EXCESS TRAVEL IN NON-COMMUTING TRIPS: A REGIONAL CASE STUDY

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ABSTRACT

In recent decades, excess commuting has become a major study topic within the discipline of transportation research (Ma and Banister, 2006). Excess commuting is that share of the commute flow (in terms of physical distance or time distance) that cannot be attributed to the spatial separation between job locations and residential locations of employees.
In recent years several authors advanced a spatially disaggregated approach as a tool for studying geographic variations in spatial proximity. When this type of research is conducted on a regional scale, it may contribute significantly to the sustainability of proposed land use developments, and to the detection of regions that are considered vulnerable because of their extreme remoteness.
To our knowledge, this research framework has only been applied to study home-to-work commuting. Recently, Horner and O'Kelly (2007) suggested that the study of excess travel for non-professional, but more or less, daily trips could become an interesting extension to this. Examples are innumerable: bringing children to day-care or school, doing the groceries, or going to sports or hobby clubs. The study of non-commuting trips, however, entails considerable methodological problems. For instance the capacity of many of the mentioned facilities is fluid, at least in comparison with employment centres that are characterized by a relatively constant number of jobs. Also, even if many non-professional trips are made frequently, they are not made on a daily basis. Moreover, there are often multiple destinations for one single travel purpose, as is, for example, obviously the case for shopping trips.
Based on the spatial distribution of some quasi-daily destination classes and reported trip distances from the Travel Behaviour Survey in Flanders, Belgium (OVG) we want to examine regional variations in excess travel in non-professional trips. To this end, we developed for various quasi-daily destination classes (such as shops, schools, public services and leisure activities) a proximity map, pointing out which neighbourhoods or municipalities are within easy reach to these facilities, and which places are, in contrast, located further away from

these. Then we compare for each considered geographical area and each travel purpose the distance to the closest facility that is able to satisfy the identified need with the reported distance that is actually travelled to reach a similar facility. Analogously to the regional variation of excess commuting (Boussauw et al., 2010) we note that in rural areas (compared with urban areas) larger distances are travelled, although the closest facility is chosen more often. In the most urbanized areas, however, we note that spatial proximity is also an important aspect in destination choice. Perhaps the larger share of pedestrians and cyclists explain this to a certain extent.
Quantification of these phenomena can support the practice of sustainable spatial planning. On the one hand it is possible to distinguish areas that are too mono-functional or too remote, and therefore need more functional diversity. On the other hand it is possible to identify areas where densification is useful because the location is closely to most quasi-daily destinations, reducing the need to travel over large distances.

Keywords: excess commuting, spatial proximity, sustainable spatial development, Flanders

Word count: 8501

INTRODUCTION

Næss (2003) reduces the relationship between spatial proximity and mobility to its geometric essence: in an area with a high density of people and services, distances that are to be covered between potential origins and destinations are small. Empirical research shows that fuel consumption for transport per capita is actually lower in areas with a high density than in regions with a low density (Newman and Kenworthy, 1989; Næss and Sandberg, 1996). This is a logical consequence, as Næss (2003) states: "The absence of any such influence would also have been quite sensational." But reality is obviously more complex than the geometric problem. All kinds of factors, such as infrastructure configuration, routes of public transport, or the lack of parking space, are distorting this obvious logic. But also an unbalanced spatial mix, often caused by functional city planning, may cancel out the positive potential of high density. Moreover, mode choice plays a role: cities with a high proportion of pedestrians, cyclists and public transport users will have less traffic problems. Besides, on the regional level a clear linear relationship exists between fuel consumption and the number of kilometres travelled per person (Boussauw and Witlox, 2009).
The main deviation between travel behaviour and geometry is due to the fact that a high degree of spatial proximity, and thus a better accessibility, gives rise to new needs. Gains, in terms of both time and money, yielded by a better accessibility are partly offset by the individual who will make use of the increased choice range. When the nearest supermarket is located just 100 m from one's front door, then the threshold for visiting the second nearest supermarket, at e.g. 500 m, is particularly low, certainly when the latter offers more products or is a little cheaper. But if the nearest store is located at 10 km, and the second nearest is only at 20 km, the same person will for sure go shopping in the nearest store. Although the use of a wider range of accessible destinations, as well as an increase of the number of trips may offset the potential efficiency gains of the compact city, the aforementioned empirical studies suggest that this is only partially the case.

Handy et al. (2005) argue that the reason for the emergence of a trip can always be situated along a choice-necessity continuum. Driving around just for fun (Mokhtarian and Salomon, 2001) is located on the "choice" end of this continuum, while buying a loaf of bread at the bakery around the corner is at the "need" end of the same spectrum. The ratio between choice and necessity determines the excessive nature of any particular trip, meaning the extent to which the trip distance exceeds the distance to the closest facility that could possibly satisfy the need of the traveller. The spatial proximity between the sites that are potential origins or destinations of trips defines the actual travelled distance. But spatial structure itself is also one of the factors that influence the decision. In an area with many options nearby, "choice" will outweigh "need". Furthermore, in this first area the total trip length - with a wide choice range - might still be less than in the second area - where there is little choice.

The excess commuting research framework offers opportunities for studying this phenomenon on a regional scale. In recent decades, excess commuting has become a major study topic within the discipline of transportation research (Ma and Banister, 2006). Excess commuting is that share of the commute flow (in terms of physical distance or time distance) that cannot be attributed to the spatial separation between job locations and residential locations of employees, and is thus rooted in the travellers' freedom of choice.

The paper is structured as follows. First, we provide a summary of the excess commuting literature and extend the concept to non-professional travel. Second, we develop a methodology to define theoretical minimum non-professional trip lengths and to distinguish spatial categories within reported trip lengths. Subsequently, results are obtained by comparing reported distance travelled with theoretical minimum distance travelled, within each spatial category. Finally, we draw conclusions from our findings and derive recommandations for sustainable spatial planning practice.

