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School travel behaviour in the Netherlands and Flanders

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ABSTRACT

Studies on school travelling frequently deal with active travelling that is considered important in preventing obesity. Most research has been done in low bicycle countries where walking is the main active mode. The paper presents an analysis for the Netherlands and Flanders, two European countries with high bicycle use. The study analyses two aspects of school travel behaviour: home-to-school distances and modal choice. Both are analysed for primary and secondary school students. A descriptive analysis learns that in Flanders trip lengths to primary schools are significantly larger than in the Netherlands and that the bicycle is more frequently used in the Netherlands. Analyses of influencing variables for both home-to-school distance and modal choice demonstrate that 'hard' factors that define the objective conditions for school choice (crucial for home-to-school distance) and modal choice are most influential. They regard the locations of eligible schools and the qualities of the eligible modes. Just one other factor is significant in the explanation of home-to-school distances: car ownership. On the other hand, modal choice is influenced by several other socio-cultural factors, where age of the pupil, size of the household, and car ownership are most important. Most outcomes are in line with other studies. The observed high bicycle use demonstrates that the bicycle has the potential to account for a large number of trips and can even be the dominant mode in school travelling.

1. Introduction

School travelling is relatively undeveloped in transport research, especially when compared with commuting to work. The reason might be that school travelling contributes little to the most envisaged transport problems: car congestion and air pollution. School travel has a modest share—according to the Dutch NTS, 9% of all trips and 5.5% of all trip kilometres have the purpose 'education'—and its contribution to car-related problems is small. In the Netherlands ca 2% of car kilometres are made for education, though in less bicycle oriented countries the share can be considerably higher. Still, there are reasons why school travel should have a more prominent position in transport research. First, pupils are in the learning phase of their lives and travelling to school can contribute to the growth to maturity, especially when they are trained to travel independently. Second, school travel generates its own problems. Most important is traffic safety: younger pupils are playful and sometimes do not have an eye for the dangers of traffic. This problem is aggravated by car congestion at school locations caused by parents who take their children by car to school and back to home. Third, active travelling by pupils is healthy and contributes to preventing obesity. The latter argument is the most important motivation for current research in this field.

School travel behaviour is mainly the outcome of two choices that are made by the pupils or their parents: choice of the school from all eligible schools and choice of the mode(s) for travelling to school. We mean with choice of a "school" the combined choices of a school as institution and of a specific location of the institution; one institution may offer training at different locations. A hypothetical process of school choice and modal choice is displayed in Fig. 1.

School choice is the outcome of the distance to the nearest eligible schools and the selectiveness in school choice. The assumption is that parents will in principal choose the nearest school for their children but may decide for a more distant school if it has a higher quality in some respects. Whether or not to choose a more distant and better school depends on the importance that is attached to a high quality of the school. This is indicated in the diagram as selectiveness in school choice. Selectiveness may be associated with personal and household characteristics; one can hypothesise for instance that parents that are highly educated by themselves are more inclined to choose a good school for their children. The distance to the nearest eligible school depends on (a) "school location factors", that are factors that define the locations of the schools and the school density in

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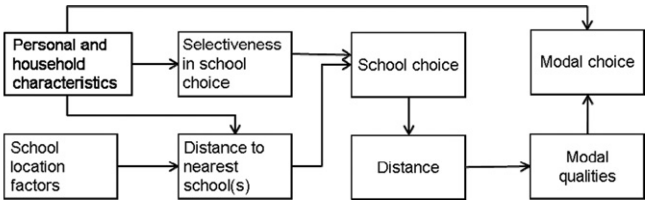

Fig. 1. Factors behind school choice and modal choice.

the area where a pupil lives, and (b) characteristics of the pupil that are related to the type of education and hence which schools are eligible. Most important characteristic is the pupils age.

Choice of the school determines the distance that a pupil has to travel, given the home location. The distance affects the modal qualities for the trip. Walking is a feasible mode for just short distance trips while motorised modes are good options for longer distances. Modal qualities and preferences of the parents or pupils—that may relate to personal and household characteristics—define the modal choice.

The choices result partly from preferences of the households regarding school quality or modal use, and partly from factors that are given for them and that define the objective conditions of their choices. The latter regard the locations of the eligible schools and the general qualities of the modes. Such factors depend on decisions on a political level. Policies can influence the spatial densities and locations of schools of several types and thus the distances to eligible schools for pupils living at a certain location and participating in a certain type of education. Likewise, political choices can affect the service levels of modes, for instance by investing in bicycle infrastructure, or providing dedicated bus transport. In the paper, we indicate the factors that are given for the households and only can be influenced by policies as 'hard' factors, and the preferences of the households as 'soft' factors.

This paper concentrates on the two mobility components of school travelling: the home-to-school distance—that is a direct result from school choice—and the modal split that results from modal choice. These components are likely to differ by school level and country. Different school levels generally go together with different school densities and accordingly with different average home-to-school distances. In different countries policies regarding school locations and modal qualities can differ, and the inhabitants may have different habits and cultures leading to different travel choices. The paper describes and analyses the two components for both primary and secondary education in two European neighbouring countries, the Netherlands and Flanders[1].

Section 2 gives a literature overview and background to the study. Section 3 deals with the data sources and the way these are used for the analyses. Section 4 gives a description of home-to-school distances and modal splits in the two countries for both primary and secondary education. In Section 5 the influence of explanatory variables on distances and mode choice is analysed. Some conclusions are drawn in Section 6.

2. Literature review and background

There is little research on school choice as an explaining factor for home-to-school distances. Gorard (1999) summarises the results of a number of studies on the choice of a secondary school in the UK, where school choice is (within limits) free. A large number of explanatory factors are defined. He categorises these into five groups: academic (level of education), situational (convenience criteria like proximity to home and having friends in the same school), organisational (school management, size, rules like wearing a uniform), selective (gender, religion, ability), and security (safety and welfare of the child at school, discipline). The different studies reviewed by Gorard give no unambiguous evidence about the relative importance of the different factors. A few Dutch studies give information about the choice of a primary school. They show that the most important variables for primary school choice are accessibility (in particular by foot), quality of the school, and religious orientation (Herweijer and Vogels, 2004; Boer and Blijie, 2006). De Boer and Blijie found that two accessibility aspects play a significant role: distance and number of traffic barriers on the route. The assessment of the different variables is dependent on income.

