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Changing Influence of Factors Explaining Household Car Ownership Levels in the Netherlands

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To contribute to existing research on the influence of various factors on household car ownership in the Netherlands, this study addressed the question whether and to what extent the influence of economic, sociodemographic, and spatial factors on the number of cars owned by households has changed over time. There seems to be an absence of studies investigating the changing influence of these factors on car ownership in recent decades, and in the Netherlands. The study used the statistical method of ordered logistic regression on household mobility data on 162,593 households, collected by the National Traffic Survey of the Netherlands in 1987, 1991, 1995, 1999, 2003, 2010, and 2014. The results show that the influence of household income, size, composition, gender, age, education, working status, and suburbanization levels on car ownership changed substantially between 1987 and 2014. The strong influence of household income on household car ownership diminished quite remarkably between 1987 and 2014, whereas the influence of household size grew significantly during the period. The results could serve as a first step toward a predictive model that endogenously estimates household car ownership levels in the Netherlands.

Household car ownership is an important determinant of household car use and is primarily interlinked with household residential location (*1, 2*). The current stabilization of car use in industrialized countries, also referred to as peak car (*3*), seems to come hand in hand with a decline in car ownership growth (*4*). In the Netherlands, the growth in household car ownership has slowly decreased, from 3.1% to 0.6% between 2001 and 2015 (*5*).

There is much unknown on the causes of this trend. The factors that have been considered include a decline in car ownership by young adults, increased suburbanization, and economic trends (e.g., the economic crisis of 2008/2009) (*6–8*). Although there is much debate on the influence of various factors, ostensibly there is consensus on the claim that the influence of certain factors might have changed over time. It has been suggested that the role of traditional factors (such as income) has weakened over the years (*3*). However, there seems to be an absence of studies that investigate the (changing) influence of factors on car ownership over time, especially in the Netherlands.

To contribute to existing approaches that study the influence of various factors on household car ownership in the Netherlands, the aim of this study was to assess whether and to what extent the influence of such factors has changed over time. Further, understanding how such factors have contributed to households' choice of the number of private cars to own is of importance to urban planners and decision makers, because car ownership levels are associated with urban sprawl and automobile travel (*9*). Especially when the factors are considered constant, and in relation to car ownership modeling, it becomes important to reveal whether the factors might have changed over the course of time.

To reveal the changing influence of various factors on household car ownership, the study used the statistical method of ordered logistic regression (ORL) (*10*). This method has previously been successfully applied to determine the effects of various factors on household car ownership levels (*10*). In this study, the dependent variable household car ownership was specified at four alternative levels: zero, one, two, and three or more cars. To estimate the ORL model, the study used disaggregated data on household mobility that were collected by the National Traffic Survey of the Netherlands from 1987 to 2014 (*11*). Notwithstanding that the ORL model has primarily an exploratory or explanatory purport, it is considered to be a first step toward a predictive model that endogenously determines the number of cars owned by households in the Netherlands.

The remainder of this paper is organized as follows. The next section discusses background literature on factors influencing car ownership levels, and statistical methods. Following a description of the data set, the results of the ORL model on household car ownership in the Netherlands will be presented. The last section provides concluding remarks.

MODELING HOUSEHOLD CAR OWNERSHIP

Background Literature on Household Car Ownership Determinants

According to previous studies, there are five main categories of determinants that positively or negatively affect household car ownership levels (*8, 12–14*). First, traditional economic factors, including household income, vehicle prices, and fuel costs affect household car ownership levels (*2, 8, 13, 15–19*). For example, higher income levels positively affect car ownership levels, whereas lower levels of income, in a limited way, affect car ownership levels (*15*). Studies reveal that lower income levels do not directly lead to fewer cars owned, because of asymmetrical income elasticity. Once a car has been bought, individuals become accustomed to car use. As a result, the disposal of a car becomes difficult when income falls (*15, 17*). Furthermore, vehicle and fuel price elasticity vary per

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household type. To illustrate, the greater car dependency in rural regions is associated with lower price elasticity of car demand. The influence of fluctuations in vehicle prices and fuel costs on car ownership levels is often smaller in rural regions compared with urban regions where the possibility to alter transport mode is greater (*16*).

Second, transportation research in the Netherlands has suggested the importance of sociodemographic characteristics (such as gender, age, household size, household composition, education, and employment status). Research has shown that males and females have different attitudes toward car use and car ownership (*20*). For age, studies have suggested that the possession of a car becomes less stringent for young singles and couples who start later with the family-building process (*21*). Household size and composition (i.e., presence of children) positively influence the level of car ownership. For example, the presence of young children increases the likelihood that a household possesses one or more cars (e.g., children need to be taken to school) (*18*). The level of education (primary, secondary, and tertiary) indirectly affects car ownership levels. Higher levels of education increase environmental concern and change people's attitudes toward vehicle ownership (*22*). Further, research on employment status or working status (i.e., full-time, part-time, or unemployed) has revealed that households with full-time working member(s) are associated with higher levels of car ownership (*2*).

