i.e. nuisances) becomes particularly evident at residential areas close to highways. People living close to highways have to deal with the negative externalities of highways which may be perceived undesirable. They may drive them to protest or even to consider moving. However simultaneously accessibility gains as a consequence of highway proximity may be highly appreciated provided an access lane is close by. Negative highway externalities may so be traded off with accessibility gains and other residential characteristics in residential moving.

For highway infrastructure planning, insight into residential moving at highway locations is valuable. Moving could be seen as a final reaction to residential stress (e.g. Speare, 1974; Rossi, 1955). Studying moving close to highways thus gives insight in the size of the impact (changes in) highway externalities could have on residents. Moreover, knowledge about the way negative highway externalities are traded off with accessibility and other residential characteristics could help planners in thinking about effective *mitigation* policy; it gives indications about to what extent (investments in) accessibility and other residential characteristics could countervail the effect of negative externalities on residential moving. Certain insights could be used to improve liveability i.e. relieve residential stress and consequent highway project delays.

Despite this societal relevance, we are not aware of studies focusing on the relation between highways and moving taking account of the relationships just described. A limited number of studies looking into the impact of highways on residential moving mainly looks into the effect of negative externalities, while not (empirically) accounting for potential countervailing effects.

That accounting for countervailing effects of accessibility and residential characteristics on highway nuisances is relevant becomes clear from a recent study on residential satisfaction. Hamersma et al. (2013) found that although negative highway externalities are important, (highway) accessibility and other residential characteristics have comparable and so counterbalancing impact. Studies on residential moving emphasize the important role of residential satisfaction; many contextual factors impact residential moving mainly via their effect on residential satisfaction(e.g. Speare, 1974). This may also be the case for highway externalities.

In this paper we aim to study relationships of *positive* and *negative* highway externalities on residential moving close to highways. In this we take account of the mediating role of residential satisfaction. Moreover we aim to study how negative effects of highways are traded off with accessibility gains and other residential characteristics in residential moving. Accessibility and residential characteristics (when appreciated) could be of comparable importance in moving intentions and so *counterbalanc*e negative highway effects. Moreover they could *directly relax* nuisance annoyance. We choose to study *moving intentions* instead of moving behavior as it gives better insight into emotional reactions as a consequence of highways; certain groups of residents may have the intention to move while not making the actual move because of costs perceived (e.g. Lu, 1999).

2. THEORETICAL FRAMEWORK

This section will discuss relevant research to build our theoretical model to assess moving intentions at highway locations. Section 2.1 introduces residential moving research and the

mediating role of residential satisfaction. Subsequently section 2.2 focusses on highway locations and moving intentions.

2.1 What makes us move

The question why people move has triggered researchers for decades. From a more or less economic point of view, Lee (1966) and Sjaastad (1962) described the moving decision as the trade-off between (perceived monetary) costs and benefits of the current and potential future location. When costs of staying are (perceived to be) too high, people may decide to move. Other studies acknowledge that this decision to move or stay is not solely derived from an evaluation of perceived monetary costs, but that there are also non-monetary costs involved (e.g. Goldstein, 1958). Rossi (1955, p. 225/226) describes the decision to move as a reaction to stress by a change in needs, aspirations or satisfaction. Mobility is used as an adjustment to housing needs. However, we have to keep in mind that the decision to move is not always similar to the intention to move; although there may be a high intention to move, people may decide not to make the actual move because of different costs perceived (e.g. Coulombel, 2011).

Speare (1974) built on these theories and hypothized that people will only consider moving when their residential satisfaction is below a certain threshold level, at least when it is a voluntary choice. His empirical model in which he tested the proposed relationship between contextual factors (in which he distinguished between socio demographic characteristics, location characteristics and social bonds), residential satisfaction and residential moving indeed confirmed these ideas. He showed that except for an independent effect of home ownership, residential satisfaction is a key factor in residential moving; contextual factors mainly impact the move *indirectly* via their impact on residential satisfaction.

After Speare, the proposed relationship between (varying objective and subjective) contextual factors, residential satisfaction and moving is several times studied by others and several variables were tested. Lu (1998) gives a summary of these studies and concludes that the conclusion of Speare may be somewhat overstated: although satisfaction is of main importance, some contextual variables are also found to have an independent relation with the intention to move. Next to house ownership, unlike Speare (1974) socio demographic aspects like having an older age, a lower income, a lower education and a larger family size are often found to negatively affect moving intentions independent of residential satisfaction (e.g. Lu, 1998; Deane, 1990; Landale and Guest, 1985; Mc Hugh et al., 1990). Regarding social bonds, having longer house tenure is often found to directly reduce moving intentions. With respect to proximity to friends and family mixed effects are found (e.g. Speare, 1974; Landale and Guest, 1985). Regarding location characteristics, aspects like neighborhood problems and environmental quality are sometimes found to have direct impact (Lee et al., 1994; Osada et al., 1997). Nevertheless we should note that except for Speare (1974), Osada et al. (1997) and Mc Hugh et al. (1990) most of these studies used mainly regression or logit models to test direct effects of contextual factors alongside residential satisfaction on explaining residential moving intentions. This means that they do not account for the fact that in some occasions direct effects of contextual factors on moving intentions may be outweighed by indirect effects via residential satisfaction in the opposite direction.

2.2 Highway locations and moving: building up a conceptual framework

Some studies give indications about the impact of highways on moving intentions and potential trade-offs with accessibility and other residential characteristics. Section 2.2.1 describes the relation between highway externalities and moving intentions. Section 2.2.2 discusses relative

importance of factors (*counterbalancing* nuisances) in residential moving. Section 2.2.3 discusses factors that (may) *relax (or increase)*nuisance annoyance. Finally section 2.2.4 presents a conceptual framework to assess moving intentions at highway locations.