More research has been done on modal choice of pupils travelling to school, in particular in North America and Australia; see the comprehensive review of studies by Sirard and Slater, 2008. The smaller number of European studies is concentrated in the UK. The focus is on the question how active travelling can be promoted. The share of active modes (walking and cycling) decreased significantly in the past (see McDonald (2007) for the US, Black et al. (2001) for the UK) while active travelling is considered important in preventing obesity. In Europe more sustainable transportation is put forward as an additional argument. The studies demonstrate that a large number of factors of varying natures have or can have significant influences on modal choice. Many studies indicate home-to-school distance as the most important variable or one of the most important variables (DiGuiseppi et al., 1998; Black et al., 2001; Granville et al., 2002; Dellinger and Staunton, 2002; Mitra et al., 2010; He, 2011). The distance analysis in the present paper is then relevant for modal choice; factors influencing distance will affect indirectly modal choice. More reported variables regard, among others, urban form (McMillan, 2007; Mitra et al., 2010), (perceived) safety or security of the route to school (DiGuiseppi et al., 1998; McMillan, 2007; McDonald et al., 2010), transportation options of the household (DiGuiseppi et al., 1998; Black et al., 2001; He, 2011), ethnicity (He, 2011), age of the child (McDonald, 2007), and gender of the child. Results on gender are ambiguous: studies in the US find that boys are more inclined to use active modes than girls (McMillan et al., 2006; He, 2011) while in Japan a higher car dependence is observed for boys (Susilo and Waygood, 2012). The gender differences in the US are associated with social control on the route (McDonald et al., 2010). A Dutch study uncovers season as a significant factor (Boer et al., 1992); this variable is seldom included in other studies.

North America, Australia, and the UK, where the mainstream of the research has been conducted, belong to the countries with the lowest bicycle use (Pucher and Buehler, 2008). Active travelling in these countries is mainly walking. However, in some other countries the bicycle has a much more important role and can even be the dominant mode in home-to-school travelling (Boer and Goeverden, 2007). The large differences in bicycle use can be explained by different travel conditions like the presence of dedicated bicycle infrastructure, flatness of the route, and provision of dedicated school bus transport. However, socio-cultural factors are likely to play a role as well, as was demonstrated for the USA by Handy et al. (2010) and for Germany by Scheiner and Holz-Rau (2007).

The analyses for the Netherlands and Flanders in this paper regard two countries with a bicycle culture. In this respect the study differs from most other studies. The analyses may indicate

[1] Flanders is not a full country, being the Dutch speaking community of the federal state of Belgium, but it has a certain national identity. The Netherlands and Belgium used to be one country before 1830. One of the reasons for the separation was the system change from Roman-Catholic schools to 'general Christian' public schools being imposed by the Dutch King William I in the whole country, including the predominantly Roman-Catholic Belgian area.

Table1
Sources: school location figures: CBS, Jaarboek onderwijs in cijfers 2010 and http://www.ond.vlaanderen.be/onderwijsaanbod.
area figures: http://www.compendiumvoordeleefomgeving.nl/indicatoren/nl0060-Bodemgebruik-in-Nederland.html?i=15–18 and http://economie.fgov.be/nl/statistieken/cijfers/leefmilieu/geo/bebouwde_gronden
population figures: (http://statline.cbs.nl/StatWeb and http://statbel.fgov.be/nl/statistieken/cijfers).

	Area (km^2)		Population (2008)			Primary schools (2011)			Secondary schools (2011)		
	Total	Resid.	*1000	per km^2 Total area	Resid. area	#	per km^2	per 1000 inhab.	#	per km^2	per 1000 inhab.
NL	33,719	2301 6.8%	16,405	487	7130	9000*	0.267	0.549	1500*	0.044	0.091
FL	13,522	1531 11.3%	6162	456	4025	2741	0.203	0.445	830*	0.061	0.135

* Estimated figure.

to which extent results from particularly modal choice studies in countries with low bicycle use are valid in countries with a clear bicycle culture. The Netherlands and Flanders are comparable in several respects: they have freedom of school choice and a competitive school system with religious and nonreligious schools; the overall population density is similar; the surface is mainly flat in both countries; provision of school transport is comparable; and both countries have a cycling culture (Boer, 2010). Supply of public transport is comparable as well; in both countries regular hourly or more frequent bus and rail services are provided in daytime, where the buses serve nearly all settlements with over 1000 inhabitants. There are some differences as well. Unlike Flanders, the Netherlands have traditionally a strict policy in concentrating new residential developments in or around the existing settlements. As a result residential land use is more concentrated in the Netherlands implying higher population densities inside the residential areas. This might affect distances to eligible schools. The latter are also affected by differences in school densities, where in the Netherlands the density of primary schools is higher and in Flanders that of secondary schools; see Table 1 for density figures. Finally, the Netherlands have more and better dedicated bicycle infrastructure than Flanders. This might affect modal choice.

3. Data used for the analysis

The analyses are based on data from the Dutch and Flemish national travel surveys: the Dutch 'Mobiliteitsonderzoek Nederland' (Dutch MON, 2011) and the Flemish 'Onderzoek Verplaatsingsgedrag' (Flemish OVG, 2011). The two most recent surveys of each country that were available at the time of the analysis are explored. The Dutch data regard the years 2008 and 2009, the Flemish data cover the period September 2007–September 2009. The organisation of the surveys in the two countries is slightly different. In the Dutch survey a sample of households is selected and the members of these households are asked about their trips on a certain day. In the Flemish survey individual persons are selected and asked about their trips on a certain day. The surveys record data on leg, trip, person, and household level. In the Flemish survey that includes data of only one member of a household, additionally some characteristics of the head of the family are asked for. For the modal choice analyses in Section 5 we add the observations of the older Flemish OVG from 2000 to the analysed data in order to have sufficient observations. The 2000-survey was organised on household level just like the Dutch MON-survey.

Both in the MON- and the OVG-surveys no clear instructions are given about the person who has to complete the forms for younger children. In the explanation to the MON-forms respondents are instructed to answer the questions as far as they are able to do so. The OVG-explanation states that parents are allowed to help their children in completing the forms.

For the analyses only the data of the first observed home-to-school or school-to-home trips of each pupil are used. Selection of just the first observed commuting trip has implications for both travel distances and modal splits. Travel distances would be slightly smaller if all commuting trips were included in the analysis, because pupils are inclined to travel more frequently between home and school when distances are shorter, especially for having lunch at home. There is also an implication for modal choice which is due to the fact that a large majority of the selected trips are home-to-school trips. These trips have in primary education a slightly higher proportion of chauffeured children than school-to-home trips (2% difference in the Netherlands, 6% in Flanders). Wong et al. (2011) report similar findings for Canada.

The analyses are based on the reported distances by the respondents, not on estimated true distances. The surveys do not provide sufficient information for an accurate estimation. Hendrikx and Moritz (1990) compared registered trip distances in the Dutch NTS with true distances and found that generally very short distances (<1 km) are underestimated (20–40% depending on mode; 40% regards car drivers) and that longer distances are somewhat overestimated (0–15%).

