Carpooling and employers: a multilevel modelling approach

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Abstract

Both public policy-makers and private companies promote carpooling as a commuting alternative in order to reduce the number of Single Occupant Vehicle (SOV) users. The Belgian questionnaire Home-To-Work-Travel (HTWT) is used to examine the factors which explain the share of carpooling employees at a worksite. The modal split between carpooling and rail use was also subject of the analysis. The number of observations in the HTWT database (n=7460) makes it possible to use more advanced statistical models: such as multilevel regression models which incorporate, next to the worksite level, also the company and economic sector levels. As a consequence, a more employer-oriented approach replaces the traditional focus of commuting research on the individual. Significant differences in modal split between economic sectors appeared. The most carpool-oriented sectors are construction and manufacturing, while rail transport is more popular in the financial and public sector. Carpooling also tend to be an alternative at locations where rail is no real alternative. Next to this, regular work schedules and smaller sites are positively correlated with a higher share of carpooling employees. Finally, no real evidence could be found for the effectiveness of mobility management measures which promote carpooling. However, most of these measures are classified in the literature as less effective and a case study approach should complete the research on mobility management initiatives.

KEYWORDS: mobility management, carpooling, commuting, multilevel modelling, Belgium

1. Introduction: the determinants of carpooling

Carpooling (ridesharing) is an important so-called single-occupant vehicle (SOV) alternative. In a carpooling arrangement, two or more employees ride together to work in a personal or company-owned car. Carpooling looks attractive due to the reduced costs, the relative door-to-door directness and a comfort level near to that of the SOV. But commuters perceive car sharing also as unreliable as they are dependent on someone else. The pick-up/drop-off delay and extra travel and waiting time make carpooling less suitable for short distances. The lack of flexibility and the loss of privacy seem also important discouraging factors. The availability of potential carpool partners which share both the same origin and destination zone is limited and is even more limited if only people with a similar socio-economic background are potential partners. In short, the economic advantage of carpool over driving alone is most of the times not strong enough to entice commuters towards the carpool alternative (Hwang and Giuliano, 1990; Comsis Corporation, 1993; Tsao and Lin, 1999; Kingham et al., 2001; Abbes-Orabi and De Wolf, 2007). The fact that only 3,8% of all Belgian employees commute as a car passenger is, as a consequence, not a surprising result (Verhetsel et al., 2007).

An overview of the determinants of carpooling is given in Table 1. Hwang and Giuliano (1990) indicate a higher concentration of employees as a first element that encourages ridesharing, due the more possible matches between employees. The more congested downtown areas, associated with a high transit access, less parking availability and higher parking costs, are, at least in the USA, correlated with a higher use of SOV alternatives. Longer commutes suits better with carpooling due the higher commuting costs and the relative shorter time spent on picking up and dropping off passengers. Finally, a regular work schedule makes it easier to find carpool partners with the same working hours.

Table 1: Main determinants of carpooling

Favourable	**Not Favourable**
Locational Characteristics	
Large firm	Small firm
Single site	Multiple sites
Downtown Area	Suburban location
High transit access	Limited transit access
Restricted parking	
Employee/Trip Characteristics	
Limited auto availability	>=one auto per worker
Long commute	Short commute
Regular work schedule	Irregular work schedule
	Household constraints

Source: Hwang and Giuliano, 1990

Different institutions take mobility management measures to promote SOV alternatives. Governments want to reduce the number of SOVs to tackle environmental problems like air pollution, but also to avoid the financial losses caused by congestion due to waiting time. One of the government strategies is to activate the private sector to take mobility management measures which promote a more sustainable commuting. But employers are not only confronted with the government regulations and recommendations, but also with recruiting problems due to accessibility problems. Especially in the USA, carpooling traditionally has been an important part of transport plans made by employers (Ferguson, 2000, p.81).

Despite the promotion of mobility management and the significant role employers play in the commute behaviour of their employees, the focus of commuting research is mainly on the individual commuter (e.g. Cao and Mokhtarian, 2005), while less attention goes towards the work side of the home to work travel (Rye, 1999; Abbes-Orabi and De Wolf, 2007; Heinen et al., 2008). The Belgian database Home-To-Work Traffic (HTWT) enables us to analyse the role of employers in the success of carpooling.