Third, a common finding is that spatial or land use characteristics play an important role in car ownership among households, including the level of (sub)urbanization and access to transport infrastructure (*2, 8, 12, 18*). Research has shown that households in highly urbanized areas are less likely to own a car compared with households in thinly populated areas where the necessity of owning a car becomes higher (*2*). Access to (public) transport infrastructure has an effect on car ownership levels among households. Infrastructure that is easily accessible for households (<5 min) seems to affect the level of car ownership negatively, but significantly. Better access leads to households being less likely to obtain a car (*13*).

Fourth, psychological factors, including perceptions, attitudes, and habits, have gained attention among researchers investigating car use and car ownership levels (*23*). Recent studies on psychological determinants of car ownership have revealed interesting insights into the psychology of car owners (and non–car owners). For example, previous research revealed that primarily convenience, but also prestige and social orderliness, influence car ownership levels, which might create anti-car trends among new generations (*24*). In addition, the influence of environmental concern has gained increasing attention from researchers. Research in this context has shown that car owners' environmental concerns have led to switching behavior toward electric cars or other modes of transport, including public transport (*25, 26*).

Fifth, transportation factors have also been explored in previous research to understand their influence on household car ownership levels (such as the average number of passengers and travel distances) (*14*). However, such variables are primarily endogenous, which makes them less common variables for explaining (household) car ownership levels.

Statistical Research Methods

Disaggregate models, which use the household as the unit of analysis, have become the preferred method for modeling discrete car ownership choice. Aggregate models (zonal, regional, or national level) suffer from high levels of collinearity between explanatory variables, whereas disaggregate models are statistically more powerful (*2, 10, 27, 28*). Static disaggregate models are the predominant type of disaggregate models that deal with the number of cars owned by a household (*12*). Applications of static disaggregate models in the Netherlands are the Dutch national model system for transport and the disaggregate models established by Bhat and Pulugurta (*28, 29*). Static disaggregate models are still often used for explaining car ownership levels. An example is the dynamic automobile market model for the Netherlands (DYNAMO), which is being used by Dutch ministries and car companies. DYNAMO models the effects of general developments and government policy on the size, composition, and use of the car fleet (*30*).

Static disaggregate car ownership models can be subdivided into two general decision mechanisms: ordered response and unordered response mechanisms (*10, 28*). Ordered response models assume that a household's choice on the number of private cars to own is dependent on a one-dimensional latent variable. The latent variable reflects the inclination of the household to own private cars. Such models are referred to as ORL or ordered probit models (ORP). Unordered response models, based on the principle of random utility maximization, assume that a household chooses the number of cars based on its individual utility, and chooses the maximum utility (*10*). Multinomial logit (MNL) modeling is the main representative type of modeling for models that use this unordered response mechanism (*31*).

In a comparison of ORL and ORP models with MNL models, MNL models do not place any restrictions on the effects of the explanatory variables. In addition, MNL models show greater flexibility, allowing for alternative effects of determinants across different car ownership levels (*10*). However, the flexibility of MNL models comes at a cost, in that the interpretation of outcomes is relatively time consuming, because of the substantial number of parameters to be estimated (*10*). Based on the parallel slopes assumption, ORL and ORP models estimate a unique coefficient per determinant, which makes interpretation of model outcomes more effortless.

DATA AND METHODS

Data Sources

To perform the logistic regression analysis, the study used data on household mobility from the National Traffic Surveys in the Netherlands. The Traffic Survey was carried out under various names (OVG, MON, and OViN) from 1985 to 2014. The data sets record all trips and trip stages for one day among participants, and include demographic as well as economic characteristics of the respondents (*32*). The annual mobility surveys use significant sample sizes, up to 50,000 unique households spread across the Netherlands. About 80% of the mobility in the country is covered by the surveys, excluding lorry traffic, holiday traffic, and individuals not residing in the Netherlands (*11*).

The annual surveys that were used in this study were OVG-1987, OVG-1991, OVG-1995, OVG-1999, OVG-2003, OViN-2010, and OViN-2014. The selection of years concerned a trade-off between accuracy and time efficiency or computing power. An interval of four years was deemed appropriate. An exception was the relatively large jump from 2003 to 2010, which was because in this period

(from 2004 to 2009), the mobility survey (known as MON) did not include household income. Because household income is one of the most important explanatory variables, it would be unrealistic to leave this variable out. The MON data sets were therefore excluded. To assess the influence of household income over time, the study therefore only made use of the OVG (before 2004) and OViN (after 2009) data sets.