EXCESS COMMUTING AND EXCESS TRAVEL

The concept of "wasteful commuting" or "excess commuting" was first introduced by Hamilton (1982). Hamilton defined excess commuting as the difference between the actual commuting distance and the theoretical minimum commuting distance, suggested by the spatial structure of the considered city. The attention paid by Hamilton (1982) to minimized commuting distances stems from the successive oil crises of 1973 and 1979-1980, when the availability, and in particular, the affordability of fossil oil products was at stake. Daily trips over large distances were suddenly considered problematic, because of their particularly high energy consumption and costs.

As transportation research progressed, the concept of excess commuting was extended and applied in different ways. The line of inquiry that was started by White (1988), compares the spatial structure of different cities on the basis of the minimum required commute; a method that was later expanded with the idea of the maximum possible commute (Horner, 2002). Both concepts are measurable properties of spatial structure, which can be applied not only to compare the morphology of cities, but also to examine time series and thus measure suburbanization and evolutions in commuting behaviour. Further, we can distinguish between the more economically-inspired research direction that uses travel time as a variable, and the more environmental approach that focuses on travel distance (Ma and

Banister, 2006). In both cases the minimum commuting distance may be considered as a measure of proximity, in terms of accessibility (when travel time is studied), or in the sense of spatial proximity (when physical distance is studied).

A recent development in the rather environmentally-oriented literature is the spatially disaggregated approach where the spatial variation of the minimum commuting distance is mapped (Niedzielski, 2006; Yang and Ferreira, 2008; Boussauw et al., 2010). When this type of research is conducted on a regional scale, it may contribute significantly to the sustainability of proposed land developments, and to the detection of regions that are vulnerable because of their extreme remoteness. This approach is, among other, relevant in the light of the peak oil theory. In the course of history, the cost of transport has shown a nearly continuous downward trend, with only a ripple at the time of oil crises. Since today transportation relies almost entirely on finite fossil fuels, we suspect that one day the cost of transport will evolve in the opposite direction, increasing systematically as oil supplies decline. The sudden, albeit temporary, surge in oil prices in 2008 seemed to forecast this hard reality. But even though there is little point in thinking in doomsday scenarios, it remains a fact that over time highly car-dependent spatial structures may be particularly vulnerable to oil shortage (Dodson and Sipe, 2008).

To date, the excess commuting research framework (hereafter extended to excess travel) has to our knowledge only been applied on the study of the home-to-work commute. There is no doubt about the primordial economic importance of the commute, which represents a significant proportion of the number of car kilometres travelled. In Flanders, the home-to-work commute represents 18.6% of trips. Yet, the average commuting trip distance amounts to 19.0 kilometres, which is much higher than the average trip length of 12.5 kilometres (for all purposes combined) (Zwerts and Nuyts, 2004). Moreover, we know that commuting trips are much less price elastic and thus more inert than other trips. All these arguments emphasize the importance of studying commuting behaviour.

By contrast, in the western world the share of commuter traffic in the overall mobility is decreasing. Leisure travel, and by extension: tourist trips, are on the rise. In essence, this evolution originates from the ever growing prosperity and the improved accessibility of high speed travel modes for an increasingly larger share of the population. Even if the penetration of the private car and the coverage of the motorway network would have reached its structural limits, we still continue to use more and more often aircrafts and high speed trains for recreational and tourist trips. In the continuum of Handy et al. (2005), these trips are situated near the "choice" end, and are much less emerging by "necessity". The changeable nature of the destinations and the consequent difficulties in data acquisition represent perhaps the real reason why researchers have not yet ventured to the study of excess leisure travel, and have thus confined themselves to the study of the home-to-work commute. Similar reasons can be found concerning the study of other non-professional trips, such as shopping, home-to-school travel or visiting public services.

However, non-professional trips did not entirely escape attention in the excess commuting discourse. Recently, Horner and O'Kelly (2007) suggested that the study of excess travel for non-professional, but more or less daily trips could become an interesting extension, possibly shedding more light on the relationship between non-professional travel behaviour and spatial structure. Examples are innumerable: bringing children to day-care or school, doing the groceries, or going to sports or hobby clubs. The study of non-commuting trips, however, entails considerable methodological problems. Following problems can be identified immediately:

- The capacity of many of the mentioned facilities is deemed elastic, compared with employment centres that are characterized by a relatively constant number of jobs.
- Many non-professional trips are frequently made, but not daily.
- There are often multiple destinations for one purpose, as is e.g. the case for multipurpose shopping trips (Handy, 2001).
- Many leisure trips are part of a trip chain that partly includes commuting, making the distinction between professional and non-professional travel vague.
- For some destination classes the trade-off between the accessibility of the widest possible range of customers and the cost of an additional establishment is inherent in the location of the facility. This is the case with branches of large chain stores, which are often sited based on a facility location model.
- There is often no area covering sample data available on travel behaviour of individuals and families, so it is not possible to aggregate data within relatively small traffic analysis zones. Moreover, available data often contains only information on reported trip distances, without mentioning the address of the visited facilities. In the latter case it is only possible to estimate excess travel that is generated by residences in a particular area, and not e.g. by stores or schools.

The conventional calculation of the minimum commuting distance using techniques of linear programming implies that we try to identify very regular travel patterns even in leisure trips, while the relative lack of regularity is just a typical characteristic of non-professional trips.

Our method, which we explain in the next section, tries to overcome some of these potential stumbling blocks. Nevertheless, it appears impossible to put up a sound mathematical model, as is usual the case in the study of excess commuting.

METHODOLOGY

Our research takes the Flemish Region and - to some extent - the Brussels-Capital Region, together constituting the northern half of Belgium, as a study area. The study consists of several stages. Given the relatively scarce data it is impossible to use traffic analysis zones as spatial units, which would be in line with the spatially disaggregated study of excess commuting. Therefore we first have to define the spatial classes that we want to distinguish. We do this by mapping the transition between more and less urbanized areas as accurate as possible.

Then we develop a non-professional equivalent to the minimum commuting distance in the form of a proximity map. This is done by defining, for each statistical ward (corresponding with a neighbourhood) and for each defined spatial class, the minimum distance that should be covered in order to reach all facilities that are visited by an average Flemish household during a week. Obviously, this method implies some simplifications. The choice of the number of destination categories or travel purposes is limited by the amount of available data. So we need to consider those facilities for which data is available as representative for a certain category of destinations. This choice is to a certain extent arbitrary. Furthermore, the activity pattern of a household is also determined by the spatial context in which this family lives, reducing the assumption of an average activity pattern to a major simplification.

