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“Let the business cycle!” A spatial multilevel analysis of cycling to work

Thomas Vanoutrive, Laurent Van Malderen, Bart Jourquin, Isabelle Thomas, Ann Verhetsel and Frank Witlox

Introduction

1 The daily commute is still the main source of traffic congestion due to its repeated and concentrated character. This concentration of traffic in both space (cities) and time (peak hours) makes commuting the prime target of mobility policies. The overall aim of such policies is a reduction of the number of Single Occupant Vehicles (SOVs). In Belgium, 66,4% of the workforce commutes as a car driver (Verhetsel *et al.*, 2007). The SOV-alternatives are carpooling, telework, public transport and the bicycle, the latter being the subject of this paper.

2 Substantial spatial variation exists in bicycle use, not only between countries but also within countries. The share of commuter cyclists in Belgian municipalities varies between zero and 21,7 % with a mean of 4,6 % (Vandenbulcke *et al.*, 2009b). To explain bicycle use, the literature refers to physical, individual, environmental and policy factors (see recent review in Vandenbulcke *et al.* 2009b). The most important physical features are topography (slopes) and meteorological conditions (rainfall and wind speed). The second group contains more individual factors like car ownership, journey distance, journey purpose, income, education, bicycle ownership, class, age and concerns for health and the environment. Environmental factors, as a third group, are related to the urban spatial structure. Examples are population density, land-use mix, city size, traffic volume and infrastructure characteristics. The last category of policy-related variables covers infrastructure, transport and land-use policies of different government agencies as well as financial incentives and education (Comsis Corporation, 1993; Rodriguez and Joo, 2004; Parkin *et al.*, 2007; Vandenbulcke *et al.*, 2009b). Martens (2004) notes huge differences in cycling cultures between European countries, however cultural differences are usually a

synonym for unexplained variance without appointing the cultural attributes that matters.

3 The focus of commuting and SOV-alternatives research is mainly on the individual commuter (e.g. Cao and Moktharian, 2005) or on the county (e.g. Zahran *et al.*, 2008) or municipality level (e.g. Vandenbulcke *et al.*, 2009a and 2009b; Rietveld and Daniel, 2004) while less attention goes towards the work side of the home to work travel. However, employers influence the commute behaviour of their employees in many ways. It is known from literature that firm location, work schedules and mobility management initiatives have a significant impact on travel behaviour (Abbes-Orabi and De Wolf, 2007; Heinen *et al.*, 2008; Van Malderen *et al.*, 2009). The results reported here deal with the role employers play in the travel behaviour of their employees. The central topic is the bicycle as main commuting mode, and particular attention goes towards the measures that employers take to promote this mode. Indeed, many employers are willing to tackle environmental, congestion and recruiting problems by using mobility management strategies. Such strategies and plans are also called "green commuter plans" (GCP), "green transport plans" or "employer (based) transport plans" (Rye, 1999). However, such measures tend to tackle the symptoms (provide cycle facilities) but fail to tackle the underlying problems (distance, complex trip characteristics, etc.). Therefore questions raised about the number of employees that could be reached with mobility management measures since only a minority of commuters puts the bicycle in their choice set (Dickinson *et al.*, 2003).

4 We here use a spatial multilevel regression model to incorporate both site-specific and contextual factors. Since bicycle use is not randomly distributed in space, the multilevel structure is also used to deal with spatial autocorrelation and to counterbalance the violation of the normality and independence assumptions. Finally, multilevel modelling using different spatial levels gives insight in the spatial structure of bicycle use.

5 The paper is structured as follows. First we introduce the database Home-to-Work-Traffic (HTWT) and give an overview of the selected variables. This is followed by a short discussion on the incorporation of space in regression models and the reasons why we chose for spatial multilevel modelling. Next the results are given together with a discussion, especially on the unexpected results. Finally, we end with some conclusions.

Data and Methods

The Home-to-Work-Traffic Database

6 For decades, census data are the main source for research on commuting (Dickinson, 1957; Verhetsel *et al.*, 2007). Following a Belgian law of 2003 a new important data source is available about home-to-work displacements of employees. This new data source is based on a three-yearly questionnaire on mobility management initiatives of large companies. The first questionnaire dates from 2005 and needed to be filled in by every company with at least 100 employees for every site with at least 30 employees. This questionnaire differs from censuses and commute diaries in the sense that employers are the respondents and information about sustainable commuting measures is delivered. The questionnaire needed to be discussed in the works council in order to control the data and to deliver a base for a debate on mobility management in companies.