A distinction will be made between primary and secondary education, because travel behaviour is likely to be different. However, information about the school level of the responding pupils is lacking in the surveys. We assume that each pupil visits the kind of school that he/she would visit in the normal situation, that is, if he/she does not repeat or skip a year at primary school. For the Dutch pupils, those aged 5–11 are assumed to visit primary schools and those aged 13–17 are assumed to visit secondary schools. Pupils of 12 years old cannot be assigned unambiguously to one type of education and are left out from the analyses. The Flemish data that include year of birth, allow defining the type of education in the normal situation for each responding pupil. A pupil is assumed to participate in primary education if the difference between the year of observation and the year of birth is less than 12, or if the difference is equal to 12 and the observation is made in the first half of the year before the summer holiday. Otherwise secondary education is assumed. It can be calculated from Dutch and Flemish statistics (http://statline.cbs.nl/StatWeb and http://www.ond.vlaanderen.be/onderwijsstatistieken) that the assumptions match well with the real participation in primary and secondary education. The mismatch is 0.17% for the Dutch primary group, 0.6% for the Dutch secondary, 0.2% for the Flemish primary and 2.0% for the Flemish secondary.

4. School travel characteristics in the Netherlands and Flanders

This section gives some descriptive figures regarding distances travelled to school and modal splits in school trips. These

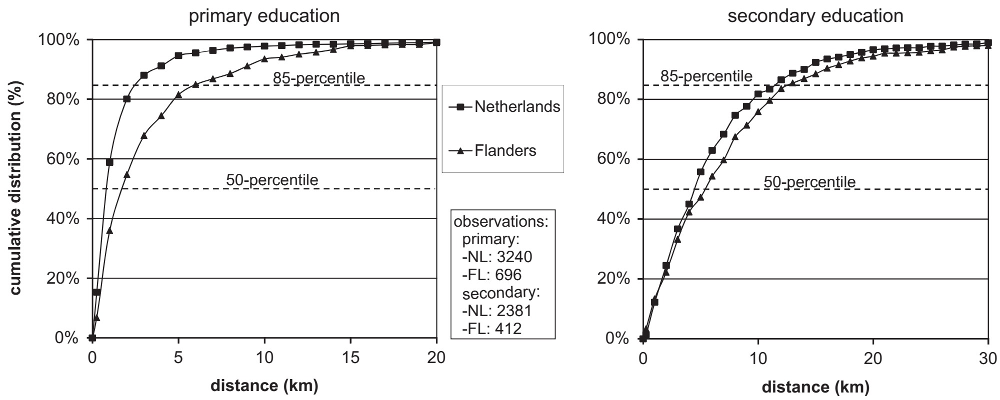

Fig. 2. Home-to-school distances for pupils in the primary school age (left) and the secondary school age (right).

inform about actual travel behaviour and may be helpful for the interpretation of the results of the analysis of the influence of explanatory variables in Section 5.

4.1. Home-to-school distances

Primary schools are widespread and are present in many smaller settlements. Therefore, home-to-school distances in primary education might be expected to be generally short, less than 5 km. Yet some pupils in the age of 5–11 may be faced with (substantially) larger distances, particularly when they visit special schools or when they opt for either education of a specific denomination like Roman Catholic, or of a distinct approach like Montessori. Secondary education is provided predominantly in the cities that function as regional or higher-level centre. They serve mostly areas in the order of 15 km around the city. Therefore, distances to secondary schools are likely to be significantly larger than those to primary schools.

The expectations regarding differences between distances to primary and secondary schools are confirmed by Fig. 2. The figure includes two graphs that show the cumulative frequency distributions of home-to-school distances for Dutch and Flemish pupils in the primary and the secondary school age. The distances underlying the graphs are the reported distances by the survey respondents.

The distributions of travel distances for pupils in the primary school age (left graph) differ substantially between the Netherlands and Flanders. Flemish pupils travel longer distances, on average nearly 2 times longer than the Dutch (3.6 km versus 2.0 km). Possible explanations are differences in the distances to be travelled to the nearest school and differences in the selectiveness of parents in choosing a school for their children. Larger distances to the nearest school in Flanders are likely because of the lower population density in residential areas (Table 1). Selectiveness in school choice is more conspicuous in Flanders; parents have the opportunity to register their children on specific days and the media show on these days hundreds of ambitious parents queuing for popular schools.

The two distance curves to secondary schools (right graph) show larger distances for the Flemish pupils as well, though the relative difference between the curves is smaller than in the case of primary schools. The average distances are 6.9 km and 8.3 km for the Dutch and Flemish respectively. The longer distances for the Flemish pupils are remarkable because the density of secondary schools is higher in Flanders (Table 1). Possibly, the differences in residential densities play here a role as well. Other possible explanations are a higher spatial concentration of secondary schools in Flanders and a more selective school choice by Flemish parents or students.

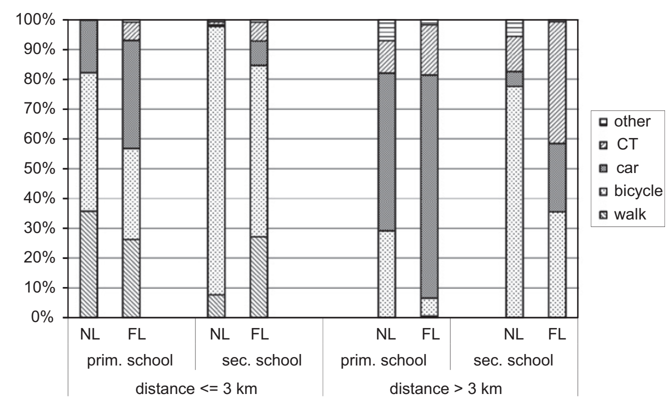

Fig. 3. Modal split in home-to-school trips in the Netherlands (NL) and Flanders (FL).

Comparison of the observed distances with older data demonstrates one significant change: the distances travelled by Flemish pupils to primary schools increased by about 50% between 1994 and 2008 (Goeverden and Boer, 2010). This increase can only to a small extent be explained by spatial developments; residential densities are slowly decreasing (by 4% between 2002 and 2008). The impression is that Flemish parents have become more selective in choosing primary schools.

4.2. Modal split

Modal choice is dependent on the relative quality of the available travel modes. These qualities are strongly related to distance. Walking is a feasible mode for just short distance trips while public transport is primarily an option for longer distances. The importance of distance is demonstrated in many studies (see Section 2). Therefore, for the modal split and modal choice analyses two distance classes are distinguished, short and long distances (≤ 3 km and > 3 km respectively). A trip distance of 3 km is about the maximum that is observed for walking trips and is also close to the point where a positive correlation between distance and bicycle use turns into a negative correlation.