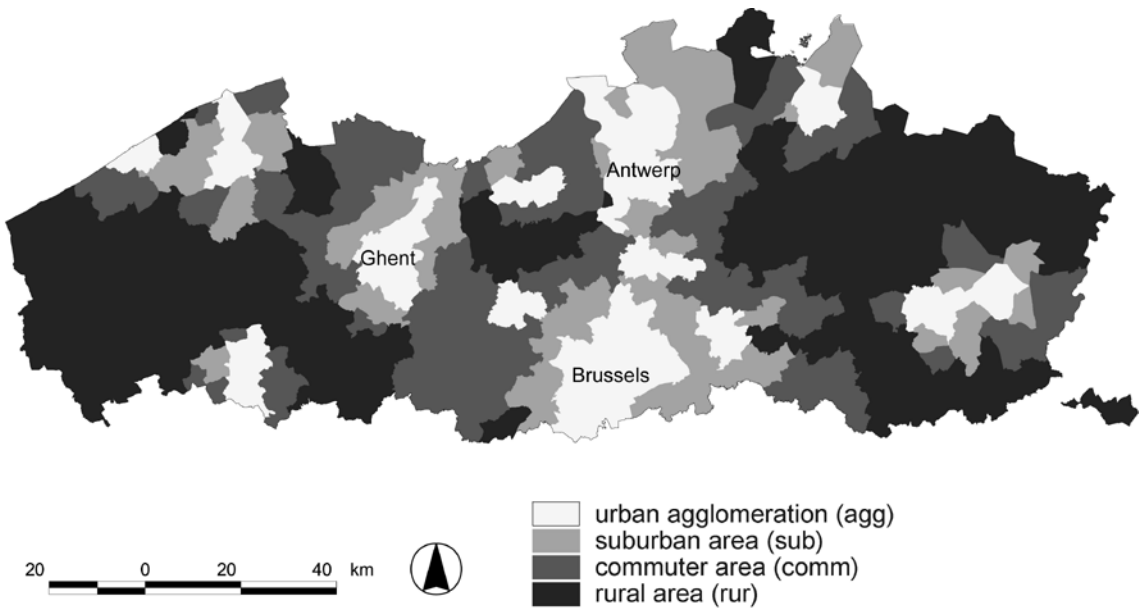
In a third phase, we examine the effective distance travelled by households during non-professional trips, based on available travel survey data, while distinguishing our predefined spatial classes and destination categories. Eventually we compare reported travel distances with calculated minimum distances, resulting in a ratio that represents a measure for excess travel. We consider variation of spatial proximity and excess travel as a spatial characteristic indicating how sustainable a certain physical structure is in relation to non-professional trips.

DETERMINATION OF SPATIAL CLASSES

Unlike data on commuting, that are based on a census (SEE 2001), data for non-professional trips are in Flanders only available in the form of a sample (Travel Behaviour Survey for Flanders 2000-2001 (Onderzoek Verplaatsingsgedrag Vlaanderen (OVG)) (Zwerts and Nuyts, 2004). This means that we cannot make a spatially continuous analysis on the basis of a map for the whole studied region, as opposed to the study of excess commuting (Boussauw et al., 2010).

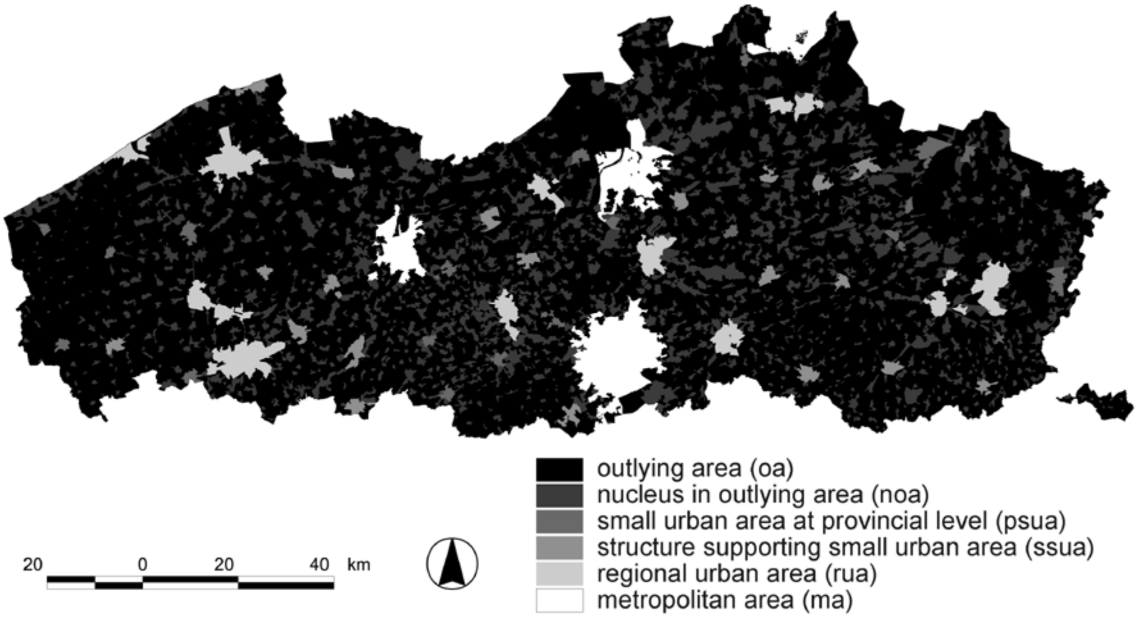
However, we want to relate the observed travel behaviour to different types of spatial structures. To retain a survey sample that is large enough for every spatial class, we look for a meaningful spatial classification for the region of Flanders and Brussels. We base our argument on the existing literature. Depending on the point of view, two major formats exist. Based on empirical data Luyten and Van Hecke (2001) assign each municipality to one of the following four categories: urban agglomeration ("agg"), suburban ("sub"), commuter area ("comm") and rural (“rur") (which is a residual category with very limited urban characteristics). We will call this the “urban region” classification. The urban agglomeration consists of those municipalities where more than half of the population lives in an urban core or in the urban fringe, characterized by a continuously built-up environment. The suburban area is the outer zone of the city, characterized by an extensive, rural morphology, combined with an urban functionality. Agglomeration and suburban area together compose the urban region. The commuter area is attached to the urban region and relies on this urban region for an important part of its employment. This classification is based on a combination of morphological characteristics and data on commuting and migration flows. The demarcation of the different classes follows the municipal borders, causing some loss of accuracy. An overview is represented in Map 1.