7 Table 1 shows the frequencies of the 15 bicycle promoting measures that could be indicated in the questionnaire. The most popular bicycle-incentives are a bicycle fee and some common bicycle facilities, like storage. The database Home-to-Work-Traffic (HTWT) contains also the Crossroads Bank for Enterprises (CBE) code for each company. With this code we identified the economic sector (Nacebel 2003) using the BELFirst database. Table 2 shows both the average percentage of cyclists and the average number of bicycle promoting measures per economic sector. The "divers government" category are worksites which could not be linked to a Nacebel code. This category contains different kinds of government agencies like police stations, public schools and municipal offices. Cycling seems to be popular at schools and workplaces of governments, while the financial sector has the lowest average share of bicycle use, despite the higher number of bicycle-promoting initiatives.

Table1. Frequency of the bicycle mobility management measures on worksites.

Type of measure	Description of measure	Frequency (%)
Financial	additional cycling fee	42,76
	additional fee for work trips	7,18
Bicycle facilities	covered bicycle storage	34,85
	secured bicycle storage	28,74
	showers	24,12
	room to change clothes	23,35
	bicycle repair facilities	3,06
	improvement of infrastructure	2,90
	rain clothes	1,61
Provision of bicycles	bicycles available for work trips	9,20
	bicycle maintenance	1,27
	bicycles available for home-to-work travel	0,84
	bicycles available at the railway station	0,64
Other and information	other	7,29
	information on cycling routes	2,88

Source : 2005 questionnaire HTWT ; n = 7460

Table 2. Bicycle mobility management measures and bicycle use per economic sector.

Economic sector (Nacebel 2003)	average number of bicycle measures	average percentage of cycling employees	# observations
Agriculture, hunting, forestry and fishing (AB)	2,08	8,78	12
Mining and quarrying (C)	2,25	5,24	12
Manufacturing (D)	1,99	7,48	1092
Electricity, gas and water (E)	1,58	3,58	111
Construction (F)	2,14	3,04	108
Wholesale and retail; repair of motor vehicles and consumer goods (G)	1,67	5,01	875
Hotels and restaurants (H)	1,69	5,02	86
Transport, warehousing and communication (I)	1,04	8,40	587
Finance (J)	2,62	2,44	182
Real estate, renting and producer services (K)	1,50	3,27	469
Public administration and defence; social security insurance (L)	2,94	4,90	18
Education (M)	2,18	12,34	136
Health and social services (N)	1,81	5,52	231
Other community, social and personal services (O)	1,70	6,03	96
Divers Government (Z)	2,11	11,92	3445

Source : 2005 questionnaire HTWT ; n = 7460

Variables

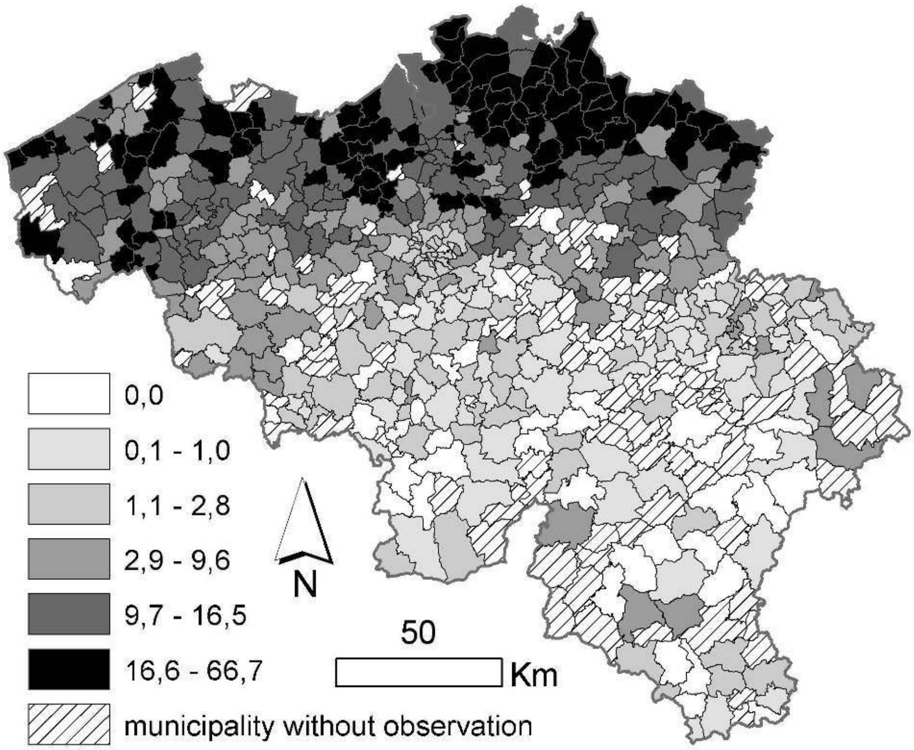
8 Table 3 shows the list of selected variables. The dependent variable (Y) is the percentage of employees at a worksite making use of the bicycle as main transport mode for their daily commute. Most worksites have a low share of cyclists in the modal split and as a result, the assumption of a normal distribution is violated and therefore the Y-variable is transformed into lnY/(1-Y) (Luke, 2004). On 1844 of the 7460 worksites there are no employees which use the bicycle as main mode for commuting (Y=0). This is another important violation of the normality assumption and therefore the zero observations are excluded from the main model. A binary logistic regression (noted Logit) is made to compare the excluded with the observations included in the main model.