2. Data

2.1. The Database Home-to-Work-Traffic

Following a Belgian law of 2003 a new important source of data is available about home-to-work displacements of employees. This new dataset is based on a three-yearly questionnaire about the home-to-work displacements and the mobility management measures taken by employers of companies with at least 100 employees. The first questionnaire dates from 2005. The goal of these new regulations is twofold. On the one hand the government wants to collect information about the home-to-work-travel to underpin their mobility policy; on the other hand, there is the obligation to discuss the questionnaire in the works council. The objective of the latter is the creation of a platform among the social partners which can lead towards a company mobility plan, or at least to measures that support a more sustainable commute. The database HTWT contains 7460 work sites with at least 30 employees which employ 1 342 119 employees in total. On more than half of these worksites (4107 of 7460) no employees carpool. In what follows we distinguish the total group of worksites (N = 7460) and the worksites with at least one employee who carpools (N = 3353).

2.2. The variables

The variable of interest is the percentage of the employees of a work site which carpools to make the daily commute. First, two maps show the spatial pattern of carpooling in Belgium. The worksites are grouped at the municipality level. The first map (Figure 1) indicates the absence of a clear spatial pattern. The degree of similarity between neighbouring municipalities is called spatial autocorrelation. A well-known measure for spatial autocorrelation is the Moran's I statistic. The low value for the Moran's I statistic (0,0564; taking into account all other municipalities within a range of 20km) proves the absence of spatial autocorrelation. Next to overall measures for spatial autocorrelation, also Local Indicator of Spatial Association exist (LISA; Anselin, 1995). Such measures have a value for each observation and indicate both spatial clusters and spatial outliers. On the LISA map (Figure 2), a cluster of municipalities with low carpool values is situated in the centre of the country and carpooling seems more popular in the east and in some other more peripheral locations.

Figure 1: Map of carpool share per municipality

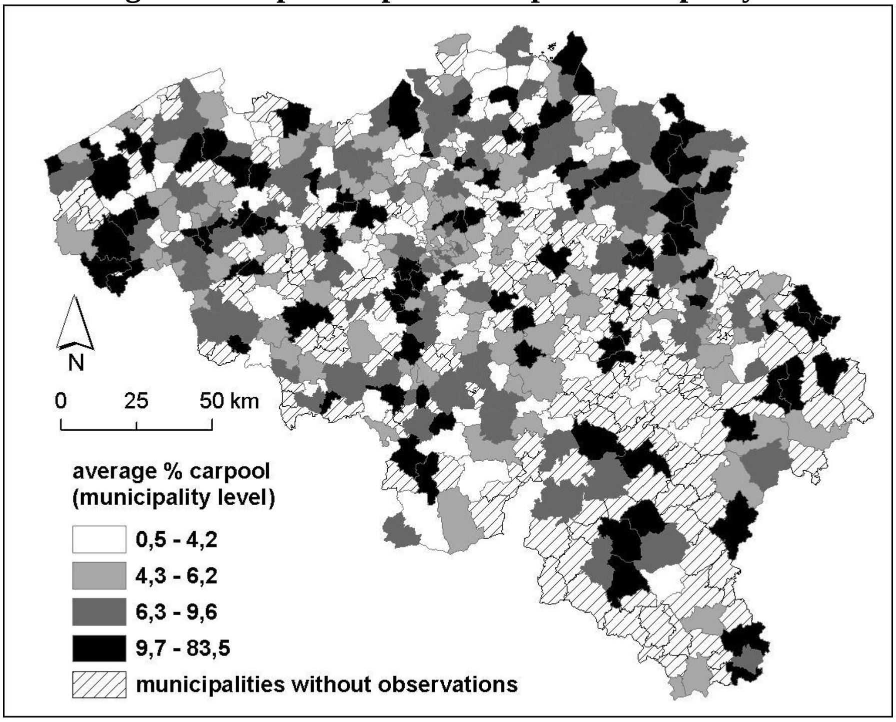
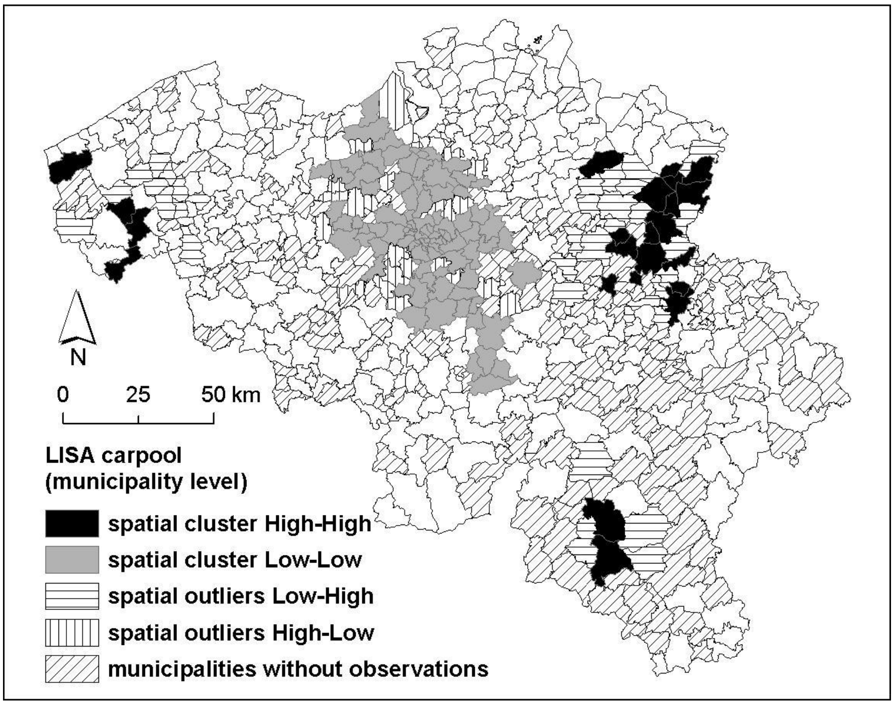