Map 1: Spatial classification according to the “urban region” approach (Luyten and Van Hecke, 2001)



The Spatial Structure Plan for Flanders (Ruimtelijk Structuurplan Vlaanderen (RSV), 1997/2004) offers a second classification, which is much more policy-oriented. This means that this format does not only take into account the current situation, but incorporates also a vision for future development which is adopted by the Flemish government. The main direction of development, favoured by RSV, is indicated by the dichotomy between urban areas and outlying areas. Urban areas are those areas that should receive most of the additional housing and businesses, and are very accurately delineated (on the ward level). The selection makes a distinction between metropolitan areas ("ma") (agglomerations with more than 300,000 inhabitants: Antwerp and Ghent, and for clarity we also add the Brussels region to this category), regional urban areas ("rua") (between 50,000 and 150,000 inhabitants) and small urban areas. Within the latter category a distinction is made between “structure supporting small urban areas” ("ssua") (being relatively important attraction and development poles) and “small urban areas at provincial level” ("psua") (being a development pole of minor importance). The demarcation of urban areas is based on a consultation process and is consolidated on the basis of cadastral boundaries. For a number of urban areas this demarcation process is still ongoing. We used a provisional definition, translated to the ward level. For simplicity, we consider everything that is not within the definition of any urban area as outlying area ("oa"). In the outlying area we can still distinguish selected residential nuclei ("noa"), generally corresponding to villages. In total we distinguish thus six categories within the framework offered by RSV. A cartographic overview is shown in Map 2.

Map 2: Spatial classification according to the RSV approach (Ruimtelijk Structuurplan Vlaanderen, 1997/2004)



Since the two proposed classifications have pros and cons, we decided to include both systems in our analysis.

DEVELOPING A PROXIMITY MAP

Method and selection of destinations

In a first phase of our research we develop a method to quantify the proximity of non-professional quasi-daily destinations. We use the ward as a spatial unit, considering the centre of gravity (centroid) of the ward as a starting point to calculate the network distance to the closest appropriate facility. The 9708 wards which cover Flanders and Brussels are therefore regarded as residential locations. Used network data consist of the seven highest categories of the Streetnet skeleton file, which contains almost all passable connecting roads.

We select 18 types of facilities for which a location dataset is available. Each facility type is judiciously assigned to one of the travel purposes that are applied in the OVG. We only used the purposes that are non-professional ("work" and "business visit" are thus excluded) and have a destination for which alternative locations can be found (so the purposes "walking/driving around" and "visiting someone" were not considered, just as the indefinite "other purpose"). The remaining purposes are: shopping (SHP), education (EDU), picking up/taking something/someone (PCK), leisure/sports/culture (LSC), services (e.g. medical doctor, commercial bank) (SRV).

The various selected facility types, data sources and links with OVG purposes can be found in Table 1. The purpose "shopping" is represented by three classes of supermarkets and some more specialized types of shops. For the interpretation of the purpose "education" the higher grades of secondary education and higher education (in general: education for students over 14 years old) were not taken into account, since we consider these facilities as too specialized. The purpose "leisure/sports/culture" is represented by cafés, restaurants, sports centres and cinemas, while the category "services" is represented by doctors and banks. We construct the purpose "picking up/taking something/someone" by a combination of education and leisure/sports/culture, supplemented with nursery. This is of course only an approximation, where we assume that mainly children are taken to and collected from their activities.

With regard to the quality of the data we mention that the data retrieved from Google Maps (2009) are based on commercial information which is less complete than the other data sets that were used (Federal Public Service of Economy (2009), Ministry of Education (2009), Child & Family (2009), Cinebel.be (2009)), which claim to be exhaustive. The location data from Google Maps include geographic coordinates. The other data sets used consist of address lists that we geocoded with the help of Yahoo! Maps Web Services (2009). Finally we calculated the network distance between each ward's centroid and the nearest location within each selected type of facility using Dijkstra's shortest path algorithm (implemented in the Closest Facility Tool of ArcGIS Network Analyst) as follows:

$$T^{O}_{wf,\min} \Big| \forall i \in f : T^{O}_{wf,i} \geq T^{O}_{wf,\min} \qquad (1)$$

in which:

T_{min} = minimum trip length
w = ward
f = type of facility
i = any possible destination belonging to type of facility f
O = indicates that the spatial unit is always considered as the base (origin) of the trip

Table 1: Selection of facilities and purposes

type of facility	***n***	***source***	***purpose OVG***
baker's	*3747*	*Google Maps*	
supermarket class 1 (hypermarket)	*54*		
supermarket class 2 (supermarket)	*1484*	*Federal Public Service of Economy*	*shopping*
supermarket class 3 (superette)	*869*		
clothes shop	*660*		
do-it-yourself shop	*199*		
household appliances (electrical)	*180*		
kindergarten	*2913*		
primary school	*2861*	*Ministry of Education*	*education + picking up/taking something/someone*
middle school (1st grade high school)	*681*		
adult education	*111*		
nursery	*2844*	*Child & Family*	*picking up/taking something/someone*
café/bar	*4746*		
restaurant	*6907*	*Google Maps*	*leisure/sports/culture*
sports centre	*1581*		

cinema	*49*	*Cinebel.be*
medical doctor	*9713*	*Google Maps services*
commercial bank	*3391*	