The mode of a trip is defined as the main mode. In multimodal trips this is the mode that is used for the longest leg of the trip. The modal splits are displayed in Fig. 3. The observation numbers are large; they range from 114 for the Flemish in the primary school age travelling > 3 km to 3639 for the Dutch in the primary school age travelling ≤ 3 km. Collective transport (CT) in the figure includes both public transport and dedicated school transport.

The figure shows large differences in modal splits. Dutch pupils are more inclined to travel by bike, while Flemish pupils more frequently are carried by car and use public transport. Remarkable results are that, in contrast to the Netherlands, in Flanders (a) only few pupils younger than 12 will use the bicycle for longer distances, and (b) it is rather common to drive pupils in the secondary school age to school by car. The general impression is that Dutch pupils travel more independently to school than Flemish pupils.

5. Analysis of influencing variables

This section explores which variables explain significantly the home-to-school distance and the modal choice in travelling to school. The analysis should clarify to which extent choices are determined by hard and soft factors. Hard factors define the objective choice conditions by pupils or parents. These are the locations of eligible schools for explaining distance and the availability and quality of travel modes for explaining modal choice. Soft factors regard characteristics of the pupils, their parents or the household. By comparing two countries with their own traditions and preferences, the influence of nationality can be assessed as well.

Generally, the data have a limited quality in describing the hard factors. There is no information about which schools are eligible for individual pupils, and data about modal qualities for individual trips are not available as well. Such factors can only be roughly approached by correlating variables. On the other hand, the data are well-suited to analyse the influence of soft factors.

5.1. Factors affecting home-to-school distances

The distance that a pupil has to cover is directly related to the choice of a school from the set of eligible schools. Which schools are eligible for a pupil depends on school level, type of education, preferences regarding religious denomination, etc. Apart from these, the distance to a school should not be too large. The data give no direct information about which schools are eligible for the responding pupils. However, some variables correlate with factors that define the distances to eligible schools and give the opportunity to include a rough description of these distances in the model. These variables are:

- Population density of the living environment. Distances may be larger when pupils are living in less densely populated areas. If the population density is low, the school density generally is low as well, particularly in secondary education. The population density is indicated by two variables: province and degree of urbanisation of the home municipality. In particularly the Netherlands most provinces can be characterised as either mainly rural or highly urbanised.
- Importance of the city where the school is located. Generally, school types with low densities are only located in the more important cities and require travelling on relatively large distances. This variable is indicated by the degree of urbanisation of the school municipality.
- Age of the pupil. As mentioned in Section 3, age enables us to make an accurate assignment to primary or secondary education. More in general, older pupils will have to travel larger distances because they participate in higher level education that is connected with a lower density of school locations.
- Gender. Boys have more frequently special needs and they are participating to a higher extent in special education than girls are. The ratios are about 2.5:1 for the Netherlands and 1.7:1 for Flanders; the ratios are similar for primary and secondary education (http://statline.cbs.nl/StatWeb and http://www.ond.vlaanderen.be/onderwijsstatistieken). Because the density of special education facilities is very low compared to the normal school density, boys will on average have to travel larger distances.

These variables can be considered as hard variables. They determine partly the ‘choice set’ of schools and related distances to home. One should note that age and gender may also have soft impacts that are independent from the relation with school type. Age will be affected when parents are not satisfied with the initially selected school and look for another school during the course. In the case of gender, parents might be more worried about their daughters’ exposure to traffic or insecurity than about that of their sons. Then they will be more inclined to choose the nearest school for girls than for boys.

In addition, one may hypothesise that the following soft variables affect home-to-school distances at given choice sets, by affecting either selectiveness in school choice or the influence of distance:

- Education level of the parents. Parents with higher education levels may be more selective in school choice.
- Household income. A higher income might both increase selectiveness in school choice and lower the resistance of distance.
- Religious orientation. Parents who prefer education of a certain religious denomination for their children will be more selective in school choice.
- Size of the household. The more children are visiting schools, the more difficult is organising transport to distant schools.
- Car ownership of the household. Higher car ownership increases the opportunity to choose a more distant school.

  Car ownership or drivers’ licence of the students themselves have no relevance because at the selected ages (under 18) children are not permitted to drive a car.

The data give information about all of the listed soft variables except for religious orientation. Therefore, the influence of this variable will not be analysed. The variable ‘education level of the parents’ is represented by the education of the highest educated responding parent in the Dutch MON-databases that principally include information about all household members, and by the education of the head of the family in the Flemish OVG.

The influence of the variables is examined simultaneously using the Structural Equations Modelling package AMOS 20. Several model specifications are tested: models with one endogenous variable (distance) and models where some of the initially exogenous variables are made endogenous by giving them an intermediate function between (some of) the other exogenous

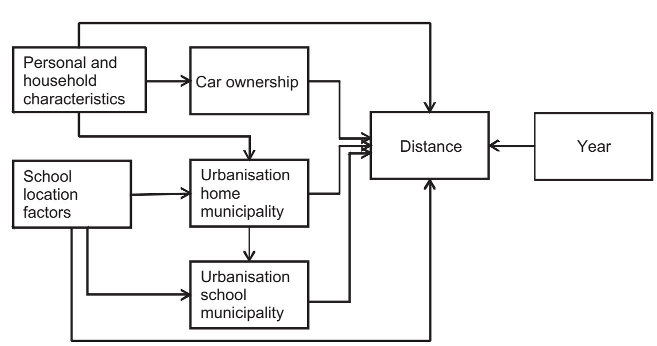

Fig. 4. Basic specification of the distance-model.

variables and the distance variable. The variables that are made endogenous are the two urbanisation variables and car ownership. The reasons are (a) observed strong correlations between these variables and most of the other exogenous variables, and (b) the theoretical notion that the urbanisation of the home municipality and car ownership are the result of choices (the choice where to live and the choice to buy one or more cars) where a relation with other personal and household characteristics might be hypothesised. The models with more endogenous variables prove to perform much better for each group than the simple model with one endogenous variable. Therefore, we choose the former for the definite analyses.

Fig. 4 displays a diagram with the general specification of the model. The intermediate variable 'car ownership' is hypothesised to be influenced only by person and household characteristics; the urbanisation of the home municipality is hypothesised to be influenced by both person/household characteristics and school location factors (other than the municipal urbanisations; in this study these 'factors' stand for just one variable, the province of the home address). A special case is the urbanisation of the school municipality. This variable is in fact an outcome of the school choice and no input, just like the distance. However, inclusion in the model improves the fit and shows a strong and highly significant influence on the distance for all groups. Besides, it is highly correlated with the urbanisation of the home municipality, in particular in primary education where home and school usually are located in the same municipality. Therefore, we included the variable as intermediate variable between urbanisation of the home municipality and the distance. Based on strong correlations with the province of the home address, we made it dependent on this variable as well. Finally, we included a variable 'year' in the model. This variable reflects the year of the survey and is added in order to neutralise possible impacts of time. It is defined as the year of the survey minus 2000.