Figure 2: LISA map of carpool share per municipality



Software: Geoda (Anselin, 2005) and ArcGIS (ESRI)
LISA statistic takes all municipalities into account within a range of 30km
Municipalities without hatching in Figure 2 (white): neither cluster, nor outlier

Table 2 gives the list of variables. Most of the determinants indicated in Table 1 are incorporated as independent variables. Only for commute distance and auto availability no proper indicators are available. The most important variable from a policy point of view is the number of carpool promoting measures on a worksite. Notwithstanding the diversity of carpool measures, more measures means that an employer is more in favour of carpooling. Table 3 shows the measures which could be marked by employers in the questionnaire HTWT.

Table 2: List of variables (N = 3353)

variable	description	min.	max.	mean	s.d.
-carpool measures	count of the measures as listed in Table 3	0	5	0,22	0,64
-regular work schedule	% of employees with a regular work schedule	0	100	38,92	37,53
-generalised time train (log)	Rail accessibility (see Annex 1)	-1,38	0,54	-0,30	0,29
-employees (log)	number of employees at the worksite	1,48	3,82	2,18	0,40
-car accessibility	accessibility by car: potential number of people that can reach a municipality by car (in millions)*;	0,39	1,66	1,17	0,25
-agglomeration	dummy indicating if the worksite is located in an agglomeration**	0	1	0,57	0,50
-parkingindex	number of parking places per employee; maximum set to 1 to avoid the effect of large customer parkings	0	1	0,51	0,34

*: Vandenbulcke et al., 2007; Vandenbulcke et al. 2009
**: Luyten and Van Hecke, 2007

Table 3: Percentage of work sites where a particular carpool promoting measure is taken

Car-Pool promoting measure	**All sites** (N = 7460)	**Sites with carpooling employees** (N = 3353)
'Organising a carpool on the site'	5,2	6,5
'Connecting to a central database'	4,6	5,7
'Dispersion of information about carpooling'	4,2	5,0
'Reserved parking places for carpooling employees'	1,9	2,4
'Guaranteed ride home for carpool passengers in case of unpredicted circumstances'	1,6	1,9
'No carpool measures'	86,6	83,9

Source: questionnaire HTWT 2005

In what follows companies are classified in 14 economic sectors. Table 4 shows the different economic sectors together with their average number of carpool-oriented mobility management measures and the share of carpool in the modal split. The database HTWT also contains the Crossroads Bank for Enterprises (CBE) code of every company. With this code we identifiy the economic sector (Nacebel 2003) using the BELFirst database. The "Z" category contains worksites which could not be linked to a Nacebel code. These sites are however part of a homogeneous group as they belong to different kinds of government agencies, like police stations, public schools and municipal offices.

Table 4: Average percentage of carpooling employees on a worksite, average number of carpool-measures and number of worksites per economic sector