The substantial data sets facilitated the investigation of relatively small subgroups within the population, such as households owning three or more cars. All the data sets were merged into a metadata set based on unique identification numbers of households. However, the data sets included a limited number of variables, which did not allow investigating all the relevant factors (Table 1).

Selection of Households

To perform the logistic regression analysis, one person per unique household (male or female) was selected as the reference person. The selection of a reference person was a necessary measure to analyze variables that could not be averaged at the household level (such as gender, education, and working status). Furthermore, children were excluded from the data set (ages 0–17 years). Children younger than age 18 in the Netherlands are legally not permitted to obtain a car. For households with two heads of family (e.g., married couples), one of the two heads was randomly selected as the reference person. The reason for this selection was not to discriminate on other aspects that were to be analyzed. Moreover, no unique cases had to be removed due to mismatches between data sets or missing values. As a result, the metadata set consisted of 162,593 households that were analyzed.

Description of the Variables

The study used eight explanatory variables (Table 1) to measure their influence over time on the dependent variable, household car ownership. Household car ownership was categorized into four alternative levels: zero, one, two, or three or more cars. The independent variable household income was defined by six categories: 0–10,000; 10,000–20,000; 20,000–30,000; 30,000–40,000; 40,000–50,000; and 50,000 or more euros/year.

Household income was not corrected for inflation, to estimate the purchasing power of the household in a specific year. Household size was categorized based on the number of persons, corresponding to 1, 2, 3, 4, 5, and 6 or more persons per household. Household composition was categorized into two types: families with and without children. The age of the reference person was categorized into 18–19, 20–29, 30–39, 40–49, 50–64, and 65–74 years, and 75 years and older. The educational level considered four categories: primary education (BO, LO), old secondary education (LBO, VGLO, LAVO, MAVO, MULO), new secondary education (MBO, HAVO, Atheneum, Gymnasium, MMS, HBS), and tertiary-level education (HBO/University). Working status or employment status was either nonemployed, part-time employed (<30 h/week), or full-time employed (>30 h/week). Finally, the number of addresses per km^2 defined the suburbanization level of the household. Based on the official categorization of Statistics Netherlands, five suburbanization levels were recognized: (*a*) very high-density areas (≥2,500 addresses/km^2), (*b*) high-density areas (1,500–2,500 addresses/km^2), (*c*) moderately high-density areas (1,000–1,500 addresses/km^2), (*d*) low-density areas (500–1,000 addresses/km^2), and (*e*) very low-density areas (<500 addresses/km^2).

TABLE 1 Overview of Included and Excluded Variables: OViN and OVG Data Sets

Category	Included	Excluded
Economic	Household income	Vehicle prices Fuel costs
Sociodemographic	Household size Household composition Gender Age Educational level Working status	
Spatial and land use	Suburbanization level	Transportation infrastructure
Attitudinal		Convenience Prestige Social orderliness Concern for environment
Transportation		Number of passengers Travel distances

Statistical Analysis

Following the descriptive analysis of the data sets, logistic regression analysis was performed on the merged data set to estimate the effects of income, size, composition, gender, age, education, suburbanization, and working status on household car ownership in 1987, 1991, 1995, 1999, 2003, 2010, and 2014. To assess the effects of the variables for every year, interaction effects were created, by introducing $k - 1$ dummy variables (where k = number of years). By doing so, 1987 was chosen as the reference year.

An MNL model and an ORL model were estimated. With a 20% hold-out sample, the percentage of correct predictions of the models was found to be more or less the same, 66% for the MNL model and 65% for the ORL model. Hence, for predictive accuracy, the ORL model performed practically equally well. Since the ORL model was more parsimonious and easier to interpret, only this model will be presented in this paper. Details on the results of the MNL model can be found in Maltha (*33*).

DESCRIPTIVE ANALYSIS

Descriptive analysis of the data sets (Table 2) shows that most households had one or more cars (87% in 2014). The number of households with no car decreased between 1987 and 2014 (68%), whereas households that owned two or more cars increased (65%). Household income steadily increased, varying from levels of 0–30,000 euros in 1987–1995, to 0–50,000+ euros in 2014. This increase was partly the result of the categorization of income levels in the 1987–1995 data sets, wherein income levels greater than 30,000 euros were not specified.

The average household size decreased over time; two-person households increased 35%, whereas four-person households decreased 67%.