Table 3. List of variables.

variables measured at the worksite level					
variable	description	source	min	max	
y	% employees using bicycle as main commute mode	HTWT database 2005	-6,91	2,63	ln y/(1-y)
LogEmploy	# employees	HTWT database 2005	1,48	3,82	logarithm
LogFixed	% employees with fixed work schedule	HTWT database 2005	-1,3	2	logarithm
ParkingIndex	car parking/employee	HTWT database 2005	0	1	
Train<1km	railway station at less than 1km	HTWT database 2005	0	1	binary
MTB<500m	metro/tram/bus-stop within 500m	HTWT database 2005	0	1	binary
DummyCEF	economic sector CEF (2005)	BELFirst	0	1	binary
DummyD	economic sector D (2005)	BELFirst	0	1	binary
DummyG	economic sector G (2005)	BELFirst	0	1	binary
DummyJK	economic sector JK (2005)	BELFirst	0	1	binary
DummyM	economic sector M (2005)	BELFirst	0	1	binary
DummyZ	economic sector Z (2005)	BELFirst	0	1	binary
Provision	# 'bicycle provision' measures	HTWT database 2005	0	4	
Facilities	# bicycle facilities	HTWT database 2005	0	7	
Financial	# 'financial' measures	HTWT database 2005	0	2	
BicyParking	bicycle parking/employee	HTWT database 2005	0	1	
variables measured at the municipality level					
variable	description	source	min	max	
LogSlope	average slope on the roads in the municipality	Vandenbulcke et al. 2008 and 2009b	-0,16	1	logarithm
LogJobDens	job density: # jobs/inhabitants age 20-64 (2005)	HTWT database 2005; FPS Economy-Directorate-general Statistics Belgium	-2,4	0,13	logarithm
Log2024	% population age 20-24 (2005)	FPS Economy-Directorate-general Statistics Belgium	-1,4	-1,05	logarithm
FamChild	% families with children < 6 (2005)	FPS Economy-Directorate-general Statistics Belgium	0,1	0,36	

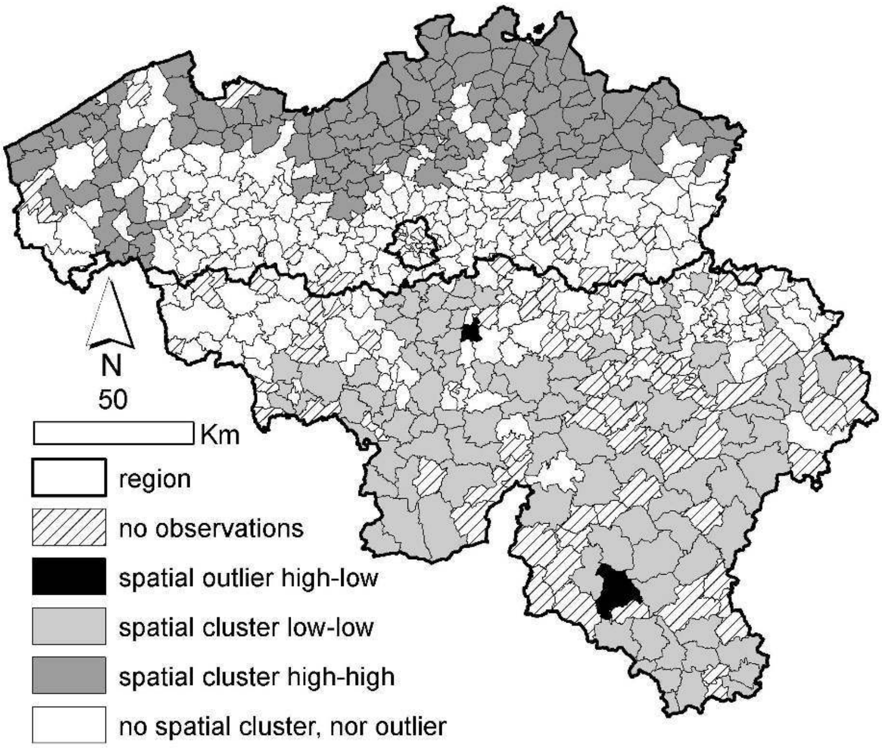
9 Figure 1 shows the average share of cycling on a worksite, aggregated per municipality. A clear north-south pattern appears with high values in the north and low values in the south. To drill deeper into this spatial pattern, a LISA map (Anselin, 1995; Figure 2) is produced to detect spatial clusters and outliers. This exploratory map challenges the common subdivision of Belgium based on a presumed Flemish cycling culture in the north, and the lack of such culture in the French-speaking (or Walloon) part of Belgium. Undoubtedly, the spatial variance in cycling originates from other factors, like commuting distance and topography, which spatial pattern better fits with that of our dependent variable. Indeed, the southern part of Flanders is no part of the spatial cluster of municipalities with high values surrounded by similar municipalities (high-high cluster), and in the north-eastern and north-western parts of the Walloon region cycling is more popular than in the rest of that region.