NACEBel code 2003 ranked on the basis of the average % carpoolers	**Average % carpoolers**		**Average number of carpool measures**		**# worksites**	
	n = 7460	n = 3353	n = 7460	n = 3353	n = 7460	n = 3353
-Education (M)	1,85	5,36	0,08	0,09	136	47
-Wholesale and retail; repair of motor vehicles and consumer goods (G)	1,92	6,58	0,14	0,19	875	255
-Hotels and restaurants (H)	2,12	7,93	0,12	0,26	86	23
-Miscellaneous government (Z)	2,41	5,77	0,14	0,17	3445	1439
-Health and social services (N)	2,45	4,79	0,14	0,20	231	118
-Finance (J)	2,62	4,30	0,91	0,96	182	111
-Real estate, renting and producer services (K)	2,69	6,89	0,17	0,20	469	183
-Agriculture, hunting, forestry and fishing and Mining and quarrying (ABC)	3,75	6,01	0,29	0,47	24	15
-Transport, warehousing and communication (I)	3,91	9,60	0,13	0,17	587	239
-Public administration and defence; social security insurance (L)	4,06	7,31	0,06	0,10	18	10
-Other community, social and personal services (O)	4,14	9,02	0,26	0,14	96	44
-Electricity, gas and water (E)	5,68	9,41	0,19	0,21	111	67
-Manufacturing (D)	6,74	9,74	0,23	0,23	1092	756
-Construction (F)	10,34	24,28	0,23	0,28	108	46

Source: questionnaire HTWT 2005

3. Method: Multilevel modelling

Different worksites can be part of one company and companies within the same economic sector are supposed to be more similar than companies from different economic sectors. An appropriate technique to incorporate the fact that sites are nested in a company and that companies are part of an economic sector is multilevel modelling (Goldstein, 1995; Rasbash et al., 2005). A multilevel regression model contains not only a residual at the lowest level (in our case: work site, e_{0ijk}) but also at the company (u_{0jk}) and at the economic sector level (ν_{0k}). More formally, this can be written as:

$$Y_{ijk} = \beta_{0ijk} + \beta_1 X_{ijk} \qquad (1)$$

$$\beta_{0ijk} = \beta_0 + \nu_{0k} + u_{0jk} + e_{0ijk} \qquad (2)$$

with i = worksite level, j = company level and k = economic sector level

Multilevel modelling has the advantage of getting a better understanding and more clear interpretation of the effects of higher levels, and ignoring the fact that data are grouped can also cause underestimated standard errors of regression coefficients (Goldstein, 1995; Maas and Hox, 2004; Schwanen et al., 2004; Rasbash et al., 2005). The main disadvantage is that multilevel models are more complex. As a consequence, diagnostics can be more complicated.

4. Results

Table 5 lists the results of three multilevel models. All models share the same explanatory variables, but have a different dependent variable. First, a logistic regression model examines the difference between work sites where nobody carpools and sites where at least one employee is ridesharing. The second model examines the share of carpooling employees on a site while the third model uses the proportion of carpoolers over rail commuters as dependent variable. The latter two models exclude worksites where nobody carpools in order to avoid biases caused by zero inflated data.

Table 5: Results

		Model 1 (logit)	**Model 2**	**Model 3**
	dependent variable:	carpoolers at worksite (1) or not (0)	log(Carpool)	log(Carpool/Train)
	level/parameter	estimate (s. error)	estimate (s. error)	estimate (s. error)
random part	economic sector (3)	0,066 (0,039)*	0,015 (0,007)	0,096 (0,042)
	company (2)	0,653 (0,073)	0,049 (0,005)	0,163 (0,018)
	worksite (1)	- (-)	0,129 (0,005)	0,430 (0,015)
fixed part	constant	-3,797 (0,252)	1,102 (0,070)	2,474 (0,140)
	carpool measures	0,100 (0,050)	0,018 (0,012)*	-0,022 (0,022)*
	regular work schedule	0,004 (0,001)	0,0013 (0,0002)	0,0022 (0,0004)
	generalised time train (log)	0,241 (0,130)*	0,205 (0,035)	1,703 (0,064)
	employees (log)	1,868 (0,082)	-0,175 (0,019)	-0,379 (0,035)
	car accessibility	-0,254 (0,143)*	-0,094 (0,038)	-0,565 (0,070)
	agglomeration	0,097 (0,067)*	0,036 (0,018)	0,009 (0,033)*
	parkingindex	0,088 (0,086)*	0,011 (0,025)*	0,132 (0,045)
	n	7460	3353	3353
	-2 loglikelihood	-	3532,538	7568,87

software: MLwiN (Rasbash et al., 2005)
*: t-value < 1,96 (not significant at the 95% confidence interval)