TABLE 2 Descriptive Statistics of Household Car Ownership and Explanatory Factors

Category	Percentage[a]						
	1987	1991	1995	1999	2003	2010	2014
Size (*N*)	6,623	5,955	46,014	38,317	18,971	23,361	23,353
Household car ownership							
Zero cars	19.0	15.0	16.6	22.0	19.7	11.9	12.9
One car	68.0	70.0	65.3	57.9	56.9	54.5	53.8
Two cars	11.7	14.0	17.0	18.3	21.0	29.0	28.6
Three or more cars	1.4	1.0	1.1	1.8	2.3	4.5	4.7
Household income							
0–10,000 euros	20.5	10.4	12.1	3.1	1.9	2.7	2.4
10,000–20,000 euros	33.4	51.5	21.2	33.8	31.0	11.9	12.0
20,000–30,000 euros	46.0	38.2	66.7	16.5	14.5	22.2	22.7
30,000–40,000 euros	0.0	0.0	0.0	46.6	52.5	22.7	21.4
40,000–50,000 euros	0.0	0.0	0.0	0.0	0.0	17.1	16.8
50,000+ euros	0.0	0.0	0.0	0.0	0.0	23.4	24.8
Household size							
1-person household	17.7	17.1	20.3	30.2	30.6	18.4	19.8
2-person household	32.1	37.3	37.1	35.8	35.5	42.4	43.2
3-person household	15.9	14.7	14.2	12.2	12.0	13.1	13.3
4-person household	25.0	21.8	19.6	15.0	15.6	18.1	16.9
5-person household	7.2	6.9	6.9	5.4	5.0	6.0	5.4
6-person household	2.1	2.2	1.9	1.3	1.3	1.9	1.4
Household composition							
Household without children	59.1	63.5	65.7	71.4	71.2	67.9	70.8
Household with children	40.9	36.5	34.4	28.6	28.8	32.1	29.2
Gender							
Male	45.1	46.8	43.8	64.6	64.5	47.2	46.8
Female	54.9	53.2	56.2	35.4	35.5	52.8	53.2
Age							
18–19 years	0.2	0.2	0.2	0.1	0.0	0.3	0.3
20–29 years	17.0	15.5	13.3	8.9	5.2	8.0	7.3
30–39 years	27.0	25.9	24.4	21.8	18.1	16.6	14.0
40–49 years	20.0	22.1	23.0	20.6	21.6	21.4	19.9
50–64 years	21.9	22.9	22.7	25.0	28.9	31.1	31.5
65–74 years	9.7	10.1	11.7	12.8	13.5	13.8	17.0
75+ years	4.2	3.3	4.8	10.8	12.7	8.7	10.1
Educational level							
BO/LO	17.8	13.3	11.0	14.7	13.7	6.9	5.7
LBO/VGLO/LAVO/MAVO/MULO	40.8	39.7	35.7	31.9	31.1	25.7	23.8
MBO/HAVO/Atheneum/Gymnasium/MMS/HBS	27.0	29.3	30.6	28.8	28.5	35.8	36.5
HBO/University	14.4	17.7	22.6	24.6	26.7	31.6	34.0
Working status							
No employment	52.8	49.6	51.8	38.0	39.9	41.1	43.3
<30 h per week	8.5	10.0	12.9	10.3	11.7	19.1	18.7
>30 h per week	38.7	40.4	35.3	51.7	48.4	39.8	38.0
Suburbanization							
Very high density	21.6	19.9	15.5	16.9	17.3	14.3	15.2
High density	28.1	28.7	21.3	26.1	27.5	25.0	24.6
Moderately high density	38.7	40.1	22.3	20.7	20.2	19.3	20.0
Low density	11.4	10.8	22.3	21.4	22.0	24.2	24.8
Very low density	0.2	0.4	18.6	14.8	13.1	17.2	15.5

[a]Because of rounded numbers the total percentage may not add up to 100%.

The presence of children in households gradually declined between 1987 and 2014; households without children accounted for 59% in 1987 compared with 71% in 2014. The distribution of males and females was around 50/50 between 1987 and 2014, with the exclusion of 1999 and 2003, when a distribution of 60/40 was observed.

The total share of younger age classes (18–39 years) decreased almost 50% between 1987 and 2014. In the same period, the share of older age classes (50+ years) increased 64%. Further, the group with secondary and tertiary education grew between 1987 and 2014. The group that attended higher professional education (HBO/university) significantly increased, 136%.

The employment status of households' reference person showed a shift of full-time employment (>30 h/week) toward part-time employment (<30 h/week). In 1987, around 53% of the reference persons were full-time employed, compared with 43% in 2014. Finally, 40% of the households lived in highly to very highly urban-

ized regions between 1995 and 2014. The years 1987 and 1991 show differences compared with other years, which are related to an outdated system that was used to measure the level of suburbanization (*34*).