Weighing

The closest facility calculation provides a proximity map for each type of facility, showing the accessibility, in terms of physical distance, from every considered ward. However, we want to limit the number of maps to the five mentioned OVG purposes, and ultimately we want one summary map. We calculate spatial proximity per spatial class and per travel purpose as follows:

$$T^{O}_{sf,\min} = \frac{\sum_{w=1}^{n} T^{O}_{wf,\min}}{n} \qquad (2)$$

in which:
s = spatial class
n = number of wards in spatial class

To join the proximity of different purposes into one map it is necessary to assign weights to the various facility types:

$$T^{O}_{wH,\min} = \sum_{f=1}^{m} a_f \cdot T^{O}_{wf,\min} \quad (3)$$

in which:
H = average weekly haul
a_f = weight by type of facility
m = total number of facility types

The weighting is determined by the weekly visit frequency to the respective facilities by an average Flemish household. As a starting point we take the number of trips per household per purpose, as reported in the OVG. Overall an average household generates 42.95 trips per week, of which 23.26 meet our criteria. Based on a number of other data (demographic statistics and market research), we estimate the average visit frequency. Visit frequencies of some destinations are extrapolated to fit in with the OVG data (visit frequency per OVG purpose). This means that some facility types are considered as representative for similar destinations: e.g. clothes shops, do-it-yourself and household appliance shops together are considered being representative for non-food specialist shops. Estimated visit frequencies are shown in Table 2. A trip is seen as a single move, which on average should be partially attributed to a trip chain. Based on OVG we expect that visit to a facility generates on average 1.68 trips, since often more than one facility is visited within one trip chain. The purpose "picking up/taking something/someone" in the table was reduced to the facility type "nursery". For comparison with reported trip lengths this purpose is extended pro rata with the purposes "education" and "leisure/sports/culture" (see below).

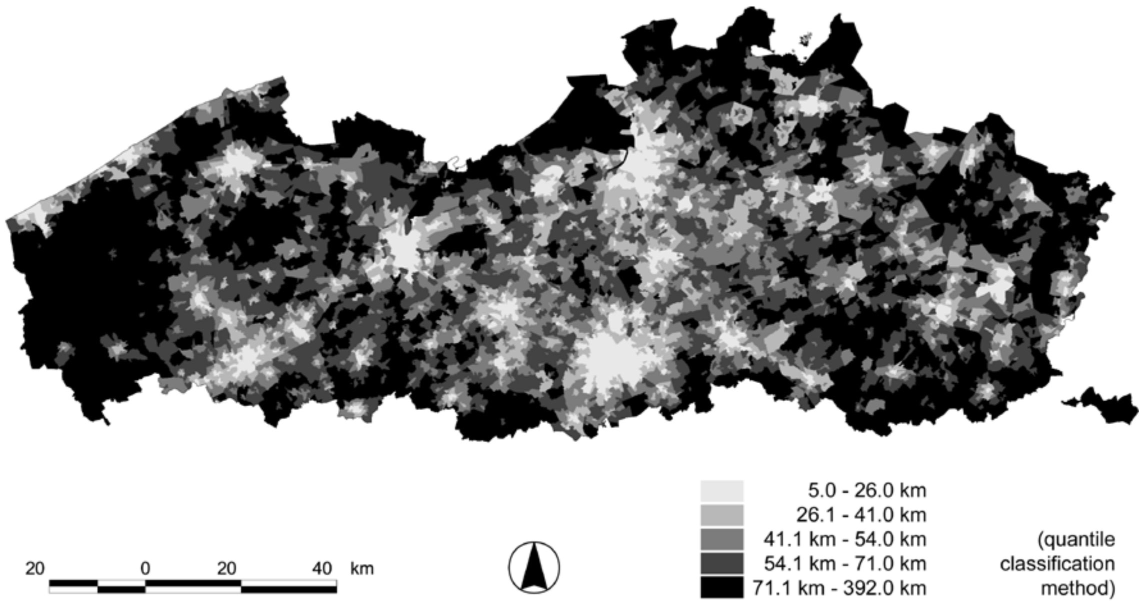
Table 2: Estimated weekly visit frequency by type of facility, per household

purpose OVG • **representative facility**	**# trips/household-week**
shopping	***8.99***
• *bakery*	*2.11*
• *supermarket class 1 (hypermarket)*	*0.69*
• *supermarket class 2 (supermarket)*	*3.26*
• *supermarket class 3 (superette)*	*0.42*
• *clothes shop*	*0.84*
• *do-it-yourself shop*	*0.84*
• *household appliances (electrical)*	*0.83*
education *(without higher secondary and higher education)*	***3.09***
• *kindergarten*	*0.68*
• *primary school*	*1.70*
• *middle school (1st grade high school)*	*0.52*
• *adult education*	*0.19*
picking up/taking something/someone *(limited to nursery)*	***0.34***
• *nursery*	*0.34*
leisure/sports/culture	***9.00***
• *café/bar*	*1.84*
• *restaurant*	*5.95*
• *sports centre*	*1.00*
• *cinema*	*0.21*
services (e.g. doctor, bank)	***1.85***
• *medical doctor*	*0.62*
• *commercial bank*	*1.23*
SUM	***23.26***

Mapped proximity per spatial class

By mapping the result of equation (3) for every ward, we get a weighted proximity map (Map 3). This map provides an overview of the spatial variation of the minimum distance, expressed in kilometres, that should at least be covered by an average Flemish household to complete its weekly programme.

Map 3: Weighted proximity map for Flanders and Brussels (shortest average weekly haul per household, for selected facilities)



To compare these calculated minimum distances with the distances reported in the OVG, we calculate the average values for each spatial class: both the values per purpose (Figures 4 and 5) and the weighted values (Table 5). Furthermore, we apply an ANOVA to test for statistically significant differences between the different spatial classes. For both applied spatial classifications the ANOVA test indicates that the differences between the spatial classes are indeed significant (significance level of 0.01).