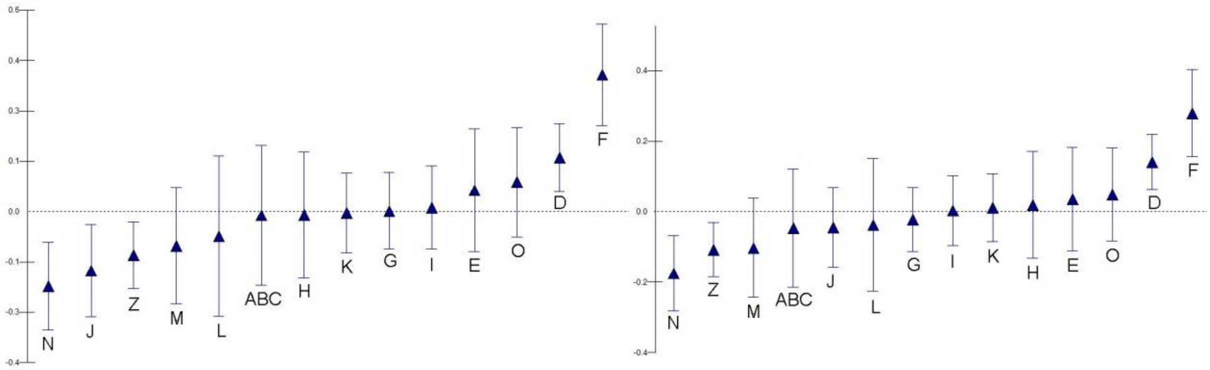
The random part of the models shows that the company and economic sector levels do matter. Most results are significant at the 95% confidence interval, except the economic sector level in model 1. The Variance Partition Coefficient (VPC; Rasbash et al., 2005) is an indicator which shows which proportion of the total variance can be attributed to a certain hierarchical level. In Model 2 for instance, 7,8% (0,015/(0,015 + 0,049 + 0,129)) of the total variance can be attributed to the economic sector level. When creating a so-called empty model by removing the independent variables in model 2, 11% of the total variance may be attributed to differences between economic sectors, 26% to differences between companies and the remaining 64% to differences between worksites. For the empty model 3, these proportions are respectively 24%, 26% and 50%. These numbers illustrate that the models explain better the differences between economic sectors than they explain differences between worksites.

The fixed part of the models contains the common regression coefficients. The first model shows that sites without carpooling employees have in general less employees, less regular work schedules, take less carpool promoting measures and are better accessible by train. Model 2 indicates that more employees with a regular work schedule positively influence the success of ridesharing. The lower the accessibility by train, the more popular carpooling is and smaller sites proportionally have more carpooling employees. The result for the car accessibility variable indicates that carpooling is more abundant in the more peripheral areas of Belgium and the same is true for agglomerations. The second model thus shows a relation between rail accessibility and the success of carpooling. Next to this, both using rail and carpooling are more suitable for longer commutes. Therefore, a third model was set up with the relation between carpool and rail as dependent variable. Roughly the same factors that explain the popularity of carpooling explain its success in relation with rail. Moreover, the number of parking places per employee is positively correlated with the carpool share divided by the share of rail commuters, but neither model 2, nor model 3 estimated a significant result for the count of carpool measures. Finally, the third model shows a higher explanatory power than the carpool model. This can be illustrated by looking at the residuals (Figures 3 and 4). The level three residuals will also deliver more insight in the role of the economic sector in the commute behaviour of their employees.

4.1. Economic Sector Residuals

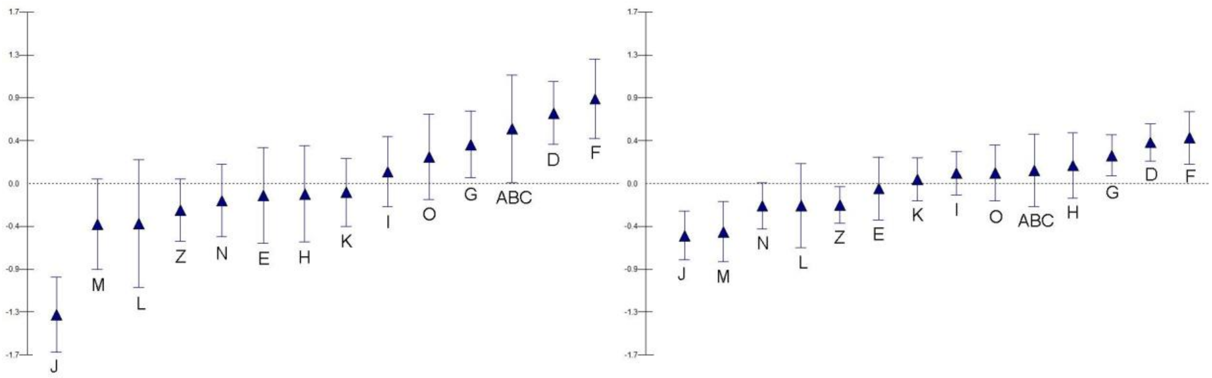
Figures 3 and 4 show the intercepts for the different economic sectors, these are the level three residuals. The left graphs are the residuals of empty models, e.g. models with only a constant and a multilevel structure, while the graphs at the right side are the result of the full model (all variables included). The mean of the economic sector residuals is zero and it is important to notice that these residuals are not just the economic sector averages but are shrunken residuals. They differ from the group means because the data outside the own economic sector are also taken into account, this is an advantage, especially for economic sectors with a limited number of worksites and companies (see Rasbash et al., 2005, p.36-37 for more detail).