ORDERED LOGISTIC REGRESSION ANALYSIS RESULTS

Figure 1 presents the estimated logit coefficients of the ORL model for household car ownership in the Netherlands. The majority of the estimated parameters are statistically significant (Table 3). The logit coefficients of the explanatory variables indicate that the effects of the explanatory variables on household car ownership changed between 1987 and 2014.

According to previous studies, household income is one of the most important variables determining household car ownership (*15, 35*). The relatively high and mainly significant values of the income coefficients in the model indicate that there is a positive relationship between annual income and number of cars owned by the household. The relative importance of household income in explaining car ownership is relatively high compared with the other explanatory variables. The relative importance or relative effect was obtained by multiplying the logit coefficient value with the minimum and maximum categorical values of the explanatory variables. The difference of both products is then divided by the total sum of all product differences of the explanatory variables. Figure 2 shows that in 1987 the relative effect of income on car ownership accounted for 38%, whereas in 2014 the relative effect was 28%. An explanation for this trend might be that the elasticity of rising income has declined over the years, compared with the elasticity of falling income, which is also referred to as hysteresis (*15*).

Household size is also an important variable explaining household car ownership in the model. The positive coefficients of household size show a positive relationship between household size and car ownership. For example, a unit increase in household size (i.e., one person) in 2014 would lead to a 0.8 logit increase in the level of car ownership. However, these results should be interpreted with care, because most of the coefficients exceed the significance level of 0.05. The relative effect of household size on car ownership has substantially increased over time. In 1987, household size accounted for 29% of the total effect, compared with 35% in 2014 (Figure 2). An explanation for the increase in the relative importance of household size might be found in the types of households that have been established over time (e.g., number of persons with a driving license and number of workers) (*2*).

For the age of the household reference person, the likelihood of owning a car decreases with higher age classes. The gender of the household reference person is positively and negatively associated with car ownership, depending on the corresponding year. A large proportion of the negative coefficients of gender are statistically significant, whereas for age more than half of the estimated parameters are significant (Table 3). The relative effects of gender decreased from 1.5% in 1987 to around 0.4% in 2014. The relative importance of age on car ownership decreased from 4.8% in 1987 to around 3.1% in 2014. As a result, the relative influence of both variables on car ownership became relatively small by 2014.

Working status, educational level, and suburbanization show relatively stable coefficient values (β) over time (Figure 1). The positive coefficients of working status, education, and suburbanization indicate that the influence of the variables is positively associated with the level of household car ownership. Therefore, the probability of owning a car becomes higher with a unit increase in one of the variables. By contrast, the influence of household composition is negatively associated with car ownership. Around half of the parameters are statistically significant (<.05 level). Their relative importance for car ownership over time increased around 2% between 1987 and 2014, but was moderate (between 3.5% and 14% in 2014) compared with the influence of household income and size.

QUALITATIVE ANALYSIS OF THE MODELING RESULTS

This section combines the results from the descriptive analysis with the ORL model outcomes. Table 4 shows the average increase or decrease of the explanatory variables over time (column: trend in

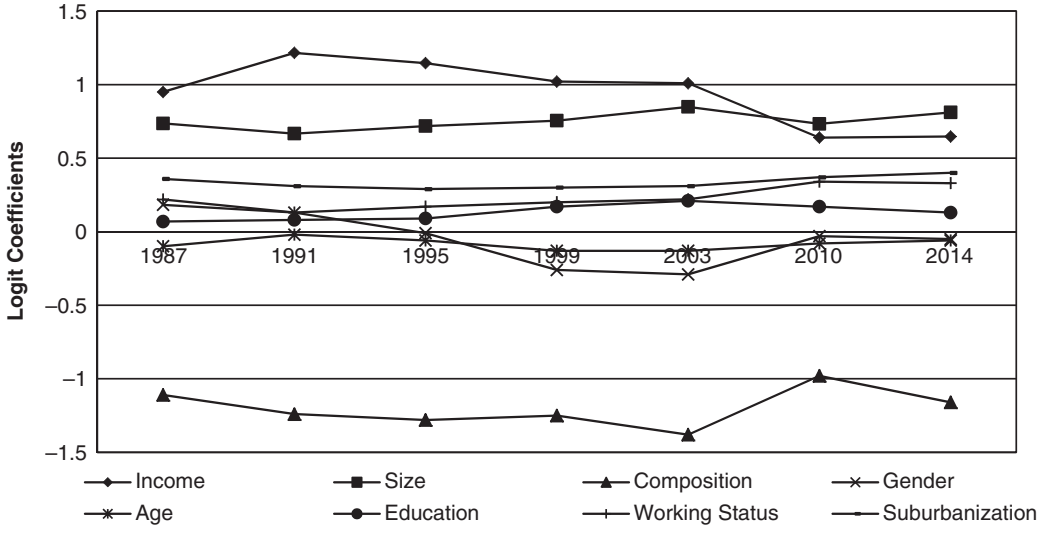

FIGURE 1 Visualization of the estimated logit coefficients.