To find out whether groups behave differently, AMOS produces results for both unconstrained and constrained models. In the unconstrained models the parameters are estimated for each group separately (Dutch primary, Dutch secondary, Flemish primary, Flemish secondary) and the coefficient of a variable can have different values for different groups. In constrained models, some restrictions are imposed on the parameters, increasing the number of degrees of freedom. A restriction can be that an explanatory variable has the same coefficient for each group. If a constrained model has a better fit than the unconstrained model, the former should be preferred and groups might not differ significantly.

The constrained models where equal values are imposed on the coefficients for all four groups perform worse than the unconstrained models. This is not surprising, considering that the distribution of the distance—the dependent variable—differs largely between primary and secondary education. However, if only the coefficients of the group pairs with the same education level are assumed to be equal, the constrained models perform best. Table 2 shows indications of the fit for the unconstrained and two types of constrained models for both primary and secondary education. The analysed constrained models are the structural weights model where the coefficients of the explanatory variables are set equal, and the structural intercepts model where in addition the intercepts are set equal.

The presented indications of the fit are the relative χ^2 (chi-square divided by the number of degrees of freedom), the root mean square error of approximation (RMSEA), and the squared multiple correlation (SMC) for the distance. For a good fit, the relative χ^2 should preferably be lower than 2, and the RMSEA lower than 0.05. The SMC indicates the proportion of the variance of the dependent variable that is explained by the explanatory variables in the model and should preferably be closer to 1 (100% of the variance is explained) than to 0 (nothing is explained).

There are no marked differences between the different models regarding their fit. The fit of each model is rather bad but not too bad. The constrained models have a somewhat better fit than the unconstrained, and within the constrained models the structural weights models perform slightly better than the structural intercepts models. Before equalising the coefficients of groups of the two countries in the constrained models we harmonised the variables that differ for the different countries. First we left the provinces, that are typically connected to one country, out of the model. In the unconstrained models the provinces have a significant influence for mainly the group Dutch secondary where in rural provinces the distances are longer than in the more urbanised provinces. Second, we reclassified the urbanisation and income variables because they have different definitions in (the data from) the two countries. We constructed an urbanisation variable with five classes that is comparable for both countries, and defined an income variable with three classes that has class limits that do not differ too much for the two countries. Table 3 gives an overview of the analysed variables and observation numbers in the best performing constrained models where the two primary age groups and the two secondary age groups are combined.

The variables gender, income, and parental education are treated in the analysis as categorical variables, the other variables as continuous variables. If a variable is ordinal, one of the two extreme classes is chosen as the reference class, in principle the extreme with the largest number of observations. In order to prevent unwanted impacts of outliers, only observations of distances shorter than 40 km in the case of primary education or shorter than 80 km in the case of secondary education are analysed.

We used three estimation methods: maximum likelihood, Bayesian estimation, and bootstrapping. Maximum likelihood selects values of the parameters that produce a distribution that gives the observed data the greatest probability. Bayesian estimation maximises the posterior expectation of a utility function. Bootstrapping is a resampling method that can be used for any distribution of the dependent variable. The three methods all produced nearly the same coefficients. The same is true for the standard deviations produced by maximum likelihood and Bayesian estimation. The bootstrapping standard deviations sometimes differ significantly from the others. We therefore present only one estimate of the coefficients (maximum likelihood) and both the maximum likelihood (ML) and bootstrapping (BT)

Table 2
Fit of unconstrained and constrained models.

	Primary education			Secondary education		
	Unconstrained	Structural weights	Structural weights and intercepts	Unconstrained	Structural weights	Structural weights and intercepts
X2/df	5.97	5.12	5.37	6.99	6.03	6.06
RMSEA	0.040	0.036	0.038	0.052	0.047	0.048
SMC distance	0.237/0.073	0.222/0.204	0.225/0.201	0.180/0.261	0.173/0.235	0.174/0.236

Table 3
Analysed variables and observation numbers.

	Variable	Category		Observation numbers	
		Netherlands	Flanders	Primary	Secondary
Exogenous variables					
	Age pupil (years)				
	Gender pupil	Male		1558	1112
		Female		1541	1125
	Yearly income household (euro's)	< 22,500	≤ 24,000	325	268
		22,500–30,000	24,000–36,000	373	293
		≥ 30,000	> 36,000	2401	1676
	Size of household	1 or 2 members		52	67
		3 members		352	378
		4 members		1497	1009
		5 members		846	547
		> 5 members		352	236
	Education level parent(s)	Primary school		35	56
		Lower secondary school		284	302
		Higher secondary school		1300	909
		Academic		1480	970
	Year–2000				
Intermediate variables					
	Urbanisation home municipality	Not urbanised		627	414
		Little urbanised		730	577
		Fairly urbanised		672	459
		Highly urbanised		299	253
		Very highly urbanised		771	534
	Urbanisation school municipality	Not urbanised		610	157
		Little urbanised		716	439
		Fairly urbanised		667	511
		Highly urbanised		307	338
		Very highly urbanised		799	792
	Number of cars in household	No car		89	97
		1 car		1424	1070
		2 cars		1519	964
		3 or more cars		67	106
Fully dependent variable					
	Distance (km)			3099	2237

Table 4a
Significant variables for home-to-school distances in the structural weights model (primary education).

Variable	Category	Coeff. ML	St.dev. ML	St.dev. BT	Crit. ratio ML	Crit. ratio BT
Urbanisation home municipality		−3.488*	0.127	0.524	−27.51	−6.632
Urbanisation school municipality		3.614*	0.126	0.520	28.58	6.923
Age		0.099*	0.023	0.023	4.237	4.304
Gender (female=ref)	Male	0.185	0.094	0.093	1.978	1.925
Number of cars in household		0.224	0.088	0.081	2.554	2.790
Income household (high=ref)	Low	0.456	0.175	0.193	2.607	2.352
	Medium	0.721*	0.161	0.205	4.478	3.483
Size of household		0.125	0.055	0.059	2.266	2.186
Year-2000		0.194	0.093	0.093	2.077	2.086
Intercept	Dutch	(−0.995)	0.860	0.849	−1.156	−1.194
	Flemish	(0.047)	0.854	0.856	0.055	0.039

* Significant on a 99% level.

Table 4b
Significant variables for home-to-school distances in the structural weights model (secondary education).