2.2.1 Highway locations: Direct and indirect relations with moving intentions

Although residential moving at highway locations is scarcely studied, some studies give indications about the question whether the relation between the highway and residential moving is direct or (mainly) indirect (over residential satisfaction).

- Nuisances: We are aware of one study specifically studying the relationship between noise nuisance and moving intentions while taking account of residential satisfaction. Osada et al. (1997) looked into the impact of noise annoyance on residential dissatisfaction and moving intentions. They studied this for women with at least three years of house tenure living along a trunk road in Tokyo, by use of path analysis. Their conclusion was that noise annoyance had a direct effect on moving intentions alongside environmental dissatisfaction (which was found most prominent), house structure and house tenure duration. Objective noise exposure did not affect the move directly, but only contributed in explaining noise annoyance. Related to this, studies looking into direct relations between objective environmental effects and moving also in general report that the relationship between objective exposure and residential moving is not straightforward (e.g. Nijland et al., 2007).

  Additionally although more general, some studies included variables relating to environmental problems. Lu (1998) found a direct positive relation between his variable 'bother' -measuring whether people found something bothersome about the neighborhood such as noise, traffic, litter and poor public services- and the intention to move after having corrected for residential satisfaction, by use of logit models. Also using logit models, Lee et al. (1994) found a marginal direct relation between the number of reported problems in the neighborhood (among those litter, noise, crime, commercial activities) and moving thoughts, independent of the overall rating of the neighborhood.
- Accessibility*:* Speare (1974) assumed residential satisfaction to be built up from among others satisfaction with distance to schools, shops and work and concluded these aspects not to have direct impact on the wish to move among residents in Road Island.

  Although not specifically looking into direct and indirect effects, several other studies argue that the impact of accessibility on residential moving considerations is limited and seemed to have decreased in the last decades (e.g. Giuliano, 1989). Molin and Timmermans (2002) conclude that the direct living environment seems to generate as much utility to people, on average, than the disutility of necessary travel. However, other studies find that groups of people may still highly value travel costs and time in their residential location decision (e.g. Tillema et al., 2010).

2.2.2 Highway locations: counterbalancing nuisance annoyance in moving intentions

Some studies give indications supporting the fact that nuisances could be counterbalanced by other residential factors in residential moving. Nijland et al. (2007) studied potential self-selection of noise sensitive people into lower exposure areas. They did not find prove for self-selection to occur. One of their explanations is that other neighborhood amenities prevent people from moving elsewhere. Rohrmann (1991) concludes that noise effects are outweighed by factors relating to type of house and work when it comes to moving decisions.

Although not studying moving intentions, Hamersma et al. (2013) looked into the relative importance of highway externalities versus residential characteristics in residential satisfaction close to highways. They concluded that accessibility measures (perception as well as actual

usage) as well as other residential aspects could (partly) counterbalance negative highway externalities in residential satisfaction.

2.2.3 Highway locations: relaxing (or increasing) effects nuisance annoyance

Theories on environmental perception emphasize the difference between the objective environment people encounter and the way they experience this environment (e.g. Kirk, 1964). With respect to noise annoyance, studies conclude that there is no one to one relationship between actual exposure and perceptions (e.g. Schreckenberg et al., 2010); other factors may relax (or increase) nuisance perception.

The effect of socio-demographics (see for an overview Miedema and Vos, 1999) and noise barriers (e.g. Join and Kang, 2010) on noise annoyance is widely studied. We are not aware of studies looking into the relation between the (perceived) level of accessibility and nuisance annoyance. What we do know is that users of a polluting source and people being dependent on a polluting source seem to be less annoyed by it (e.g. Kroesen et al., 2010; Miedema and Vos, 1999). Also relationships between other residential characteristics and nuisance perception are scarcely studied. We do know that greenery is in general found to relax annoyance (e.g. Li et al., 2010; Gidlöf-Gunnarsson and Őhrstöm, 2007). However, it is also found that green noise barriers are, although more appealing, perceived to be less helpful in reducing noise compared to opaque ones (Join and Kang, 2010).

2.2.4 Theoretical model: moving intentions at highway locations

Figure 1 presents the theoretical model to assess moving intentions at highway locations. We used the original model as proposed and tested by Speare (1974) and other researchers (see Figure 1) as a basis and extended it for our research purposes.[1]