Table 3: Minimum distance by purpose (km) (urban region classification)

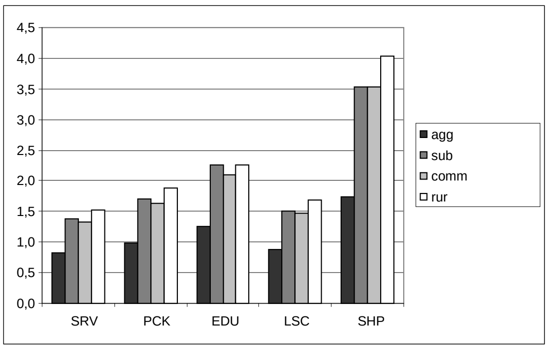


Table 4: Minimum distance by purpose (km) (RSV classification)

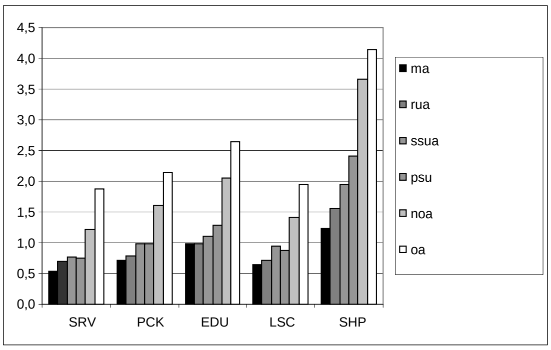
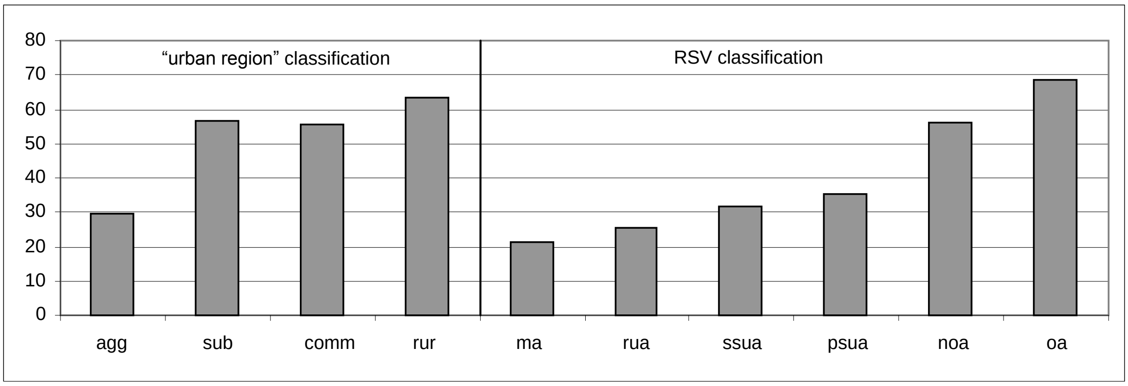


Table 5: Shortest average weekly haul per household (km)



As expected agglomerations and metropolitan areas score points in terms of spatial proximity. The differences between suburban and commuter areas are minimal, as well as the differences between the structure supporting small urban areas and small urban areas at provincial level. The rural area and outlying area (including the residential nuclei in the outlying area) score poorly, as expected. In particular the spatial classification according to the RSV shows a systematic increase of the minimum distances to be covered when we move from a more urbanised to a less urbanised area.

REPORTED TRIP LENGTHS

Data

Data on the effective length of trips made by the inhabitants of the respective spatial classes are obtained from OVG. This survey reports on travel behaviour of a sample of 3028 households over two consecutive days. The sample does not contain households from Brussels (which is administratively not part of the Flemish Region) and Ghent (for which a separate survey was conducted). For our study we added a random selection of data from Ghent to the Flemish data.

For our study we selected only those trips originating from or ending at the residence of the respondent, with a destination or origin corresponding with one of the five selected purposes. Thus, we do not only consider tours from home to the facility and back, but also parts of trip chains between the house and the facility. For each trip we know the reported distance travelled, the ward where the respondent resides, and thus the spatial class in which the residence is located. However, we do not know the location of the visited facility.

Since we are looking for quasi-daily travel behaviour, trips that cover extremely large distances are considered as outliers. We eliminated outliers per purpose, while setting the threshold at three standard deviations above the mean trip length. Table 6 shows the remaining number of observations after selection.

Table 6: Summary of the retained trips and corresponding OVG purposes

n	***SHP***	***EDU***	***PCK***	***LSC***	***SRV***
agg	*1977*	*777*	*936*	*1377*	*413*
sub	*816*	*427*	*530*	*483*	*166*
comm	*1273*	*623*	*669*	*794*	*308*
rur	*1632*	*835*	*904*	*1141*	*352*
ma	*941*	*365*	*451*	*636*	*203*
rua	*850*	*334*	*390*	*556*	*188*
ssua	*411*	*171*	*158*	*222*	*96*
psua	*281*	*119*	*143*	*202*	*61*
noa	*1990*	*1022*	*1104*	*1291*	*429*
oa	*1225*	*651*	*793*	*888*	*262*

Method

To link up the minimum distance to be covered and the reported travelled distances (Witlox, 2007), we follow two different approaches, in parallel. First we calculate the average reported distance per purpose, per spatial class:

$$T^{O}_{sp,obs} = \frac{\sum_{r=1}^{q} T^{O}_{sp,r}}{q} \qquad (4)$$

in which:
T_{obs} = average reported distance per purpose
T_r = reported length of trip r
p = purpose
q = total number of reported trips based in spatial class s and with purpose p

In a next phase we compare this with the minimum distance to be covered, according to equation (2).
This procedure gives an indication about the influence of the degree of proximity of a certain type of facility on the actual distance travelled to reach a similar facility. However, the information obtained in this way is not sufficient if we want to understand the relationship between sustainability of travel patterns and spatial structure. In this second case also information about trip frequencies is important, since it is conceivable that people who make relatively short trips will compensate their benefit - in terms of time and costs - by making more trips, cancelling out gains in fuel consumption (as an indicator for sustainability).
Therefore we calculate the average distance travelled by a household during one week by adding up the distances covered by all selected reported trips per spatial class, and extrapolate this sum to a time frame of one week:

$$T^{O}_{sH,obs} = 3.5 \cdot \frac{\sum_{h=1}^{t}\sum_{r=1}^{q} T^{O}_{sh,r}}{t} \qquad (5)$$

in which:
h = individual household
t = total number of households in spatial class s and included in the survey
(factor 3.5 extrapolating the two-day survey to a time frame of 7 days)

In a next step we will compare this distance travelled with the weighted average minimum distance to be covered by an average household to satisfy its needs (equation (3)).