TABLE 3 ORL Model Estimates

Variable	β[a]	SE	Wald	df	Sig.	95% Confidence Interval	
						Lower	Upper
Threshold values							
[Car = 0]	2.152	0.051	1,775.056	1	0.000	2.052	2.252
[Car = 1]	6.215	0.054	13,187.917	1	0.000	6.109	6.321
[Car = 2]	9.189	0.058	25,481.145	1	0.000	9.076	9.302
Household income							
Income 1987 (ref[a])	0.950	0.039	580.216	1	0.000	0.873	1.027
Income[a] 1991	0.266	0.063	17.680	1	0.000	0.142	0.390
Income[a] 1995	0.196	0.043	20.929	1	0.000	0.112	0.279
Income[a] 1999	0.071	0.042	2.848	1	0.091	–0.011	0.153
Income[a] 2003	0.059	0.045	1.725	1	0.189	–0.029	0.146
Income[a] 2010	–0.310	0.041	57.159	1	0.000	–0.390	–0.230
Income[a] 2014	–0.303	0.041	54.571	1	0.000	–0.384	–0.223
Household size							
Size 1987 (ref[a])	0.736	0.034	467.205	1	0.000	0.669	0.803
Size[a] 1991	–0.069	0.050	1.926	1	0.165	–0.167	0.029
Size[a] 1995	–0.018	0.036	0.247	1	0.619	–0.090	0.053
Size[a] 1999	0.019	0.037	0.269	1	0.604	–0.054	0.093
Size[a] 2003	0.113	0.041	7.738	1	0.005	0.033	0.193
Size[a] 2010	–0.003	0.039	0.007	1	0.935	–0.079	0.073
Size[a] 2014	0.075	0.039	3.690	1	0.055	–0.002	0.151
Household composition							
Composition 1987 (ref[a])	–1.108	0.084	175.001	1	0.000	–1.272	–0.944
Composition[a] 1991	–0.128	0.123	1.081	1	0.298	–0.369	0.113
Composition[a] 1995	–0.171	0.090	3.625	1	0.057	–0.348	0.005
Composition[a] 1999	–0.138	0.092	2.257	1	0.133	–0.318	0.042
Composition[a] 2003	–0.275	0.100	7.510	1	0.006	–0.471	–0.078
Composition[a] 2010	0.130	0.095	1.865	1	0.172	–0.057	0.317
Composition[a] 2014	–0.053	0.095	0.312	1	0.577	–0.240	0.134
Gender							
Gender 1987 (ref[a])	0.183	0.050	13.471	1	0.000	0.085	0.281
Gender[a] 1991	–0.055	0.072	0.583	1	0.445	–0.197	0.087
Gender[a] 1995	–0.195	0.053	13.575	1	0.000	–0.298	–0.091
Gender[a] 1999	–0.446	0.054	67.984	1	0.000	–0.552	–0.340
Gender[a] 2003	–0.475	0.059	65.525	1	0.000	–0.590	–0.360
Gender[a] 2010	–0.213	0.055	14.778	1	0.000	–0.322	–0.104
Gender[a] 2014	–0.233	0.056	17.544	1	0.000	–0.341	–0.124
Age							
Age 1987 (ref[a])	–0.099	0.017	34.566	1	0.000	–0.131	–0.066
Age[a] 1991	0.076	0.024	9.553	1	0.002	0.028	0.123
Age[a] 1995	0.042	0.018	5.708	1	0.017	0.008	0.076
Age[a] 1999	–0.032	0.018	3.321	1	0.068	–0.067	0.002
Age[a] 2003	–0.027	0.019	2.018	1	0.155	–0.065	0.010
Age[a] 2010	0.024	0.018	1.748	1	0.186	–0.012	0.061
Age[a] 2014	0.043	0.019	5.509	1	0.019	0.007	0.080
Education level							
Education 1987 (ref[a])	0.069	0.029	5.586	1	0.018	0.012	0.126
Education[a] 1991	0.010	0.043	0.060	1	0.807	–0.073	0.094
Education[a] 1995	0.022	0.031	0.511	1	0.475	–0.039	0.083
Education[a] 1999	0.099	0.031	9.979	1	0.002	0.038	0.161
Education[a] 2003	0.141	0.034	17.636	1	0.000	0.075	0.207
Education[a] 2010	0.096	0.033	8.404	1	0.004	0.031	0.160
Education[a] 2014	0.058	0.033	3.072	1	0.080	–0.007	0.123
Working status							
Working status 1987 (ref[a])	0.219	0.030	51.566	1	0.000	0.159	0.279
Working status[a] 1991	–0.085	0.045	3.624	1	0.057	–0.172	0.003
Working status[a] 1995	–0.051	0.033	2.485	1	0.115	–0.115	0.013
Working status[a] 1999	–0.015	0.033	0.212	1	0.645	–0.081	0.050
Working status[a] 2003	0.004	0.037	0.011	1	0.915	–0.068	0.076
Working status[a] 2010	0.123	0.035	12.455	1	0.000	0.055	0.191
Working status[a] 2014	0.113	0.035	10.461	1	0.001	0.045	0.182