Variable	Category	Coeff. ML	St.dev. ML	St.dev. BT	Crit. ratio ML	Crit. ratio BT
Urbanisation home municipality		−2.782*	0.147	0.202	−18.97	−13.78
Urbanisation school municipality		2.312*	0.157	0.214	14.77	10.80
Age		1.054*	0.114	0.128	9.231	8.289
Gender (female=ref)	Male	0.838	0.329	0.338	2.548	2.456
Number of cars in household		0.748*	0.278	0.278	2.695	2.683
Parental education (academic=ref)	Lower sec. school	1.512*	0.504	0.578	2.999	2.602
Intercept	Dutch	−8.926*	3.326	3.238	−2.683	−2.771
	Flemish	−9.382*	3.163	3.041	−2.966	−3.090

* Significant on a 99% level.

estimates of the standard deviations and the critical ratios. The critical ratios are defined as the ratios of estimated means and standard errors and they are close to the t-values in large samples.

Tables 4a and 4b show the estimation results of the structural weights model. The presented results are limited to the explanation of the distance, the only dependent variable we are interested in. Only the variables that are significant on a 95% level for the primary and secondary age groups are displayed. Initially all variables were included in the model and then variables that were not significant on a 95% level were left out.

An interesting observation is that in both tables the intercepts for the Dutch and Flemish do not differ significantly, despite the fact that the structural intercepts models have a slightly worse fit than the structural weights models. If still the intercepts are assumed to be equal, most results are close to those presented in Tables 4. However, there is one remarkable difference: the year variable in Table 4a is not significant any more. Car ownership and income become more significant.

What can be concluded from the results of the analyses? First, the observation that the constrained models perform better than the unconstrained models suggests that nationality has no important influence, at least with regard to the two studied countries. Second, looking at the rather bad fit of the models (Table 2), the explanatory variables make just a limited contribution to the explanation of the distance. One or more important explanatory variables are missing. We hypothesise that the distance to the nearest school is the most important missing variable. In that case, the location of the schools relative to the home locations is highly influencing on home-to-school distances. Third, looking at the significant variables in the model, both hard and soft variables play an important role, though the hard seem to dominate. Hard variables are in the context of Tables 4 the variables that relate to the locations of eligible schools: the two urbanisation variables, age and gender. Most influencing are the degrees of urbanisation of the home and school municipalities; these two variables are highly significant in all models. Age of the pupil is highly significant as well, in particular in secondary education. We hypothesise that the main reason is that at increasing age students participate in higher level education that is connected with a lower density of school locations, the 'hard' component of age. The influence of gender is in conformance with the expectations based on the higher participation of boys in special education. But a higher concern on the problems that girls might experience during their trips might play a role as well. The influences of the hard variables are all according to the hypotheses.

Each of the other—soft—variables have significant influences for at least one group. Car ownership increases the distance in both primary and secondary education. In primary education, distances are relatively large in the lower income classes and in large households. In secondary education, distances are relatively large when the parental education is low. The influence of car ownership is in conformance with the hypothesis, the influences of income, household size, and parental education are unexpected. A possible explanation is that these variables are not fully 'soft' but have hard components that affect the distance reversely. It may be hypothesised that pupils with special needs, that have to travel relatively large distances, are overrepresented in large households, households with low income, and households with low educated parents.

The main conclusion is that the home-to-school distance is predominantly explained by the hard variables. There is just one soft variable with a clear influence: car ownership. Lowering the resistance of distance by buying a car increases the distance travelled. This observation indicates that there is some selectivity in school choice. However, this selectivity is not clearly related to the other investigated variables.

5.2. Factors affecting modal choice

The analysis of modal choice regards the choice of the main mode of trips, defined as the mode that is used for the longest leg in the case of multimodal trips. Modal choice can be hypothesised to be influenced by modal attributes describing the qualities of the separate modes (hard variables), and by factors that influence mode choice via personal preferences (soft variables). Data about modal attributes were not available and could not be analysed. However, some available variables are (strongly) related to modal qualities and might give an indication of their influences. These variables and their hypothesised influences are:

- Distance. The longer the distance to school, the more competitive are the faster modes.
- Population density. In densely populated areas the quality of public transport is usually high, while the traffic conditions are relatively unfavourable for using active modes and in particular for the bicycle for reasons of safety. Public transport generally provides good services if the destination area is highly urbanised; usage of the car is then more difficult, partly because of parking problems.
- Weather. Bleak weather conditions will lower the probability of the 'outside' modes walking and cycling and increase the probability of car and PT use. Sabir (2011) found that in the Netherlands temperature is the most influencing weather variable on travel behaviour. The bicycle is the most sensitive mode to weather conditions.

Variables that may influence mode choice via personal preferences are:

- Age. The older the pupil, the more independent he/she will be in using travel modes.
- Gender. Girls may be travelling less independently than boys because they are exposed to higher security risks.
- Education level of the parents. The higher the education of the parents, the more they may be aware of the merits of independent travelling by their children.
- Household income. High income facilitates travelling with the relatively expensive motorised modes.
- Size of the household. The larger the number of school visiting pupils, the lower the probability to be escorted by the parents. When pupils travel together to the same school, the need for escorting is smaller; when they travel to different schools, escorting all pupils is more difficult to practice. This hypothesis is in line with existing studies. Weigand and McDonald (2011) observe that children of larger families learn to travel without a parent in order to simplify school commuting. Susilo and Waygood (2012) find a negative relation between household size and car dependence of children.
- Ethnicity. In the Netherlands large differences in modal splits between groups of different nationalities are found. A common observation is that immigrants use the bicycle less frequently than natives do (Harms, 2006). Differences in modal choice in travelling to school can then be expected as well. Influences of ethnicity are also found in the US (He, 2011).
- Car ownership of the household. Higher car ownership will increase the probability of car use.

The influences of all listed variables are investigated, except for ethnicity. The survey data give no information about ethnicity of the respondents. In contrast to the analysis in 5.1 population density is represented by the published municipal degrees of urbanisation that are defined differently in the two countries. For the analyses of modal choice in longer distance trips (> 3 km) the urbanisations of both the home and the school municipalities are included in the model. In the case of short distance trips only the urbanisation of the home municipality is included because for this segment home and school are nearly always located in the same municipality. Inclusion of the urbanisation degrees of both municipalities would imply inclusion of two variables that are extremely correlated. Weather is represented by the period of the year. A distinction is made between cold (December–February), moderate (March–April and October–November) and hot (May–September).

For analysing modal choice by the Flemish pupils we combined the databases of 2000 and 2008–2009 in order to enlarge the number of observations. When using only the data of 2008–2009 too many subcategory-mode combinations have no observations. We hypothesise that the modal choice process will not have changed significantly in the period 2000–2009. The large increase in average distance to primary schools should in principle not affect modal choice but only modal split. By including the variable 'year' possible changes in modal choice can be detected.