Results

For the observed (reported) values we also calculate averages and display these by spatial class. Again, the ANOVA test indicates that significant differences between spatial classes exist (significance level of 0.05). The averages for each purpose are shown in Figures 7 and 8, while the total observed distances (extrapolated to a full week) are shown in Table 9.

Table 7: Reported trip length by purpose (km) (urban region classification)

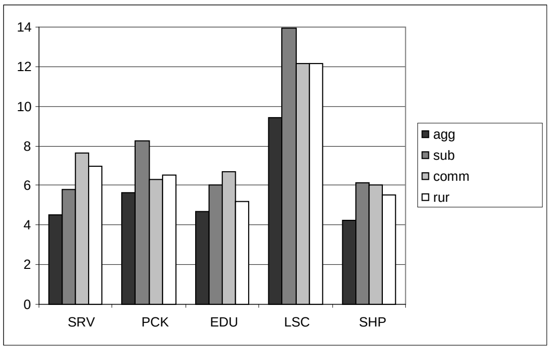
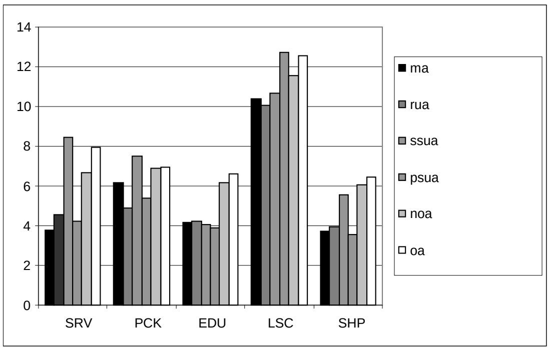
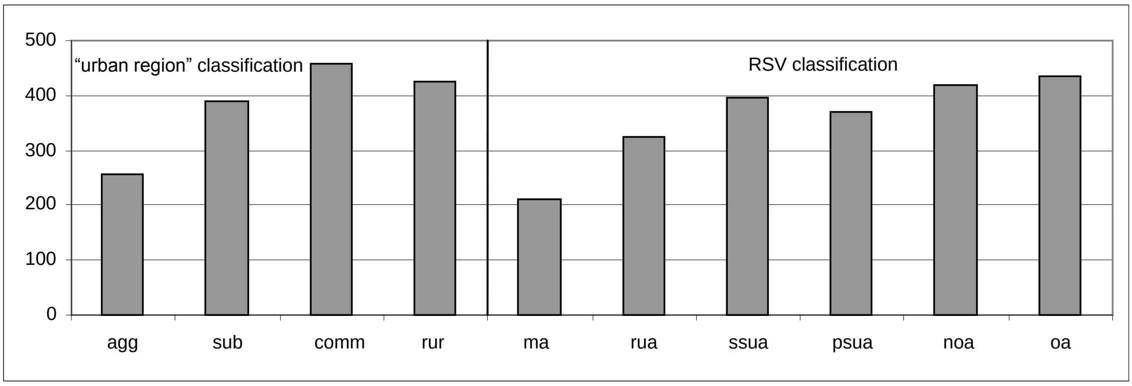


Table 8: Reported trip length by purpose (km) (RSV classification)



Figures 7 and 8 give a rather surprising picture. The differences between the spatial classes are much smaller than what we might expect based on the major differences in spatial proximity. For most purposes, the least urbanized classes do not necessarily provide the greatest distances travelled: the largest trip lengths are rather recorded in the suburban and commuter areas. Also the minor differences between the metropolitan and regional urban areas stand out.

Table 9: Reported weekly haul length per household (km)



The results that are shown in Table 9 take into account the spatial differences in trip frequency. Although, while assessing the results, we must not forget that our selection method takes no account of trips that do not have either their origin or their destination at the respondent's home. There are indications that a more urban environment is associated with more complex trip chains, in our analysis perhaps leading to an underestimation of the number of trips per household in these areas (Banister, 1999). Yet, complex trip chains are usually very efficient tours, conducting a series of activities within a minimum tour distance.

When we consider the "urban regions" classification, it appears that agglomerations, as expected, yield the shortest average weekly haul. The commuter area - thus not the rural area - yields the longest weekly haul. When examining the RSV classification, metropolitan areas constitute the shortest weekly haul. The weekly hauls are much longer in the regional urban areas, but still shorter in comparison with the small urban areas (the structure supporting small urban areas in particular). In the outlying area, we record the longest weekly haul.

These relations are quite consistent with British research, recording the shortest travel distances in the major British cities (>250,000 inhabitants), except London. Small towns and rural areas score poorly (Banister, 1999). Our study adds a new element: commuter areas which fit morphologically with the rural area but are still within the sphere of influence of the agglomeration are scoring worse than the more remote "real" rural area.

Parts of the results are probably explained by the utilization of the available choice potential due to spatial proximity. This is the case in metropolitan and regional urban areas better as they are both functionally and morphologically more urbanized than the rest of Flanders. On a lower geographical scale the structure supporting small urban areas generate more mileage than the small urban areas at provincial level. However the nature of the former class is more urban than the second. Perhaps the structure supporting small urban areas are functionally more focused on the larger cities.