(continued)

TABLE 3 *(continued)* **ORL Model Estimates**

Variable	β[a]	SE	Wald	df	Sig.	95% Confidence Interval Lower	95% Confidence Interval Upper
Suburbanization							
Suburbanization 1987 (ref[a])	0.359	0.028	168.349	1	0.000	0.305	0.413
Suburbanization[a] 1991	–0.050	0.041	1.530	1	0.216	–0.130	0.029
Suburbanization[a] 1995	–0.065	0.029	5.131	1	0.023	–0.121	–0.009
Suburbanization[a] 1999	–0.056	0.029	3.776	1	0.052	–0.112	0.000
Suburbanization[a] 2003	–0.045	0.030	2.244	1	0.134	–0.104	0.014
Suburbanization[a] 2010	0.006	0.029	0.037	1	0.848	–0.052	0.063
Suburbanization[a] 2014	0.039	0.030	0.030	1	0.188	–0.019	0.097

NOTE: SE = standard error; df = degrees of freedom; sig. = significance.
[a]The coefficients of 1991–2014 can be calculated by summing the main effect (β_{1987}) with the interaction effect of the reference year. To illustrate, the coefficient value of household income in 1991 can be calculated as follows: income 1987 + income 1991 = 0.950 + 0.266 = 1.216.

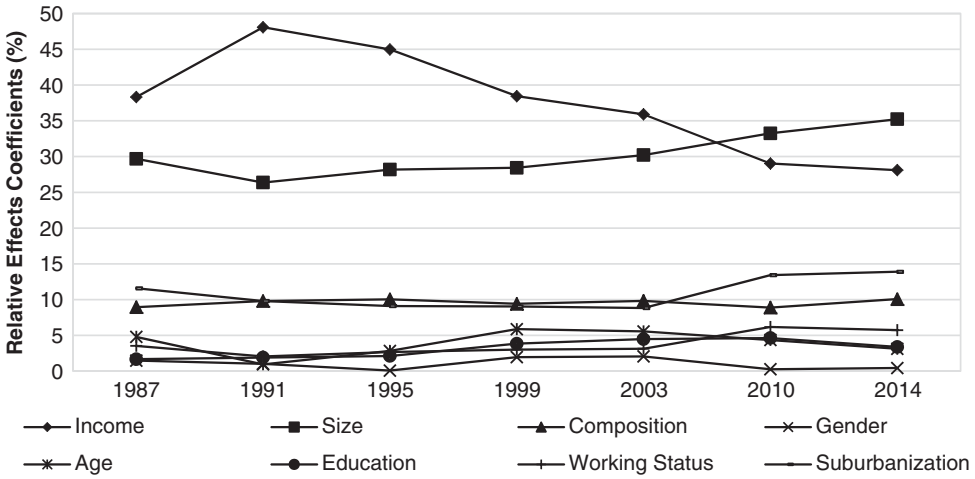

FIGURE 2 **Visualization of the relative importance of the estimated logit coefficients.**

TABLE 4 **Qualitative Analysis of Descriptive Statistics and ORL Model Results**

Statistical Test	Trend in Variable (Table 2)	Influence of Parameter (Table 3)	Trend in Parameter (Table 3)	Combined Effect on Household Car Levels
Household income	+	+	–	[a]
Household size	–	+	+	[a]
Household composition	–	–	0	+
Gender	0	±	–	[a]
Age	+	–	0	[a]
Education	+	+	+	+
Working status	–	+	+	[a]
Suburbanization	0	+	+	+

[a]Combined effect is unclear.

variable). The second column (influence of parameter) shows the positive or negative influence of the parameter on household car ownership. The third column (trend in parameter) shows the change in influence of the parameter on household car ownership as estimated by the ORL model. The combined results of the columns give an indication of the increase or decrease in household car ownership levels over time.