Figure 3: level 3 residuals of the log(Carpool) model: empty (left) versus full (right) model



The level three variance of the empty model 2 is larger (0,023) than the level three variance of the full model (0,015). This is visible on figure 3, as the values at the right side are closer to zero and have smaller standard deviations. Standard deviations are large for sectors with a limited number of worksites (ABC and L). In Health and Social Services (N) and in the public sector in general (Z), there are less carpooling employees than estimated. The Construction (F) and Manufacturing (D) sectors have the highest numbers of carpooling employees, even after controlling for the determinants of carpooling included in the model.

Figure 4: level 3 residuals of the log(Carpool/Train) model: empty (left) versus full (right) model



When examining the relation between carpooling and train use, the difference in level three variance between the empty (0,305) and the full (0,096) models indicates more explanatory power for the third model (carpool/train) than for the second model (carpool). Figure 4 shows that the train is more popular in the sectors Finance (J), Education (M), Health (N) and the public sector in general (Z), while carpooling is more popular in the Construction (F), Manufacturing (D) and the Wholesale and Retail (G) sectors.

5. Discussion

More employees with a regular work schedule have, as expected, a positive influence on the proportion of the employees which carpools. The probability that some employees on a site carpool is higher when more employees are working on that site but on larger sites, the share of carpooling employees is lower. Organising collective transport (other than carpool) is easier on a larger site and another reason for this negative correlation is the fact that our dataset contains only larger sites, e.g. sites with at least 30 employees of companies with at least 100 employees. A better rail accessibility has a negative influence on ridesharing as has a location in an agglomeration. At first sight this is contradictory to Hwang and Giuliano (1990) who indicate that a downtown location with a good public transport accessibility is favourable for carpooling. In Belgium however, rail has traditionally a more dominant position in commuting than in the USA, even nowadays where single occupant vehicles are dominant (ca. 70%). Both rail and carpool suit better with longer commutes and compete with each other as SOV alternatives. A model which takes the proportion of carpool to rail as dependent variable seems to have more explanatory power than a model which only examines the share of carpool.

The possible impact of carpool-measures taken by employers is a relevant variable from a policy perspective. But for the number of carpool promoting measures no significant results could be found. However, this does not mean that carpool-incentives have no impact at all. This variable is a count of the carpool-promoting measures, assuming that this reflects the attitude of an employer towards ridesharing. Nevertheless, these measures are diverse in nature. Hwang and Giuliano (1990) distinguish the more and the less effective ridesharing incentives (see Table 6) and the measures that could be checked by employers in the Belgian questionnaire HTWT are all indicated as “less effective”. This could be an explanation why no significant impact of car-pool-promoting measures on carpooling is found. Next to this, green commuting measures are often part of general HRM and corporate sustainability strategies. These general strategies often not contain the right mix of measures to tackle the site-specific accessibility problems. Finally, from a more technical point of view one should notice that on 83,9% of the 3353 sites the number of measures is zero. This can affect the standard deviation and as a result also the significance.

Table 6: Effectiveness of Ridesharing Incentives

More Effective	**Less Effective**
Parking Charges	Preferential parking
Parking Restrictions	AWH (Alternative Work Hours)
Transportation allowance	Marketing
	Matching Service
	Guaranteed Ride Home

Source: Hwang and Giuliano, 1990

The use of an 'economic' hierarchy in the multilevel models made it possible to examine the role of economic sectors in commuting behaviour. Public sector (s.l.) and finance appeared to be more rail than carpool oriented, while in manufacturing and especially in the construction sector, carpooling is more popular. The main commuting characteristics of the construction sector are the changing location of construction sites, long commute distances (especially in larger companies) and a low use of public transport (1,4%). The majority (81%) of the workers makes at least partly use of a vehicle of the employer to go from their home to the construction site. Transport organised by the employer with a round trip picking up the workers at home (42%) or via a central meeting point (34%), is widespread (Meersman et al. 1998). However, it is probable that the categories carpooling and transport organised by the employer are mixed up by some respondents of the HTWT questionnaire. In this questionnaire, the average percentage of employees (workers and others) in the construction sector making use of transport organised by the employer is 11%, which is remarkably lower than in the research of Meersman et al. (1998).