The influences of the variables are examined simultaneously using multinomial logistic regression (SPSS 16.0). The analyses

Table 5
Observation numbers by group, distance class and mode.

Group	≤3 km				>3 km			
	Walk	Bike	Car	Other*	Bike	Car	CT	Other*
Dutch primary	1021	1550	476	17	108	172	36	27
Dutch secondary	61	689	6	20	1143	85	347	104
Flemish primary	134	199	231	28	18	198	30	9
Flemish secondary	56	167	35	22	229	152	261	29

* Excluded from the analysis.

Table 6
Variables influencing modal choice in school trips ≤3 km. (bicycle is the reference).

Variable	Group	Category	Walk			Car		
			Coeff.	St.dev	P	Coeff.	St.dev	P
Distance (km)	DP		−4.053	0.170	0.000	0.484*	0.075	0.000
	DS		−4.394*	0.570	0.000			
	FP		−2.785*	0.350	0.000	0.861*	0.144	0.000
	FS		−1.977*	0.342	0.000			
Season (warm=ref)	DP	Cold				0.588*	0.142	0.000
		Moderate				0.361*	0.135	0.008
	FP	Cold				1.174*	0.296	0.000
		Moderate				1.173*	0.272	0.000
Urbanisation home municipality (not urb./low=ref)	DP	Little urbanised				0.478*	0.167	0.004
		Fairly urbanised	0.453*	0.159	0.004	0.479*	0.172	0.005
		Highly urbanised	0.832*	0.162	0.000	0.584*	0.174	0.001
		Very highly urb.	0.926*	0.236	0.000			
	DS	Very highly urb.	1.793	0.833	0.031			
	FP	High	1.443*	0.349	0.000			
	FS	High				−1.357	0.659	0.040
Age (year)	DP		−0.074*	0.027	0.006	−0.331*	0.030	0.000
	FP		−0.207	0.089	0.021	−0.340*	0.070	0.000
Gender (female=ref)	FS	Male				−1.183	0.469	0.012
Car ownership household (no car=ref)	DP	1 car	−0.752	0.343	0.028	2.093*	0.758	0.006
		2 cars	−0.863	0.352	0.014	3.023*	0.762	0.000
		3 or more cars	−1.850*	0.515	0.000	2.906*	0.840	0.001
	DS	1 car	−1.852*	0.589	0.002			
		2 cars	−1.428	0.615	0.020			
		3 or more cars	−2.978	1.312	0.023			
	FP	2 or more cars				1.655*	0.632	0.009
	FS	1 car	−1.699	0.672	0.011	15.20*	0.608	0.000
		2 or more cars	−1.984	0.823	0.016	16.95	0[a]	-[a]
Yearly income household (> €36,000=ref)	FP	≤ €24,000	1.059	0.443	0.017			
	FS	€24,000–€36,000	−1.622*	0.596	0.007			
Size of household (>5 memb.=ref)	DP	1 or 2 members	−1.416*	0.517	0.006	2.033*	0.486	0.000
		3 members	−0.459	0.228	0.044	0.947*	0.271	0.000
		4 members	−0.503*	0.177	0.004	0.631*	0.226	0.005
	DS	3 members	−2.094*	0.785	0.008			
	FP	4 members	−1.258*	0.478	0.008			
	FS	<4 members	−1.741	0.701	0.013			
		4 members	−1.622	0.645	0.012			
		5 members	−1.591	0.665	0.017			
Parental education (academic=ref)	DP	Lower sec. school	0.636*	0.187	0.001			
		Higher sec. sch.	0.381*	0.117	0.001			
	FS	Lower sec. school				2.377*	0.756	0.002
Group dummy (FS=ref)	DP					14.87*	1.596	0.000
	FP					18.10*	1.681	0.000
Group dummy (FP=ref)	DP					−3.235	1.293	0.012
Intercept	all		5.381*	1.168	0.000	−18.07*	1.360	0.000
Pseudo R^2 (McFadden)			0.38					

* Significant on a 99% level.
[a] No observed car trips in the reference category 'no car'.

are performed separately for the two distance classes defined in Section 4.2: ≤ 3 km and > 3 km. The four groups (Dutch primary, Dutch secondary Flemish primary, Flemish secondary) are combined in the analyses, and dummy variables indicating whether an observation belongs to a certain group are added to the models. Observations with distances exceeding 150 km are excluded. The analysed modes are walking, bicycle and car for the short distances, and bicycle, car and collective transport for the longer distances. The mode collective transport includes both public transport and dedicated school bus transport. Excluded modes have always few observation numbers, with one exception: Dutch pupils in the secondary school age that use the moped for distances > 3 km. This group has 86 observations, about as many as those using the car. For comparability of the results for the different segments as well as for different ages (only persons aged 16 years and older are allowed to drive a moped), we excluded this mode. Table 5 shows the observation numbers by group, mode and distance class.

In the modal choice analyses most variables are treated as categorical variables. The only continuous variables are distance, age and year. Tables 6 and 7 show the results for the two distance classes. Only variables/categories that are significant on a 95% level are included in the table. Significance on a 99% level is indicated by an asterisk.

The figures in the two tables demonstrate that both the hard variables describing modal qualities (distance, season and urbanisation) and the soft variables can be highly influential. Distance is the most influencing variable. Increasing distance decreases the probability of walking and increases both usage of car and CT (collective transport). The other hard variables have significant influences as well. Increasing temperature increases the probability of cycling at the cost of both usage of car and CT. Increasing urbanisation lowers the probability of cycling for short trips at the benefit of both walking and–except for the highest level of urbanisation–car use. For longer trips, urbanisation generally enlarges use of CT. There is one exception: the Dutch travelling to primary schools and living in rural municipalities are relatively inclined to use CT. The latter is the only finding that is not according to the hypotheses. In the group Dutch primary travelling longer distances, dedicated bus transport accounts for a large part of collective transport and the hypothesised relation between public transport and urbanisation might not be valid for dedicated bus transport.

Most of the soft variables have a larger or smaller significant influence as well. Increasing age increases the probability of cycling at the cost of both walking and car use in primary education. In the case of Dutch secondary, both usage of car and CT increase with increasing age at the cost of the bicycle. Gender has only an impact in Flanders. Boys are more likely to use the bicycle for travelling to secondary schools at the cost of both car and collective transport. Car ownership generally increases car use and is beneficial for the bicycle as well in the choices between bicycle and both walking and CT. Income has few and sometimes ambiguous impacts. Earning a low income is both favourable and

Table 7
Variables influencing modal choice in school trips > 3 km. (bicycle is the reference).