Figure 1. Average share of cycling employees in Belgian municipalities.



SOURCE: DATABASE HTWT 2005

Figure 2. LISA cluster map of cycling employees in Belgian municipalities taking into account the 4 nearest neighbouring municipalities (LISA: Local Indicators of Spatial Association; Anselin, 1995).



SOURCE: DATABASE HTWT 2005

10 We now will describe the explanatory variables in Table 3. Size is a first characteristic of a worksite. Sites with more employees have in general more possibilities for collective transport and a longer average commuting distance. Parking is another important mode choice determinant. A lack of parking space is often cited as one of the most important reasons for the popularity of SOV-alternatives (Naess and Sandberg, 1996; Banister and Gallent, 1999; Potter *et al.*, 1999; Ferguson, 2000). Therefore the number of parking places per employee is included in the model. The maximum value of this parking index is limited to 1 to avoid the effect of large customer parking. SOV-alternatives, other than cycling, can also affect the success of the bicycle. Therefore, the accessibility by public transport is modelled using dummy variables indicating a metro, tram or bus stop or a railway station within respectively 500m and 1km.

11 Work regimes have a large impact on the activity and travel patterns of employees (Abbes-Orabi and De Wolf, 2007; Heinen *et al.*, 2008). The proportion of the workforce with a fixed work schedule is used as variable. Mode choice depends also on the economic sector. The economic sectors given in Table 2 are grouped to obtain a set of dummy variables. Only sectors or groups of sectors with more than 100 observations are maintained. One of the major shortcomings of the database HTWT is the lack of information on company cars. However, company cars and free parking are the most important incentives for not choosing SOV-alternatives (Kingham *et al.*, 2001; O'Fallon *et al.*, 2004). The economic sector variables will pick up some of the company car effect, nevertheless for a straightforward estimation data at the workplace level should be available.

12 Three categories of bicycle promoting measures are distinguished. The first covers financial measures, the second is a group of bicycle facilities at the worksite and the third one are the more “advanced” measures like the provision of bicycles and bicycle maintenance. The measures “other” and “delivering information on bicycle paths” are excluded from the analysis. For every worksite a count is made of the number of measures per category.

13 Contextual factors explain for a large part the popularity of cycling. Therefore several variables measured at the municipality level are included. In most cases functional divisions are preferred over pure administrative spatial divisions (Arauzo-Carod, 2008). Municipalities can in the first place be considered as administrative units but are nevertheless also a functional spatial division since municipalities have competences on parking policy, public transport, the development of industrial zonings and town and country planning. Moreover, extensive data availability at the municipal level is an advantage.

14 Hilliness is the most important physical feature since the variation of the other relevant physical factor, meteorological conditions, is relative small in rather small countries like Belgium. The average slope on the road network in a municipality was calculated by Vandenbulcke *et al.* (2008 and 2009b). The age and household structure are relevant as it is supposed that households with young children cycle less and young people cycle more. Therefore, the proportion of households with children under six years old and the proportion of the population between 20 and 25 years are introduced as variables. The last factor at the municipality level is density, which is often used in transport research and is a proxy for different other phenomena, like the availability of public transport, congestion and higher parking costs (Chen *et al.*, 2008).