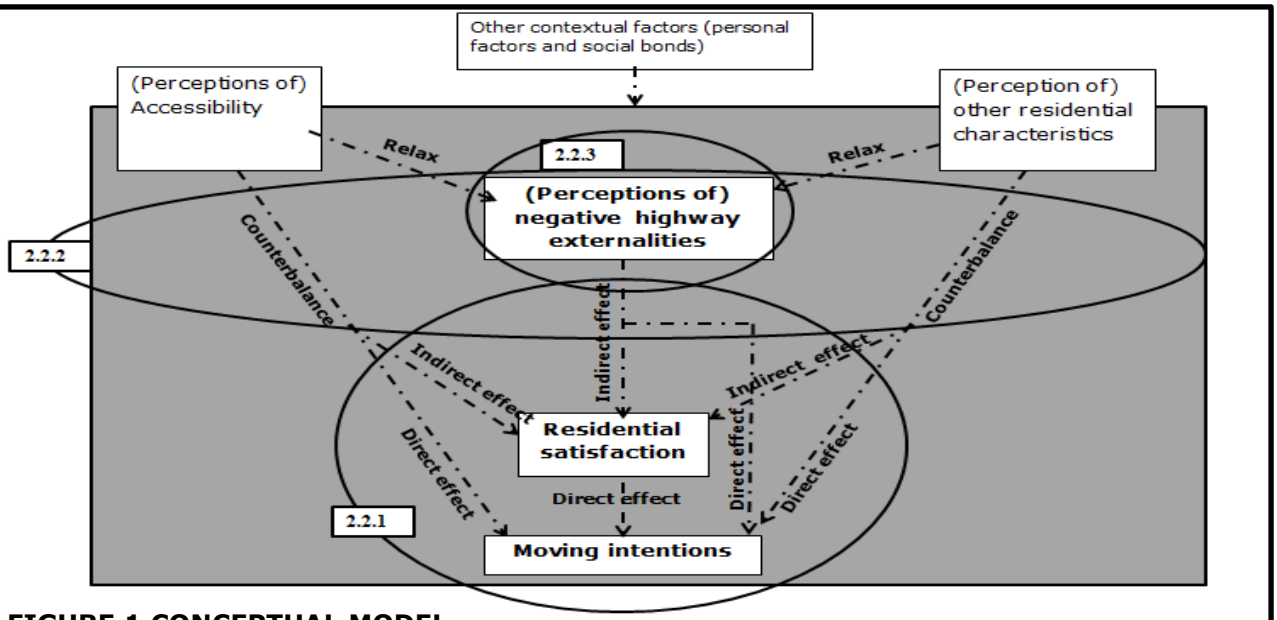

FIGURE 1 CONCEPTUAL MODEL

In the model highway externalities are included alongside residential characteristics (and other contextual factors). Both subjective and objective measures are included.

[1] Although perceptions of accessibility and other residential characteristics are in theory also based on interactions between personal characteristics and the environment, we will not empirically test these linkages as it is not our main research focus.

- Direct and indirect effects on moving intentions (as discussed in section 2.2.1). All contextual variables in the model are allowed to impact moving intentions either directly and indirectly via residential satisfaction.
- Relative importance (counterbalancing) in moving intentions (as discussed in section 2.2.2). The effect of negative highway externalities could be counterbalanced by (highway) accessibility and other residential characteristics (when appreciated), having an opposite effect on moving intentions.
- Relaxing (or increasing) effects on nuisance annoyance (as discussed in section 2.2.3). Accessibility and other residential characteristics are also allowed to impact perceptions of negative externalities directly. By that they could directly reduce annoyance.

We control for other contextual variables (socio-demographics and social bonds).

3. DATA AND METHOD

This section presents the operationalization of our research. Section 3.1 presents the data-collection, followed by a description of the method (Section 3.2) and the included variables (Section 3.3). Finally in Section 3.3 the descriptive statistics of the main variables in our analysis will be described.

3.1 Data collection

To study the theoretical model a in highway context (Figure 1), data were collected by a questionnaire set out at seven highway locations in the Netherlands in 2011, a high population-dense country with a well-developed transport network. The selected locations are geographically spread through the Netherlands and are all within one kilometer of a highway. This radius is chosen for two reasons. First, studies indicate that noise effects seem to fade away at a distance of 300-600 meters from a highway *(*Eliasson, 2005; Nelson, 1982). Second, to get enough variation in exposure levels, we extended the distance to 1,000 meters. In total 5,500 questionnaires were manually distributed, from which 1396 were received back, which means a response rate of 25%. The response was found representative with respect to distance from the highway (respectively 22.7% within 0-300m; 27.2% within 300-600m and 23.1% within 600-1000m from the highway) and neighborhood composition (based on gender, household composition and age).

With the questionnaire, subjective evaluations of the neighborhood, residential satisfaction and moving intentions were collected, supplemented with background characteristics regarding the individual, the house and the exact residential location. Based on the latter, the distance between the 6-digit zip code and the highway and highway access lane were calculated. Also noise and air exposure levels were linked in this way. Finally the average house price in the neighborhood was linked to the dataset.

3.2 Method

We applied a Structural Equation Modeling (SEM) approach to test the theoretical model by use of LISREL. In assessing the fit of the model, we will focus on the Root Mean Square Error of Approximation (RMSEA) and the Comparative Fit Index (CFI), being the most popular fit measures (Ullman and Bentler, 2003).

3.3 Variables

A SEM model consists of Endogenous (dependent) and Exogenous (independent) variables (Hair et al., 2006). The Endogenous variables are explained by other factors in the model, while Exogenous variables are explained by factors outside the model. We can distinguish between observed and latent variables, whereby the former stands for itself whereas the latter is constructed from two or more indicator variables (Ullman and Bentler, 2003).

- Endogenous variables*:* The estimated model consist of five endogenous variables. The first three are all relating to negative highway externalities; following Tillema et al. (2012) we distinguish between perceived highway noise, air pollution and barrier-nuisance. The other two are respectively residential satisfaction and moving intention. Regarding negative highway externalities, factor analysis was performed prior to the analysis to check the reliability of hypothized latent constructs. Based on this, ´perceived highway noise´, ´perceived air pollution´ and ´perceived barrier-effect´ nuisance were found to be separate constructs, formed by respectively four, four and three indicators. Although the latent construct 'perceived barrier effects' is not that strong (relatively low estimates, see Table 1), it was decided to not exclude indicators from the construct as this decreased model fit. 'Residential satisfaction' was built up by house and neighborhood satisfaction; both aspects are found to be highly correlated (Correlation of 0.6). The construct 'Moving intention' was formed by two variables (i.e. a one about the moving intention within 2 years and one about willing to move in general.
- Exogenous variables: Accessibility-related measures, objective exposure, residential characteristics and control variables (i.e. socio-demographics and social bonds) are included as exogenous variables in the model to explain and to control (see Table 2). With respect to accessibility perceived as well as objective accessibility level related measures are included. One perceived variable measures satisfaction with accessibility of the residential location. We are aware that this could incorporate more than only highway accessibility, however we could assume that the highway has an important contribution. We have more specific information about perceived highway accessibility by car only for working respondents based on our questionnaire. An additional model for working respondents with inclusion of the perceived home to work accessibility by car variable is therefore estimated (see also Table 2). Next to perceived measures more objective accessibility-level measures are included. Traffic jam frequency is included as a dummy, being '1' when the respondent is frequently stuck in traffic jams and '0' otherwise. Moreover we included the 'distance (in meters)' between the residential location and the nearest access lane. Additionally we added a variable indicating whether people had a prior 'preference to live near a highway' (as proxy for household highway-usage), which was measured on a scale of '1' ('no preference') to 7 ('high preference'). Finally we included the 'attitude towards car driving' on a 1-7 scale ('1' indicating a negative attitude and '7' a very positive attitude'). The latter is included as a latent construct, as we had specific statements with sufficient correlation to make a construct on this aspect.