However, a conclusion with respect to the combined effect on car ownership can be drawn only when the trends in the variable and parameter have the same sign (or if one is neutral). This is the case for household composition, education, and degree of suburbanization. When the effects are in opposite directions, a conclusion with respect to the combined effect cannot be drawn. For example, the average household income has increased over time. However, the (positive) influence of the parameter on household car ownership has substantially decreased over time. Therefore, based on this qualitative analysis, it cannot be concluded whether the average number of cars owned by households has increased or decreased over time on the basis of household income. The same applies to household size, gender, age, and working status.

According to the outcomes in Table 4, it can be concluded that household composition, education, and suburbanization have increased the average number of household cars over the years. Comparing the outcomes with the actual development of the number of cars (Table 2), the results seem to reflect the growth of the average number of household cars in the Netherlands. Unfortunately, the stabilization in the growth in the number of household cars since 2010 (Table 2) cannot be explained based on the limited outcomes of the qualitative analysis.

A comparison of the findings in Table 4 with previous empirical research shows that for household composition, a positive relationship with the level of car ownership would be expected (i.e., the presence of children increases car ownership (*8*)). The opposite sign may be due to the additional inclusion of household size in the model, which does have a positive effect on car ownership. It might be that the effect of child(ren) is captured by this variable, and that the (additional) effect of household composition reflects the difference between households with adult children and households with young children. In this case, households with young children will have lower levels of car ownership than households with adult children have. The trend in household composition is negative; the portion of households with child(ren) has decreased over time (Table 2). Combined with the negative influence of this variable (and no clear trend in the size of the parameter), it had a positive effect on car ownership in the considered period.

The results for the positive effect of the level of education are in line with the study by Eakins (*36*), who also found that education level increases car ownership. However, Eakins (*36*) did not include income, so it might be that the income effect was captured by this variable. Table 2 shows there is a clear increase in the level of education over time. Combined with the positive and increasing effect of education, it would be expected that educational levels increased households' average number of cars between 1987 and 2010 in the Netherlands.

Recent empirical research on the effect of suburbanization on the level of cars has shown there is a positive relationship, which is also supported by the findings of this study (influence of parameter) (*2, 8*). Given that the influence of suburbanization has increased, the growth in car ownership between 1987 and 2010 can partly be attributed to the influence of this variable.

CONCLUSION

To contribute to existing research that investigates the influence of various factors on household car ownership in the Netherlands, this study addressed the question whether and to what extent the influence of such factors has changed over time. The main motivation for this research was the current observed stabilization of car use in the Netherlands, also referred to as peak car, which seems to come hand in hand with a decline in car ownership growth. To reveal the changing influence of various factors on household car ownership, the statistical method of ORL was used on household mobility data, which were collected by the National Traffic Survey of the Netherlands in 1987, 1991, 1995, 1999, 2003, 2010, and 2014.

The results show that the influences of household income, size, composition, gender, age, education, working status, and suburbanization level on car ownership, in general, have changed over time. The relative influences of household income and household size are substantial, contributing more than 60% of the total influence on household car ownership in all the years studied. Whereas the influence of household income on car ownership decreased over time (from 38% in 1987 to 28% in 2014), the influence of household size increased (from 29% in 1987 to 35% in 2014). Household income and household size show a positive relationship with the number of cars owned by a household.

The same positive relationship is observed for education, working status, and suburbanization with household car ownership. The relative influence of these variables on household car ownership has gradually grown, by an average total of 2% between 1987 and 2014. Household composition has a relatively strong negative relationship with car ownership, which remained relatively stable between 1987 and 2014 (around 10%). Age and gender show predominantly a negative relationship with the number of cars owned by a household. Their influence on car ownership decreased over 1% between 1987 and 2014, and was relatively small in 2014.

Overall, the logistic regression analysis has proven to be a suitable method to explore the changing of influence of important car ownership determinants over time; however, some limitations can be identified. First, gender, age, education, and working status are so-called proxies, measured at the individual level (i.e., based on the information on the households' reference person), whereas car ownership levels are measured at the household level. Second, not all the variables are most effectively measured by linear analysis. For example, the influence of the variable age on household car ownership is better described by a quadratic function, rather than a linear function. Third, the influence of some parameters (e.g., negative influence of having children on car ownership) would have been expected to be different in relation to the findings of other studies. And fourth, the data collected by the National Traffic Survey excluded some important factors that are considered to affect household car ownership levels, such as attitudinal and psychological factors. Incorporating such factors into the regression model could therefore further extend this study.

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