Incorporating space in regression models

15 As Anselin (2002) points out, three main approaches exist in spatial regression analysis. The first is a geostatistics approach, which defines space as a continuous surface. In our case however, observations are not continuous but discrete objects. Moreover, a geostatistics approach easily changes into a black box with difficulties to explain the rationale behind the imposed spatial structure. The second approach uses an object view and the corresponding lattice model. In this case, a spatial structure is imposed using a spatial weights matrix that underlies a spatial process model. This is the so-called spatial econometric approach and the LISA map in Figure 2 is an exploratory application of this method. The most distinctive characteristic is the incorporation of the value of neighbouring observations. The third way to impose a spatial structure is the spatial error components approach, as used in spatial multilevel modelling. In a random intercept multilevel regression model there is not only a residual at the lowest level (worksite, e_{ij}) but also at the municipality level (u_{oj}). More formally, this can be written as :

$y_{ij} = \beta_{0j} + \beta_1 x_{ij} + e_{ij}$ (1)

$\beta_{0j} = \beta_0 + u_{0j}$ (2)

with i = worksite level and j= municipality level.

16 This model allows that different level-2 units have different intercepts (and this is therefore called random intercept model). The u0j -terms are the level-2 random effects

or the level-2 residuals. Multilevel modelling not only has the advantage of getting a better understanding and more clear interpretation of the effects of higher (spatial) levels, but 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 models become more complex. As a consequence, diagnostics can be more complicated.

17 Multilevel modelling is increasingly used to incorporate contextual factors in regressions and to investigate the role of higher geographical scales. Examples can be found in health (e.g. Langford *et al.*, 1998), housing market (e.g. Orford, 2000) and commuting research (e.g. Schwanen *et al.*, 2004). A multilevel structure enables us to incorporate both variables at the worksite level and at the municipality level in a statistically correct way. A related advantage is that different levels (scales) can be modelled simultaneously (Subramanian *et al.*, 2001). Since our dataset consists of individual workplaces and we do not want to ignore the municipality level, the use of a spatial multilevel model is preferred over a spatial econometrics approach (for a more in-depth comparison between spatial multilevel modelling and spatial econometrics: see Vanoutrive and Parenti (2009)). However, cycling is still spatially autocorrelated at the municipality level. When grouping the data at the municipality level and using a spatial weights matrix using the four nearest neighbours, a Moran's I of 0,72 is found for the Y-variable. This measure indicates significant spatial autocorrelation as expected from Figures 1 and 2. Indeed, neighbouring municipalities often share similar characteristics and as a result, similar proportions of cyclists. Next to this, commuters can cycle to a neighbouring municipality. In our multilevel model, workplaces are nested in municipalities and next to variables at the worksite level, also variables at this municipality level are used. An underlying assumption is that the majority of potential cyclists lives in the same municipality as where they work. To relax this assumption, we add a third level: the arrondissement. Doing this, the population characteristics not only of the municipality, but also of the arrondissement are taken into account. We thus assume that a majority of the cyclists does not leave the own municipality, and if they do, they go to a municipality in the same arrondissement. The 43 Belgian arrondissements are in the first place administrative units, nevertheless in most cases they consist of a central city surrounded by less urbanised municipalities. A more functional spatial division, like labour basins (e.g. De Wasseige *et al.* 2000) is less appropriate in this case for two reasons. First, the division of Belgium in labour basins is particularly based on longer commutes and on other modes than the bicycle. Second, labour basins are far from equal. Indeed, the labour basin of Brussels dominates, together with those of some other large cities. No less than 27% of the workplaces are located in the Brussels labour basin, and 17% in the second largest, Antwerp. Arrondissements on the other hand, divide Belgium in a more regular way. Summarising, the model deals with the spatial autocorrelation by means of its three-level structure.

Results

18 Table 4 shows the results of four multilevel models. The first model is a logit model (noted Logit) which compares the data included (1) and excluded (0) in the next three models. The excluded observations are the 1844 worksites without cycling employees. The next model, Model A, contains only a constant and a three-level structure while in

model B all variables are included except variables which measure the degree of mobility management. Finally, Model C includes all variables.

Table 4. Results of the four multilevel models (Software = MLwiN).