  With respect to negative highway externalities we included three exogenous variables, being the noise exposure level the resident is exposed to (in decibels), the level of air-pollution exposure (NO^2 in ug/m^3) and the distance from the highway.

  Regarding residential characteristics we included the 'average house price in the neighborhood' (obtained from Statistics Netherlands) as well as people's subjective evaluations of the 'traffic safety', 'attractivity of buildings', the 'amount of greenery', the 'facilities' and the 'number of parking slots' in the neighborhood. Subjective neighborhood variables were all measured on a '1' (very negative) to '7' (very positive) scale.

Additionally control variables were added. The perception of the 'number of contacts'(1-7 scale) as well as objective 'tenure duration' (years living in the house) were included to measure social bonds. In line with other studies looking into the relationship between context, satisfaction and moving (e.g. Speare, 1974; Lu, 1999; Lee et al., 1994), we included, household composition, gender, education, income and house ownership as socio-demographics in our model.

TABLE 1 Descriptive statistics endogenous variables and factors scores constructs[b]

Construct	Made of	Mean	Estimate
Total of respondents N=1225			
Moving intentions (2x)	*I want to move in 2 years from now[a]	2.6	0.50
	*If possible, I will move from this neighborhood[a]	2.3	0.90
Residential satisfaction(2x)	*I'm satisfied with my house[a]	5.9	0.51
	*I'm satisfied with my neighborhood[a]	5.7	0.74
Perception Noise nuisance (4x)	*I hear noise from the highway when I'm inside my house[a]	2.6	0.80
	*I'm concerned about the effect of noise of highway traffic on my health[a]	2.6	0.54
	*I perceive noise annoyance from highway traffic when I'm inside my house[a]	2.1	0.93
	*I perceive health problems from noise of highway traffic[a]	1.7	0.75
Perception Air nuisance (4x)	*The air quality in my neighborhood is bad[a]	3.3	0.71
	*I'm concerned about the possible effect of pollution on my health[a]	3.5	0.78
	*I perceive annoyance from pollution of highway traffic when I'm inside my house[a]	2.1	0.79
	*I perceive health problems because of the pollution of highway traffic[a]	2.1	0.76
Perception Barrier nuisance (3x)	*The highway is a barrier; it is difficult to reach the other side[a]	1.9	0.16
	*The highway is insufficiently integrated in the landscape[a]	4.3	0.38
	*The highway is ugly[a]	4.2	0.56

[a](1=totally not agree; 7=totally agree)
[b]Descriptives of the exogenous variables could be provided by the authors on request

3.4 Descriptive statistics

Before we explain relationships, we first describe the means of our main variables on a 7-point scale. Table 1 shows that generally speaking the intention to move is modest close to highways (mean ≈ 2.5, see Table 1) and not different from the average Dutch household (e.g. Blijie et al., 2012). Moreover people seem to be quite satisfied in the researched areas (mean of respectively 5.9 and 5.7 for respectively house and neighborhood). They seem to only modestly perceive negative externalities. They are comparably annoyed by noise and air (mean of respectively 2.1 and 2.1), but are slightly more concerned and have somewhat more health problems regarding air pollution. In general people do not really see the highway as a barrier in the landscape (mean=1.9). However, residents are on average less positive about the integration of the highway in the landscape (mean=4.3) as well as its physical appearance (mean=4.2).

4. RESULTS

This section presents the results of the structural equation model. Subsequently we discuss the model fit (Section 4.1), direct and indirect effects on moving intentions (Section 4.2), counterbalancing effects in moving intentions (Section 4.3) and relaxing effects on nuisance annoyance (Section 4.4). We describe significant effects with at least 0.05 confidential alpha-level.

4.1 Model fit

The estimated model shows a reasonable fit (Table 2). The Root Mean Squared Error of Approximation (RMSEA) has a value of 0.084. Values below 0.06 have good fit, values larger than 0.10 are indicative of poor-fitting models (Browne and Cudeck, 1993). The Comparative Fit Index is 0.925, which is below 0.95 which indicates a good fit (Hair et al., 2006).

4.2 Direct and indirect effects on moving intentions (Figure 1, 2.2.1)

In general we can conclude that most variables mainly impact the intention to move via the mediating effect of residential satisfaction. Residential satisfaction has by far the strongest effect on moving intentions (Table 2, C.1). Next to residential satisfaction only being older, house ownership (Table 2, C.2.4) and lower house tenure (Table 2, C.2.5) have direct negative effect on moving intentions. Some other variables also show direct effects on moving intentions, however are outweighed by indirect effects via residential satisfaction.