6. Conclusions

Both public policy-makers and private companies promote carpooling as a commuting alternative in order to reduce the number of Single Occupant Vehicle (SOV) users. This paper takes the employer as prime research unit since the work side of home to work travel receives less attention in commuting research. The Belgian questionnaire Home-To-Work-Travel (HTWT) generated data at the worksite level, but this information can also be aggregated at the company and at the economic sector level. A three-level multilevel model simultaneously incorporated the three aforementioned levels in order to analyse the factors which explain the share of carpool at a site and the relation between carpool and rail. Moreover, the multilevel model gives insight in the differences between economic sectors. The most carpool oriented sectors are construction and manufacturing and also in the wholesale and retail sectors carpool is more popular than rail. The rail alternative tends to be more popular in the financial sector and in the public sector in general, including health and education.

Like most SOV alternatives, carpooling is somewhat more popular in agglomerations, but it is especially an alternative at locations where rail is no real alternative. Next to this, regular work schedules and less employees at a site are positively correlated with a higher share of carpooling employees. For the effectiveness of carpool promoting measures no evidence could be found. This can partly be explained by the fact that the selected measures are described in the literature as less effective. Next to this, green commuting measures are often part of general HRM and corporate sustainability strategies. As a consequence, companies not always implement the most suitable mix of measures to tackle the own, site-specific accessibility problems.

Acknowledgements

This research is conducted within the ADICCT-project (Assessing and Developing Initiatives of Companies to control and reduce Commuter Traffic) which is financed by Belgian Science Policy in the Science for a Sustainable Development research programme. We are also grateful to Grégory Vandenbulcke (UCL) and the FPS Mobility and Transport for delivering data and information.

Annex 1: Calculation of the generalised time by train

Generalised time

The modal choice of commuters depends among others on the characteristics of alternative modes. Thereby, the difference in travel time of the competing modes is of first importance. The total travel time is the sum of the in-vehicle time, the walking time and the waiting time, while the excess time is the sum of the latter two (Blauwens et al., 2008, p.271). As the accessibility of a worksite by public transport is of our interest, the excess time can be used as an accessibility measure. Therefore, both frequency and distance are used to calculate the generalised time (Vandenbulcke et al., 2007, p.199-229).

As a first step we calculated the distance between a worksite and the five nearest railway stations in Belgium. This was done in ArcGIS (network analyst) using the Belgian road network (NAVstreets). Since it is most unlikely that someone will use the private car to travel from the worksite to the railway station, highways were excluded. The resulting distances could be used to estimate the walking (cycling) time between a worksite and a railway station. Next to the walking (cycling) time to a railway station, the waiting time needs to be estimated. In general, the frequency divided by two is used as average waiting time. Since commuters can use other stations than the nearest one, the five nearest stations are taken into account. Especially stations with a higher frequency (more trains/day) can improve the accessibility of a site, even when there is a nearer station. Table A1 shows that only for a minority of the worksites (2471 out of 7460), the nearest station is sufficient to calculate the rail accessibility.

Table A1: Number of railway stations taken into account for the calculation of the generalised time measure

Number of stations taken into account	Number of observations
1	2417
2	1570
3	1377
4	976
5	1120

waiting time = 40/#trains; walking (cycling) speed = 10 km/h

To calculate the generalised time as an accessibility measure, while incorporating several possible stations, the average walking time is used and the average waiting time is divided by the number of stations. The lowest of the five calculated values is taken as accessibility measure for rail. After some comments on the advantages and disadvantages of the generalised time measure, an example is given to illustrate this method.

The generalised time is used as an accessibility measure for rail. The major advantages are the incorporation of both distance and frequency in one measure while several railways stations are taken into account. One can discuss the assumption that the waiting is the frequency divided by two, since commuters often adapt their working hours to the public transport time schedule. Next to this, the number of trains per day does not tell anything about the number of possible destinations, nor about the in-vehicle time. However, the proposed generalised time offers an appropriate measure to define the rail accessibility of a site in general. As a consequence, the generalised time should be understood more as a relative than as an absolute measure. Moreover, the absence of in-vehicle time in the calculation of the generalised time is no major shortcoming as the value of a unit in-vehicle time is lower than for waiting or walking time, and in-vehicle time can have a positive utility and can even be seen as productive time (van Wee et al., 2006; Lyons and Chatterjee, 2008). The walking time at the home side of the rail trip is not part of the model, but again, this trip is less important than the trip from the worksite to the railway station. Indeed, for several modal choice explaining factors, the destination side is more important than the origin side (Limtanakool et al., 2006; Chen et al., 2008).