		Logit		Model A		Model B		Model C	
		Estimate	Standard. Error	Est.	S.E.	Est.	S.E.	Est.	S.E.
Random part	level 3	0,660	0,162	0,968	0,221	0,405	0,095	0,345	0,082
	level 2	0,001	0,017	0,117	0,017	0,068	0,012	0,061	0,011
	level 1	-	-	0,880	0,017	0,707	0,014	0,687	0,013
Fixed part									
constant	constant	1,401	1,358	-2,921	0,154	0,916	0,863	0,668	0,834
level 1	LogEmploy	1,883	0,095			-0,500	0,031	-0,436	0,031
	LogFixed	0,125	0,022			0,053	0,009	0,052	0,009
	ParkingIndex	-0,330	0,086			-0,413	0,036	-0,481	0,036
	Train<1km	0,040	0,064			0,053	0,026	0,045	0,025
	MTB<500m	-0,069	0,097			0,147	0,037	0,116	0,037
level 2	LogSlope	-2,235	0,289			-1,260	0,183	-1,252	0,176
	LogJobDens	-0,131	0,103			-0,233	0,063	-0,233	0,061
	Log2024	1,948	0,993			1,720	0,627	1,626	0,606
	FamChild	-6,590	1,518			-3,600	1,114	-3,546	1,070
economic sector (level 1)	DummyCEF	-0,544	0,166			-0,441	0,083	-0,419	0,082
	DummyD	0,221	0,117			-0,036	0,046	-0,038	0,045
	DummyG	0,301	0,111			-0,047	0,051	-0,049	0,050
	DummyJK	-0,016	0,118			-0,311	0,055	-0,323	0,054
	DummyM	1,018	0,264			0,458	0,086	0,319	0,086
	DummyZ	0,796	0,087			0,438	0,037	0,369	0,037
mobility management (level 1)	Provision							0,127	0,030
	Facilities							-0,019	0,008
	Financial							0,009	0,020
	BicyParking							0,683	0,055
	-2 loglikelihood			15667,23		14356,97		14180,27	
n level 3	arrondissement	43		43		43		43	
n level 2	municipality	490		442		442		442	
n level 1	worksite	7460		5616		5616		5616	

19 The random part of the model shows the variance at each hierarchical level. The Variance Partition Coefficient (VPC ; Rasbash *et al.*, 2005) compares these variances, and indicates which percentage of the total variance can be attributed to a certain hierarchical level. Model A shows that only 6 % (0,117/ (0,968+0,117+0,880)) of the total variance may be attributed to differences between municipalities, but 49 % to differences between "arrondissements" and 45 % to the worksite level. The worksite level also covers the variance between individuals (Tranmer and Steel, 2001), for which no data was available.

20 The fixed part of the model estimates the variables measured at the worksite and at the municipality level. Worksites with less employees, a higher proportion of staff with a fixed work schedule, less parking places per employee and more public transport facilities in the neighbourhood are associated with a higher proportion of cycling. The logit model shows that logically, the probability that there is at least one cycling employee is higher on a large site (more employees).

21 Differences between economic sectors appear to be relevant. When comparing the order of economic sectors in Table 2 with the results of model B, the sectors finance, real estate, renting and producer services are no longer at the bottom of the list, the lowest estimate is now for construction, electricity, gas and water and mining and quarrying. The top position is still for government-related sectors and education. At the municipality level, hilliness has a negative effect on cycling as have locations in an area with a high job density. A higher proportion of young active people (age 20-24) and a lower proportion of families with young children (age 0-5) are associated with more commuters who use the bicycle as main transport mode.

22 Model C contains also four variables related to mobility management initiatives at the worksite. A positive relation appeared between the provision of bicycles and the number of cycling employees. However, for the bicycle facilities parameter the model estimated a negative significant result. For financial measures which promote the bicycle there is only a positive result when we leave out the economic sector variables. Finally, a positive relation is found with the number of bicycle parking places.

Discussion

23 The use of a spatial multilevel model made it possible to incorporate contextual factors in a statistically correct way and to investigate the role of different spatial scales. Up to 49 % of the total variance can here be attributed to the arrondissement level and only 6 % to the municipality level. These results suggest the limited importance of analyzing the data at the municipality level. However, municipal policies are probably spatially autocorrelated as well, and as a result, more important than the result notes. About 45 % of the variance in bicycle use between worksites can be attributed to the worksite level. But one should notice that the worksite level covers also relevant differences between individual employees like gender, age and income (Heinen *et al.*, 2008).

24 Worksites with many employees are associated with less bicycle use. This can easily be explained by the fact that large worksites might be quite isolated from urban centers and hence the average commuting distance is larger, and that there are more possibilities for collective transport. Less car parking places are traditionally seen as an important incentive for alternatives to car use. More employees with a fixed work schedule have also a positive effect on bicycle use as such a regular work regime fits better with cycling than for instance shifts.

25 Public transport facilities in the neighbourhood of the worksite are associated with more cycling commuters. These facilities are commonly linked with more dense areas, but the model estimated a negative result for job density. A lower share of cyclers in large agglomerations but a larger share in regional and small cities can explain this result (Vandenbulcke, 2009a and b).