- (Highway) accessibility: We can conclude that accessibility variables mostly do not impact moving intentions independently but only via residential satisfaction. Preference for a highway location has a direct positive effect on the intention to move, but the effect is outweighed by a negative indirect effect via residential satisfaction. People with preference for a highway location are in general more inclined movers (causing a direct effect). However they are also more satisfied with living close to highways, this causing a negative indirect effect on their moving intention. Traffic jam frequency is found to have positive impact on moving intentions via a mediating effect of residential satisfaction; Being frequently stuck in traffic jams lowers residential satisfaction which results in a higher moving intention. Suprisingly, satisfaction with accessibility of the residential location[2] or the commute (Table 2, C.2.1) has no (direct or indirect) impact on the intention to move. The same goes up for distance to an access lane and attitude about car driving. The finding that accessibility affects residential moving only to a limited extend is in line with studies arguing that the impact of accessibility in (re)location has been decreased (e.g. Molin and Timmermans, 2002; Giuliano, 1993).
- Negative highway externalities: Also highway nuisances impact moving intentions mainly indirectly. Perceived noise, air and barrier-effects positively impact moving intentions via a mediating role of residential satisfaction (Table 2, C.1). For perceived air nuisance, a positive indirect effect via residential satisfaction overrules a weaker direct negative effect. People with high perceived air nuisance have characteristics which make them less inclined to move in general (causing a direct effect). However their lower residential satisfaction while living close to highways (causing an indirect effect) corrects for the negative direct effect, resulting in a total higher moving intention. Our finding that there is not a direct effect on moving intentions for perceived noise nuisance is in contrast with the study of Osada et al. (1997). The difference in findings may have to do with differences in respondent-selection; Osada et al (1997) focused only on females with at least three years of house tenure. That perceived nuisances have strong negative effects on residential satisfaction (causing the indirect effects on moving) is in line with other studies (e.g. Hamersma et al., 2013; Kroesen et al., 2010; Hur and Morrow-Jones, 2008). Moreover, no additional effects on moving intention are found for noise, air exposure and distance from a highway when accounting for both direct and indirect effects (Table 2, C.2.2). In line with other studies (e.g. Hamersma et al., 2013; Van Praag and Baarsma, 2005) we can conclude that perceptions outweigh objective exposure measures.
- Residential characteristics*:* Similar to accessibility and negative highway externalities, also residential characteristics mainly impact moving intentions via residential satisfaction (Table 2, C.2.3). Satisfaction with attractiveness of buildings and traffic safety have a strong indirect effect on moving intentions via residential satisfaction. For both variables, similar to perceived air nuisance, the indirect effect overrules a direct but weaker positive effect on moving intentions. With respect to neighborhood house prices, people in areas with lower house prices are found more satisfied while living close to highways, causing an indirect negative effect on moving

[2] Only significant when excluding the 'satisfaction with attractivity of buildings' variable.

intentions. However compared to people in higher house price areas they are more inclined movers (causing a direct effect), despite higher satisfaction. Satisfaction with greenery, facilities and the number of parking places are not found to impact moving intentions either directly or indirectly.

- Control variables (socio-demographics, social bonds): Regarding socio demographics being older and house ownership have stable direct effect on the intention to move (Table 2, C.2.4) . This finding is in line with other studies (e.g. Speare, 1974; Lu, 1998) and could relate to higher (perceived) cost of moving (e.g. Coulombel, 2011). Other control variables mainly impact moving intentions via residential satisfaction. Higher educated and lower incomes are found to have higher moving intention when including the mediating effect of residential satisfaction; the indirect positive mediating effect is stronger than a direct negative effect. Women and households with children are found not to move more or less when adding up direct and indirect effects. With respect to social bonds (Table 2, C.2.5) long house tenure is found to have direct positive impact on moving intentions, also after correcting for the indirect effect via residential satisfaction. Although this group may be highly willing to move, costs of moving may prevent this group from leaving (e.g. Coulombel, 2011). Additionally, cognitive dissonance may play a role; people living shorter in the area may first relax attitudes about negative aspects of the neighborhood, convincing themselves that they made a right choice buying the house. Finally satisfaction with the number of contacts has negative indirect impact on moving intentions.

4.3 Assessing relative importance -counterbalancing effects (Figure 1, 2.2.2)

When accounting for the indirect effect via residential satisfaction, perceived highway externalities are among the strongest influencers of total (direct + indirect) moving intentions close to highways. Perceived noise nuisance has strongest impact, followed by perceived barrier-effect nuisance and perceived air nuisance. In this section we discuss in how far accessibility and other residential characteristics (when appreciated) could counterbalance for negative externalities in total moving intentions.

- Accessibility*:* Based on total effects on moving intentions we can conclude that accessibility can only partly counterbalance effects of perceived negative externalities. Only low traffic jam frequency has a considerable impact on moving intentions. Other included accessibility variables (i.e. perceived residential location accessibility, preference for a highway location, distance from an access lane or car attitude have no counterbalancing effect; they do not contribute significantly to total moving intentions.
- Residential characteristics: Some residential characteristics have strong effects on total moving intentions, of comparable strength as nuisance annoyance. Especially satisfaction with attractiveness of buildings and to a lesser extent perceived traffic safety have strong negative impact on moving intentions, the former ranking even higher in total effects compared to perceived noise nuisance. Greenery, facilities, number of parking places and lower house prices do not counterbalance negative externalities as they do not impact total moving intentions.
- Control factors (socio-demographics, social bonds)*:* Age strongly impacts total moving intentions with a comparable impact as perceived negative externalities. The impact of house ownership, higher income and lower education on total moving intentions is weaker compared to the effects of highway nuisance annoyance. Regarding social bonds, satisfaction with the number of contacts and short house tenure have strong (i.e. comparable strength) impact on moving intentions. Their impact is comparable to the impact of perceived noise nuisance.