Variable	Group	Category	Car			Collective transport		
			Coeff.	St.dev	P	Coeff.	St.dev	P
Distance (km)	DP		0.509*	0.102	0.000	0.553*	0.103	0.000
	DS		0.234*	0.023	0.000	0.356*	0.021	0.000
	FP		0.779*	0.255	0.002	0.880*	0.257	0.001
	FS		0.291*	0.036	0.000	0.348*	0.036	0.000
Season (warm=ref)	DP	Moderate	1.003*	0.378	0.008	2.090*	0.655	0.001
	DS	Cold	0.886*	0.297	0.003	0.549	0.240	0.022
Urbanisation home municipality (not urb./low=ref)	DP	Little urbanised				−4.132	1.741	0.018
		Highly urbanised				−4.647	1.962	0.018
	DS	Highly urbanised				1.738*	0.296	0.000
		Very highly urb.				2.811*	0.352	0.000
	FS	High				0.916*	0.272	0.001
Urbanisation school Municipality (not urb.=ref)	DP	Little urbanisEd				5.031	2.007	0.012
		Highly urbanised				5.641*	2.076	0.007
Age (year)	DP		-0.577*	0.096	0.000			
	DS		0.302	0.089	0.001	0.432*	0.070	0.000
	FS		−0.139	0.070	0.047			
Gender (female=ref)	FS	Male	−0.634*	0.229	0.006	−0.909*	0.218	0.000
Car ownership household (no car=ref)	DP	1 car	21.95*	1.358	0.000			
		2 cars	22.52*	1.337	0.000			
		3 or more cars	24.68	0 [a]	- [a]			
	DS	1 car				−1.470*	0.387	0.000
		2 cars				−1.473*	0.398	0.000
		3 or more cars				−1.776*	0.577	0.002
Yearly income household (≥ €30,000=ref)	DP	< €15000	2.058	1.014	0.042			
Size of household (> 5 members=ref)	DP	3 members	1.666	0.706	0.018			
		4 members	1.126	0.531	0.034			
	FS	< 4 members	1.402	0.557	0.012			
Year	DS		0.570	0.240	0.018			
Group dummy (FS=ref)	DP		−19.47*	2.000	0.000			
	DS					−8.777*	2.281	0.000
Group dummy (FP=ref)	DP		−19.16*	1.980	0.000			
	DS					−5.941	2.333	0.011
Group dummy (DS=ref)	DP					5.853	2.945	0.047
Intercept	All		(−1.189)	1.157	0.304	(−1.436)	1.065	0.177
Pseudo R^2 (McFadden)			0.44					

* Significant on a 99% level.
[a] No observed car trips in the reference category 'no car'.

unfavourable for walking by the Flemish (in primary and secondary education respectively) and seems favourable for car use to primary schools in the Netherlands. Increasing household size increases walking at the cost of the bicycle and increases bicycle use at the cost of the car. Parental education has only some impacts on short distances. When the parents are higher educated, their children are more likely to use the bicycle unlike walking in the case of Dutch primary and unlike car use in the case of Flemish secondary.

A few findings are unexpected and opposite to the hypotheses. The first is the observed decrease of the bicycle use at the benefit of car and CT at an increasing age for the Dutch travelling to secondary schools on longer distances. Are Dutch teenagers more devoted to a luxury lifestyle when they grow older? Or do they take decisions less dependent from the parents who possibly prefer cycling? Or should pupils that use the moped when they are 16 or older otherwise have predominantly used the bicycle rather than car or CT? Other unexpected results regard the influences of income. Possibly, correlation with other variables like education level of the parents affects the outcomes for the income variable.

A remarkable additional result is that car use in trips to secondary schools on longer distances by the Dutch has significantly increased in the short period covered by the analysed data (2008–2009). We add here that the influence of the year on the choice between car and bicycle for the Flemish travelling to primary schools is the reverse, but this influence is just not significant on a 95% level and is therefore not included in the table.

The group dummy variables indicate that there are significant differences between the two levels of education and also between the two countries. At short distances, car use is relatively high in primary education. At longer distances, Dutch pupils are more inclined to use collective transport when they travel to primary schools, which is to a large extent dedicated bus transport for this group. A clear difference between the two countries is that Dutch pupils are more inclined than the Flemish to use the bicycle. Flemish pupils more frequently use the car in primary education and collective transport in secondary education.

The reported intercepts are the intercepts of the model where the Flemish secondary are taken as the reference for the group dummies. When choosing another reference, the intercept changes. For this reason, the findings for the group dummies are put in italics when Flemish secondary is not the reference.

A general conclusion is that the hard variables play a dominant role. Most important is the distance. Still, many soft variables are highly significant as well. The significant variables include nationality. The Dutch use more frequently the bicycle, the Flemish the car and collective transport. However, a tendency of increasing car use is observed for the Dutch pupils while the outcomes suggest an opposite tendency for the Flemish pupils. Both countries might slowly come closer to each other.

6. Conclusion and discussion

This paper analyses school travel behaviour in two countries with high bicycle use: the Netherlands and Flanders. Educational policies and geographical conditions are similar in the two countries but there are differences in spatial concentration of urban activities and in culture. Outstanding differences regarding school travelling are that Flemish pupils travel substantially larger distances to primary schools and that Dutch pupils use the bicycle more frequently.

School travel behaviour has two important components: the distance between home and school and the modal use. Both components are mainly explained by 'hard' factors, that define the objective conditions for school choice or modal choice: the locations of the eligible schools and the qualities of the eligible modes respectively. The home-to-school distance itself is the most important hard factor for explaining modal choice. There are good opportunities for policy interventions because the hard factors are the factors par excellence that can be influenced by policy. If the objective is to increase the share of active modes, both a school location policy that aims to shorten the distances to the nearest school and an infrastructure policy that improves the travel conditions for walking and cycling can be effective.

Other, socio-cultural factors, are less important. This is particularly true for the explanation of distances, where just one 'soft' variable has a clear significant influence: car ownership. In the case of modal choice several socio-cultural variables play a role. Car ownership is again very important, other important variables are size of the household and age of the pupil. Remarkably, gender has a significant influence in Flanders only; in the Netherlands there is no trace of any impact. The Flemish findings that boys in the secondary school age are more inclined to use the bicycle than girls, are roughly comparable to findings in the US that with seventh to twelfth grade travellers, boys use more active modes and are less car dependent than girls (He, 2011). Most other outcomes are in line with other studies as well.

An important additional conclusion from the study is that the bicycle has the potential to account for a large number of trips and can even be the dominant mode in school travelling. Promoting cycling can be effective in increasing the share of active modes and thus in reducing car dependency. The bicycle competes with car and public transport on much larger distances than walking does. In the Netherlands generally five requirements for a good bicycle infrastructure are adopted: connectivity of the network, directness, safety, attractiveness of the route, and comfort (CROW, 2007). An additional requirement, in particular for children and women, is a good security.

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