26 As expected, population characteristics like a higher share of young active people (20-24) and a lower share of families with young children, influence cycling in a positive way. As a side remark, we note that for these population characteristics, the model assumes that the majority of the employees lives and works in the same municipality, or at least in the same arrondissement. The importance of the relief is demonstrated by the lower percentage of cyclists in hilly areas. Less commuters cycle in the construction, electricity, gas and water, and mining and quarrying sectors. Research by Meersman *et al.* (1998) about the Belgian construction sector showed that due to the changing location of construction sites, collective transport and carpool are more popular, and cycling less. Cycling is also less common in the sectors finance, real estate, renting and producer services. The large offices of the financial sector are associated with locations near railway stations, company cars are more frequent and the image factor (dress code) is probably more important in this sector. The high estimate for education can be explained by the fact that schools are often locally based, less spatially concentrated and company cars are exceptional.

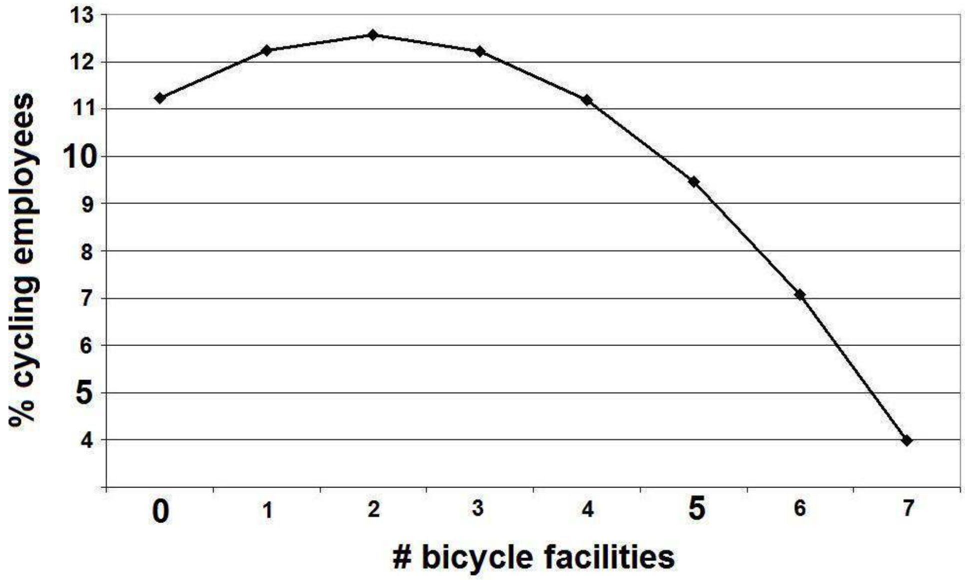
27 The active provision of bicycles by employers seems to influence the proportion of cycling employees in a positive way. However, one may not forget that this kind of measures is rather rare as showed in Table 2. For the financial measures no significant result is obtained but when leaving out the economic sector variables there is a significant positive effect. The “Additional cycling fee” is a result of the collective bargaining process which is subdivided in parity committees, which are to a certain extent related to economic sectors. The financial measures variable is as a consequence related to the economic sector variables.

Table 5. Frequencies of the number of bicycle facility measures on a worksite (n = 5616).

# measures	frequency	%	average % cycling employees
0	2596	46,23	11,07
1	1100	19,59	12,70
2	656	11,68	13,20
3	630	11,22	11,65
4	499	8,89	10,26
5	111	1,98	11,62
6	21	0,37	10,03
7	3	0,05	6,63

28 The negative result for bicycle facilities at a worksite is somewhat surprising. A first important remark is that regression models do not assume nor estimate a causal relationship. The potential simultaneity between measures and cyclists, i.e. only employers of sites where employees do cycle invest in facilities, is covered by omitting workplaces without cycling employees. But a closer look at the surprising result remains useful. A random slope model which allows a different slope for every municipality and/ or arrondissement does not change the loglikelihood and is as a consequence not useful to explore the bicycle facilities variable (Rasbash *et al.*, 2005). Therefore a polynomial regression is made (Figure 3). The graph shows a positive effect until the number of measures is equal to 2 and then a decline. A seeming outlier effect could not be confirmed since leaving out the three observations with seven measures does not change the result. The estimate for three measures is still above the estimate for zero measures. Considering that 78 % of the worksites take less than three measures and 89 % of the worksites less than four, the negative result can be modified.