TABLE 2 Results structural equation model

	A			B			C		
	Perceived noise	**Perceived air**	**Perceived barrier**	**Residential Satisfaction**			**Moving intention**		
	Direct$_b$	Direct$_b$	Direct$_b$	Direct	Indirect	Total	Direct	Indirect	Total
1 Endogenous									
Residential Satisfaction	na	na	na	na	na	na	-1.191***	na	-1.191***
Perception Noise	na	na	na	-0.182***	na	-0.182***	-0.02	0.217***	0.197***
Perception Air pollution	na	na	na	-0.151***	na	-0.151***	-0.103***	0.18***	0.077***
Perception Barrier effect	na	na	na	-0.098***	na	-0.098***	0.053	0.116***	0.169***
2 Exogenous									
2.1 Accessibility -aspects									
Satisfaction accessibility res. location	-0.019	0.044	0.015	0.035	-0.005	0.03	0.046	-0.039	0.007
Satisfaction commute$_a$	-0.049	-0.076**	-0.044	-0.039	0.034**	-0.005	0.057	0.035	0.092**
Preference to live near highway	-0.081**	-0.041	-0.233***	0.084***	0.045***	0.129***	0.121***	-0.159***	-0.038
Attitude car driving	-0.108***	-0.162***	-0.228***	-0.027	0.072***	0.045*	0.024	-0.04	-0.016
Frequent in traffic jam	0.046	0.029	-0.014	-0.114***	-0.015	-0.129***	0.051	0.144***	0.195***
Distance access lane	-0.03	0.007	0.005	-0.003	-0.001	-0.004	-0.041	-0.002	-0.043
2.2 Objective Nuisance									
Noise exposure (DB)	0.25***	0.265***	0.259***	-0.015	-0.109***	-0.124***	-0.157***	0.131***	-0.026
Air exposure (HWN)	0.149***	0.193***	0.083*	0.069**	-0.065***	0.004	0.031	-0.024	0.007
Distance from highway	0.042	0.081**	0.1**	0.004	-0.028**	-0.024	-0.078*	0.027	-0.051
2.3 Other res.characteristics									
Average house price neighborhood	0.015	0.105**	-0.035	-0.133***	-0.015	-0.148***	-0.098**	0.164***	0.066*
Satisfaction Attractivity buildings	-0.216***	-0.165***	-0.204***	0.502***	0.086***	0.588***	0.42***	-0.688***	-0.268***
Satisfaction Traffic safety	-0.063*	-0.076**	-0.046	0.127***	0.029***	0.156***	0.101***	-0.177***	-0.076**
Satisfaction Greenery	0.031	-0.06*	-0.087**	-0.027	0.012	-0.015	-0.011	0.018	0.007
Satisfaction Facilities	-0.058	-0.032	0.011	0.001	0.019**	0.02	0.073**	-0.012	0.061*
Satisfaction nr.r of Parking spaces	0.029	0.058	0.001	0.000	-0.001	-0.001	0.015	0.012	0.027
2.4 Socio demographics									
Age	0.872***	0.827***	0.881***	0.117	-0.36***	-0.243***	-0.329***	0.245***	-0.084**
Age-squared	-0.712***	-0.685***	-0.873***	-0.108	0.309***	0.201***	-0.003	-0.212***	-0.215***
Gender: Woman	0.005	0.052	0.137***	-0.032	-0.02**	-0.052*	-0.124***	0.066**	-0.058*
Higher Education level	0.044	0.014	0.104**	-0.122***	-0.019**	-0.141***	-0.078**	0.173***	0.095***
Income above 2000eu	-0.125***	-0.066	0.078	0.189***	0.027**	0.216***	0.088**	-0.242***	-0.154***
Household with Children	-0.001	0.07*	-0.14**	-0.11***	0.003	-0.107***	-0.062	0.112**	0.05
Owned house	0.136***	-0.015	0.127**	0.000	-0.03**	-0.03	-0.21***	0.048	-0.162***
2.5 Social bonds									
Satisfaction with contacts	0.049	0.03	0.099*	0.249***	-0.021**	0.228***	0.072	-0.268***	-0.196***
House Tenure Duration	0.1***	0.083**	-0.132***	-0.075**	-0.02**	-0.095***	0.096**	0.093**	0.189***
% of variance explained	**26.0%**	**30%**	**36.4%**		**75.6%**			**77.7%**	
Total respondents:									
Fit indices	**4,105**			**RMSEA**	**0.084**		**CFI**	**0.925**	

$_a$Based on a separate model for working respondents only.

$_b$Only direct effects estimated.

4.4 Direct effects on perceived highway externalities (Figure 1, 2.2.3)

Corresponding with previous findings (e.g. Miedema and Vos, 1999), actual exposure of noise and air pollution is found important however not the only explaining factor perceived negative externalities (Table 2, A.2.2). Controlled for exposure, people living further away from the highway perceive more noise as well as barrier-effect. This may be a sign of self-selection; people living closer to the highway may be more tolerant towards nuisances. Moreover we find indeed find some direct relationships with accessibility, other (non-highway related) residential characteristics (and other contextual factors); below we describe the results in more detail.

- Accessibility*:* We find no direct relations between accessibility level related variables and perceived negative highway externalities; Satisfaction with accessibility, as well as traffic jam frequency and distance to an access lane show no direct relationship with either perceived noise, air or barrier effects (Table 2, A.2.1). In line with other studies (e.g. Kroesen et al., 2010; Miedema and Vos, 1999), we do find direct relationships with accessibility interest; people with a preference to live near a highways (proxy for highway usage) perceive less noise and barrier-effects. Additionally we find that people with a positive attitude towards car driving are less annoyed by its (noise, air and barrier-effect) nuisances.
- Residential characteristics*:* Being satisfied with attractivity of buildings in the neighborhood shows direct relationship with perceptions of highway noise, air and barrier-effects (Table 2, A.2.3). Other characteristics only show direct relations to one of the perceived negative highway externalities. Annoyance of air quality is lower when people are more satisfied about traffic safety or when house prices are lower. Moreover, people seem to perceive less highway barrier-effects when they are satisfied with the amount of greenery in their surrounding area. In contrast to studies (e.g. Li et al., 2010; Gidlöf-Gunnarsson and Öhrström, 2007), we find no direct relation with perceived noise or air quality. A reason for this may be presented by Joing and Kang (2010). They indicate that greenery is aesthetically appreciated but less effective as a noise or air barrier. Finally satisfaction with facilities and the number of parking places have no impact on perceived negative externalities.
- Control factors (socio-demographics, social bonds)*:* In line with other studies (e.g. Miedema and Vos, 1999) middle aged people perceive significantly more noise, air and barrier-effect nuisance (Table 2, A.2.4). Women, higher educated and households without children perceive more barrier-effects. Lower incomes perceive more noise nuisance. House owners perceive higher noise as well as barrier-effect nuisance. This may have to do with concerns about the effect of nuisances on their house price (i.e. Miedema and Vos, 1999). Being more satisfied about contacts in the neighborhood does not directly impact perceived negative externalities. Having longer house tenure is however positively related to perceived noise and air nuisance according to our study. Cognitive dissonance may play a role.