Example

This example illustrates how the generalised time measure for a particular worksite is calculated. Figure A.1 shows the routes between the worksite (Belspo in Brussels; black square) and the five nearest railway stations (black dots). Table A.2 gives these five railway stations together with the number of trains per day. The corresponding waiting time is the frequency divided by two, assuming a day of 20 hours. The waiting time decreases when taking more stations into consideration, and as a result, more possible trains to catch. For the walking (cycling) time, the speed is set at 15 km/h and the distance over the road network is used. In this example, the lowest value for the generalised time measure (0,090) is obtained when three stations are used. This value is the generalised time by train of the worksite.

However, the relative importance of waiting and walking time can be subject to discussion for several reasons: the value of waiting time is supposed to be higher than for walking time, the average walking or cycling speed can be higher or lower than 15km/h, and when calculating the frequency, one can assume more trains during peak hours. Therefore, different weights are given to walking and waiting time in order to obtain a rail accessibility measure which best explains the share of employees which uses a certain mode. In table A.2, the waiting time is 10 divided by the number of trains per day. The highest correlation between the generalised time measure and the share of employees which use the train (log), is reached for a value of 75 in stead of 10 (Pearson correlation: -0,507). For the share of carpooling employees this value is 40 (Pearson correlation: 0,097). In the latter case, waiting time has an average share of 40,6% in the generalised time. As a consequence, distance is somewhat more important than frequency in rail accessibility. In this paper, the waiting time is set at 40 divided by the number of trains per day and the walking/cycling time is set at 10km/h.

Figure A.1 map of the routes between a worksite (Belspo) and the five nearest railway stations

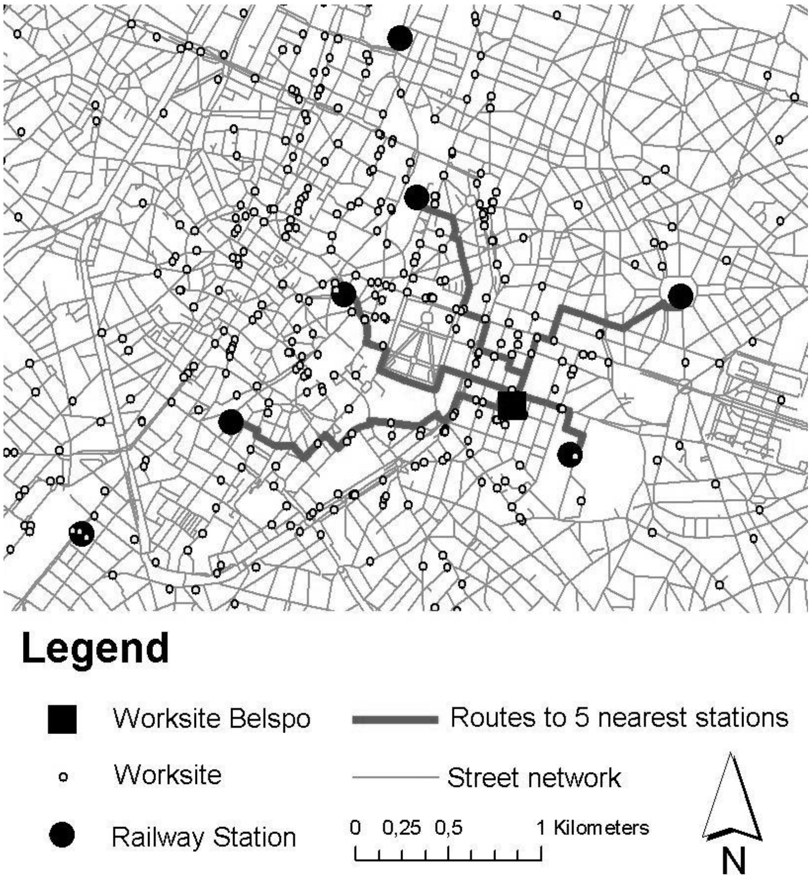


Table A.2: Example of the calculation of the generalised time of a worksite

Railway station	**Frequency (Number of trains per day)**	**Waiting Time (h)**	**Waiting time (incl. other stops; h)**	**Distance (km)**	**Average travel time (h)**	**Generalised time (h)**
BRU.-LUXEMBG	224	0,05	0,045	0,695	0,046	0,091
BRU.-SCHUMAN	219	0,05	0,023	1,386	0,069	0,092
BRU.-CENTRAL	1014	0,01	0,011	1,473	0,079	0,090
BRU.-CONGRES	50	0,20	0,019	1,583	0,086	0,104
BRU.-CHAPELLE	50	0,20	0,020	1,986	0,095	0,115

time in hours (decimal)

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