Figure 3. Estimated bicycle use versus the number of bicycle facility measures.



29 The common focus on cycling infrastructure neglects other aspects of cycling. Cycle facilities often just tackle the symptoms but do not affect underlying cycling discouraging factors like commute distance and complex trip characteristics. Facilities in the first place help to stabilise existing levels of bicycle use, less than they attract new bicycle users (Dickinson *et al.* 2003 ; Heinen *et al.*, 2008 ; Cupples and Ridley, 2008).

30 Next to this, only employees which use the bicycle as main transport mode are considered in this analysis. The bicycle is however also an important mode for the travel between public transport stops and the worksite (Martens, 2004), but the impact of bicycle promoting measures on public transport use is outside the scope of this paper. Employers also often invest in transport-related measures for non mobility-related reasons. To filter out these potential effects, more in-depth case study research is necessary.

31 Finally, bicycle facilities are cheaper to implement on large sites outside city centres which are less attractive for cyclists, due to the longer travel distance. The urban fringe is overrepresented in the group of worksites with more than three bicycle facilities. Also the positive correlation between the number of bicycle facilities and the number of car parkings per employee seems to prove this assumption (Pearson correlation : 0,11). And it is definitely not a bad thing that employers invest more in facilities on sites which are less attractive for cyclists.

Conclusion

32 The work end of home-to-work travel is often not taken fully into account. The Belgian Home-to-Work-Traffic (HTWT) database now offers the opportunity to use a large database which contains information on accessibility, work regimes and mobility management initiatives of large employers located in Belgium. At the worksite level unsurprisingly, less employees, more fixed work schedules and less parking space per employee are positively related to the share of cycling employees. Significant differences exist between economic sectors, with less cycling employees in the construction,

electricity, gas and water, and finance, real estate, renting and producer services sectors and more cyclists in government-related sectors, including education. The model controlled also for contextual factors like hilliness, job density and household characteristics, all measured at the municipality level.

33 The provision of bicycles by the employer and similar mobility management initiatives are positively related to the share of cycling employees. However, workplaces which offer several cycling facilities often have a lower share of cyclists. The main reason seems to be that bicycle facilities are easier to implement at large industrial sites outside agglomerations, which are less accessible by bike. Next to this, a focus on cycle infrastructure and facilities neglects other distinctive factors like commuting distance and trip complexity and can therefore in the first place be described as a treatment of the symptoms. Due to the large dataset, the results are a good reference for the evaluation of case studies. But it is obvious that more detailed data are necessary for the evaluation of mobility management initiatives at a particular site. For a better understanding of the effectiveness of mobility management programmes, case study research thus remains necessary.

34 Finally, spatial multilevel modelling proved to be a proper technique to incorporate both contextual and worksite level factors into a regression model, to explore the role of different spatial scale levels and to counterbalance spatial autocorrelation.

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ABSTRACTS

The daily commute is still the main source of traffic congestion. Despite transport research emphasis on commuters, the work end of home to work travel receives less attention. However, employers influence the commute behaviour of employees in different ways. The Belgian database Home-to-Work-Traffic (HTWT) contains information on accessibility, work regimes and mobility management initiatives of 7460 worksites of large employers in Belgium. In a spatial multilevel regression model both contextual and worksite factors are incorporated to investigate the share of cycling employees. While controlling for different economic, physical and other factors, the provision of bicycles by the employer seems to be successful, while the effect of bicycle facilities is less clear, partly due to the fact that bicycle facilities are more popular in less cycle-friendly areas.

Het dagelijkse pendelverkeer is nog steeds de voornaamste bron van verkeerscongestie. Ondanks de nadruk die transportonderzoek legt op dit pendelverkeer, blijft de werkkant van het woon-werkverkeer onderbelicht. Nochtans beïnvloeden werkgevers het pendelgedrag van hun werknemers op verschillende manieren. De Belgische databank woon-werkverkeer bevat informatie over de bereikbaarheid, de arbeidstijden en mobility management maatregelen van 7460 werklocaties van grote werkgevers gevestigd in België. In een ruimtelijk multilevel regressiemodel zijn zowel omgevings- als werklocatiefactoren opgenomen om het aandeel fietsende werknemers te verklaren. Rekening houdend met economische, fysische en andere factoren, lijkt het actief aanbieden van fietsen door de werkgever een succesvolle maatregel, terwijl het effect van de klassieke fietsvoorzieningen minder duidelijk is, onder meer omdat deze vooral terug te vinden zijn in minder fietsvriendelijke gebieden.

INDEX

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motsclesnl fiets, woon-werkverkeer, België, multilevel modellen

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