5. CONCLUSION

People living close to highways may be affected by negative (i.e. noise, air and barrier-effects) externalities. However positive externalities (i.e. accessibility gains) and other residential characteristics may countervail. In this paper we investigated moving intentions of residents living close to highways in this broader perspective, by analyzing a questionnaire set out at seven highway locations within the Netherlands. Structural Equation Modeling was used to test a theoretical model. We particularly aimed to study whether (positive and negative) highway externalities and other residential characteristics affect moving intentions directly or mainly indirectly over residential satisfaction. Moreover we aimed to study in how far negative externalities are traded-off with (appreciated) accessibility and other residential characteristics;

both could have a counterbalancing effect in moving intentions as well as could directly relax the way negative externalities are perceived.

Our study shows that generally speaking moving intentions of people living close to highways are modest. Highway externalities (accessibility and nuisances) as well as other residential characteristics are found to impact moving intentions (mainly) indirectly via the mediating effect of residential satisfaction, the latter having a prominent role in explaining moving intentions. In other words, highway externalities and other residential characteristics do not affect moving intentions independent of residential satisfaction.

When accounting for effects via residential satisfaction perceived negative highway externalities are among the most important factors in explaining moving intentions. Accessibility only counterbalances negative externalities to some extent. A lower traffic jam frequency reduces moving intentions (accounting for the effect via residential satisfaction) with considerable impact. However other tested accessibility related aspects (i.e. satisfaction with accessibility, living closer to an access lane, preference for a highway location) have no counterbalancing effect. With respect to other residential characteristics, satisfaction with building attractivity and traffic safety have strong positive effect on residential satisfaction and so indirectly lower moving intentions. By that they counterbalance the effect of negative externalities. The same goes up for being older, being satisfied with social contacts, having shorter house tenure, owning a house, having higher income or lower education.

Also with regard to relaxing effects on nuisance perception the role of accessibility seems to be limited. Higher levels of accessibility (i.e. higher satisfaction with accessibility, closer distance to an access lane and lower traffic jam frequency) do not seem to temper nuisance awareness. We do find that people with a preference for highway locations (as proxy for use) and a positive attitude towards cars seem to perceive less noise, air and barrier-effects. Regarding residential characteristics, residents being satisfied with building attractivity and traffic safety seem less annoyed by negative externalities. Additionally having longer house tenure, being middle aged and owning a house seem to increase awareness of negative externalities.

The results of our study have practical relevance. The fact that we find relatively low moving intentions close to highways indicates that other (residential) aspects may prevent people from willing to move elsewhere. Investing in attractive and safe neighborhoods seems worthwhile; both aspects seem to have mitigating effect on perceived nuisances. Although interventions to improve accessibility (reducing traffic jams) could counterbalance negative externalities, they do not seem to reduce annoyance directly. This means that people may be satisfied with accessibility and annoyed by nuisances at the same time. Additionally we also have to keep in mind that interventions relating to accessibility come with a construction period which may cause negative concerns (e.g. Hamersma et al., 2013).

Further research should dive deeper to broaden our understanding of the residential context close to highways. First, it may be worthwile to study in how far moving intentions lead to actual moving behavior, for example by longitudinal data analysis. Second, it may be interesting to study potential differences in the importance attached to accessibility and negative externalities for different groups of residents in their moving intentions. For example differences based on highway use, based on tenure duration or based on country specific aspects may be interesting to study. Third, it could be useful study the role of accessibility and residential characteristics more in-depth by use of qualitative research, to better understand why trade-offs do (not) exist. Fourth, next to a 'stable' situation of living close to highways as we looked into, it may be interesting to study reactions to highway planning projects, to better understand how mitigation in designing plans could relieve residential reactions towards these plans. .

6. REFERENCES

- Blijie, B., L. Groenemeijer, K. Gopal and R. van Hulle. *Wonen in ongewone tijden.* Ministry of the interior and kingdom relations the Netherlands, 2012.
- Boomsma, A. and J.J. Hoogland. The robustness of LISRELL modeling revisited. In: R. Cudeck, S. du Toit and D. Sörbom (Eds). *Structural Equation Modeling: Present and Future*, pp. 139-168, Chicago, Scientific Software International, 2001.
- Browne, M. W. and R. Cudeck. Alternative ways of assessing model fit. In: Bollen, K. A. and J.S. Long (Eds.).*Testing Structural Equation Models*, pp. 136–162, Beverly Hills, CA, Sage, 1993.
- Coulombel, N. Residential choice and household behavior: State of the Art. *SustainCity Working Paper, 2.2a*, ENS Cachan, 2011.
- Deane, G.D. Mobility and adjustments: paths to the resolution of residential stress*. Demography,* Vol.27, 1990, pp. 65 – 79.
- Eliasson, J. Variations in valuations of noise and intrusion effects. Are stated choice results compatible with hedonic prices? European Transport Conference (ETC), Strasbourg, 2005.
- Gidlöf-Gunnarsson, A. and E. Öhrström. Noise and well-being in urban residential environments: The potential role of perceived availability to nearby green areas. *Landscape Urban Planning,* Vol. 83, 2007, pp.115–126.
- Giuliano, G.New Directions for Understanding Transportation and Land Use.*Environment and Planning A*,Vol.21,1998,pp.145-159.
- Goldstein, S. *Patterns of Mobility, 1910-1950*. Philadelphia, University of Pennsylvania Press, 1958.
- Hair, J. F., W.C. Black Jr., B.J. Babin, R.E. Anderson, and R.L.Tatham. *Multivariate data analysis*, New Jersey, Prentice Hall, 2006.
- Hamersma,M.,T.Tillema, J.Sussman and J.Arts.Living close to highway: the impact of perceived highway externalities on (changes in) residential satisfaction.Presented at the 92th Annual Meeting of the Transportation Research Board,Washington D.C. 2013.
- Hur, M. and H. Morrow-Jones. Factors that influence residents' satisfaction with neighborhoods. *Environment and Behavior*, Vol.40, 2008, pp. 619-635.
- Joing, J.L. and J. Kang. The influence of preconceptions on perceived sound reduction by environmental noise barriers. *Science of the Total Environment*, Vol.408, 2010, pp. 4368–4375.
- Kirk, W. Problems in Geography, *Geography* , Vol. 48, No. 4, 1963, pp. 357-371.
- Kroesen, M., E. Molin, H. Vos, S. Janssen and B.van Wee. Estimation of Effects of Transportation Noise Annoyance on Residential Satisfaction. *Transportation Research D*, Vol.15, 2010, pp. 144–153.
- Landale N.S. and A.M. Guest. Constraints, satisfaction and residential mobility: Speare's model reconsidered. *Demography,* Vol. 22, 1985, pp. 199 – 222.
- Lee, E.S. A Theory of Migration. *Demography*, Vol.3, 1966, pp. 47-57.
- Lee, B.A., R.S. Oropesa and J.W. Kanan. Neighborhood context and residential mobility.*Demography,*Vol.31,1994,pp.249– 270.
- Li, H.N., C.K. Chau and S.K. Tang. Can surrounding greenery reduce noise annoyance at home? *Science of the Total Environment*, Vol. 408, No. 20, pp. 4376-84.
- Lu, M. Analyzing migration decision making: relationships between residential satisfaction, mobility intentions, and moving behavior. *Environment and Planning A*, Vol. 30, 1998, pp. 1473 -1495.
- McHugh K E., P. Gober and N. Reid. Determinants of short- and long-term mobility expectations for home owners and renters. *Demography,* Vol.27, 1990, pp. 81 -95.
- Miedema, H.M.E. and H. Vos. Demographic and attitudinal factors that modify annoyance from transportation noise. *Journal of the Acoustical Society of America*, Vol. 105, No. 6, 1999, pp. 3336-3344.
- Molin, E. and H. Timmermans. Accessibility Considerations in Residential Choice Decisions: Accumulated Evidence from the Benelux. Presented at the 82nd Annual Meeting of the Transportation Research Board, Washington D.C., 2002.
- Nelson, J.P. Highway noise and property values – a survey of recent evidence. *Journal of Transport Economics and Policy*, Vol. 16, No. 2, 1982, pp. 117-138.
- Nijland, H., S. Hartemink, I. van Kamp and B. van Wee. The influence of sensitivity for road traffic noise on residential location: does it trigger a process of spatial selection? *Journal of the Acoustical Society of America*, Vol. 122, 2007, pp. 1595–1601.
- Osada, Y., T. Yoshida, K. Yoshida, T. Kawaguchi and Y. Hoshiyama. Path analysis of the community response to road traffic noise. *Journal of Sound and Vibration,* Vol. 250, No. 4, 1997, pp. 382-387.
- Parkes, A., A. Kearns and R. Atkinson. What makes people dissatisfied with their neighbourhoods? *Urban Studies*, Vol.39, 2002, pp. 2413–2438.
- Rohrmann, B. The influence of noise on housing decisions. In: *Contributions to Psychological Acoustics (V)* eds. Schick, A., J. Hellbruck, R. Weber, pp. 75–86, Bibliotheks- und Informationssystem der Universität Oldenburg (BIS), Oldenburg, 1991.
- Rossi, P.H. *Why families move: A study in the social psychology of urban residential mobility*. Free Press, Glencoe, IL, 1955.
- Schreckenberg, D., B. Griefahn and M. Meis. The associations between noise sensitivity, reported physical and mental health, perceived environmental quality, and noise annoyance. *Noise & Health*, Vol. 12, No. 46, 2010, pp. 7-16.
- Sjaastad, L.A. The Costs and Returns of Human Migration. *Journal of Political Economy*, Vol.70, No.5, part 2, 1962,pp.80-93.
- Speare, A. Jr. Residential satisfaction as an intervening variable in residential mobility. *Demography*, Vol.11, 1974, pp.173–188.
- Tillema, T., M. Hamersma,.J. Sussman and E.J.M.M. Arts. Extending the scope of highway planning: accessibility, negative externalities and the residential context. *Transport Reviews,* Vol. 32, No. 2, 2012, pp. 745-759.
- Tillema, T., B. Van Wee and D. Ettema. The influence of (toll-related) travel costs in residential location decisions of households: A stated choice approach. *Transportation Research Part A*, Vol. 44, 2010, pp. 785-796.
- Ullman, J.B. and B.M. Bentler. *Sructural Equation Modeling:Handbook of Psychology,* New Jersey,John Wiley and Sons Inc., 2003.
- Wee, van B. The traffic and transport system and effects on accessibility, the environment and safety: an introduction. In:*The Transport System and Transport Policy* eds. Van Wee, B., J.A. Annema and D.Banister,pp.4-16, Edward Elgar,Cheltenham, 2013.