Possible biases in the results

The discussion above assesses the number of kilometres travelled per household. However, there are substantial differences between average households in the various studied spatial classes. It is generally assumed that households in urban areas are relatively small, while

household income peaks in the suburban areas near large cities. These factors may play a role in the sustainability of travel behaviour, even though the precise effect is often unclear.
A larger number of family members may lead to more kilometres travelled per household. Yet, within these families carpooling occurs more often, while children travel only few kilometres independently. Thus, calculated per person, larger households are expected to produce less kilometres. When examining the influence of spatial structure, calculation of the number of kilometres travelled can be justified both per household and per person, albeit from different viewpoints.
Household income plays a role too. At the macroeconomic level, there is a linear relationship between income and the number of kilometres travelled (Schafer and Victor, 1997). If there would exist significant income differences between the various spatial classes, it would make sense to control for this variable. Determining income, however, raises additional methodological problems. It is for example possible that the effect of a higher income in an urban environment is primarily reflected in increased tourist travel, and not in longer daily journeys (Holden and Norland, 2005). Moreover, we downplay car ownership, an intermediary variable that is influenced both by income, by the surroundings (supply of alternative transportation and parking) and by household size.
These assumptions add much more complexity to the study of the role of spatial structure in the sustainability of travel behaviour. Should we measure the distance travelled per household or per person? Is it useful to take income into account, and if so, how do we tackle this issue? To avoid oversimplification, we do not incorporate these variables in a statistical analysis. However, below we shed more light on the possible role of spatial structure in itself in relation to the mentioned issues by providing a few basic figures.

Household size

Some Flemish policy plans argue that the average family size is lower in urban areas than in suburban and rural areas, and consider this phenomenon as a social problem (Boudry et al, 2003, p. 114). It is also assumed that the phenomenon of shrinking household size occurs more rapidly in the urban areas, increasing the identified problem. Champion (2001) paints a more balanced picture. Small households, particularly one-person households, are only rarely based on the stereotypical young career maker with a very urban lifestyle. Young singles stay continuously longer living in the parental home, while more one-person households than before are the result of a divorce, and are in many cases located in a suburban area. In contrast, in western city cores especially the immigrant population is keeping average family size at a relatively high level.
For Flanders (2006) we find the following values (Table 10):

Table 10: Average household size per spatial class (2006)

class (urban regions)	n	class (RSV)	n
agg	2,19	ma	2,13
sub	2,55	rua	2,23
comm	2,44	ssua	2,24
rur	2,48	psua	2,33
		noa	2,50
		oa	2,61

In urban agglomerations and metropolitan areas households are actually smaller than average. Yet, an exploratory linear regression, trying to explain weekly distance travelled by variation in family size does not yield any significant results. When we calculate the average number of kilometres travelled per person, rather than per household, then differences between spatial classes (as shown in Table 9) are somewhat smaller. When using the spatial classification according to RSV, structure supporting small urban areas stand more out, making travel patterns of the inhabitants of this class now appearing the least sustainable. The outlying areas and small urban areas at provincial level follow shortly. The agglomerations and metropolitan areas still score best.

Income

By way of illustration we examine the average household income, based on the assessment forms of direct taxation for the year 2006. The available data are aggregated for each municipality. This level of aggregation allows us to regroup the data according to the "urban region" classification, but not to the RSV classification. It is important to keep in mind that here too the Brussels-Capital Region is not included in the analysis.

Table 11: Average household income per spatial class (2006)

class (urban regions)	€
agg	28448
sub	28950
comm	26778
rur	24862

There seems to exist a slightly downward trend when we move from more urbanized into less urbanized areas. This is particularly the case when we would take into account household size (income per person). Yet, also in this case an exploratory linear regression does not yield any significant correlation between the weekly number of kilometres travelled and the level of income per household or per person. We conclude therefore that the macro-economic theory, arguing that higher income results in more kilometres, does not apply at the regional scale of our study area. This finding provides an additional argument for the proposition that spatial structure indeed plays an important role in the genesis of travel behaviour.

EXCESS TRAVEL

We find that the influence of spatial proximity does not work out in the same way for each spatial class. We examine this phenomenon in analogy with excess commuting research methods. We define excess travel as the difference between the minimum distance that must be covered to visit the desired type of facility (e.g. the nearest supermarket) and the observed distance covered. The observed trip length is always larger than the minimum trip length because of non-spatial factors that are determined by e.g. personal preferences, transport cost, price differences between similar facilities, or the organization of trip chains. We choose to express this difference as the ratio between the minimum distance to be covered and the observed distance travelled. This ratio is called the excess rate:

$$E_{sp}^{O} = \frac{E_{sp,obs}^{O}}{E_{sp,\min}^{O}} \quad (6) \qquad E_{sh}^{O} = \frac{E_{sH,obs}^{O}}{E_{sH,\min}^{O}} \quad (7)$$

in which:
E_p = excess rate by purpose
E_H = excess rate for an average weekly haul

As shown by equations (6) and (7), we calculate excess rates in two ways. First we determine per purpose and for each spatial class the relationship between the reported average distance of a trip with the considered purpose (as shown in Table 3 and 4), and the minimum distance to be covered to reach a similar destination (as shown in Table 7 and 8). This excess rate per purpose is shown in Figures 10 and 11. Secondly, we determine the ratio between the weighted minimum weekly haul (shown in Table 5) and the total reported distance travelled, extrapolated to a full week (shown in Table 9). This weekly haul excess rate is shown in Table 14.

Table 12: Excess rate by purpose (urban region classification)

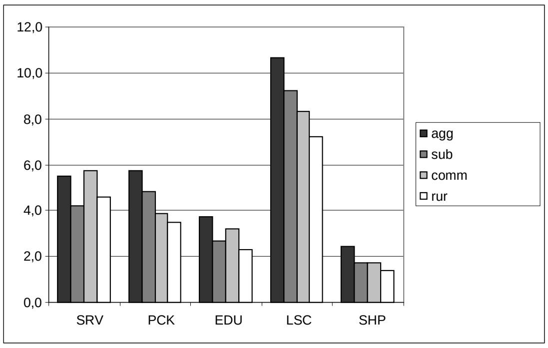


Table 13: Excess rate by purpose (RSV classification)

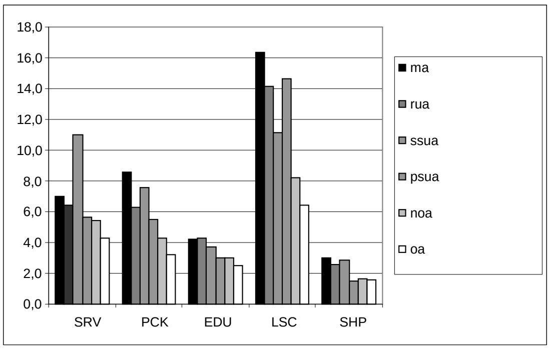
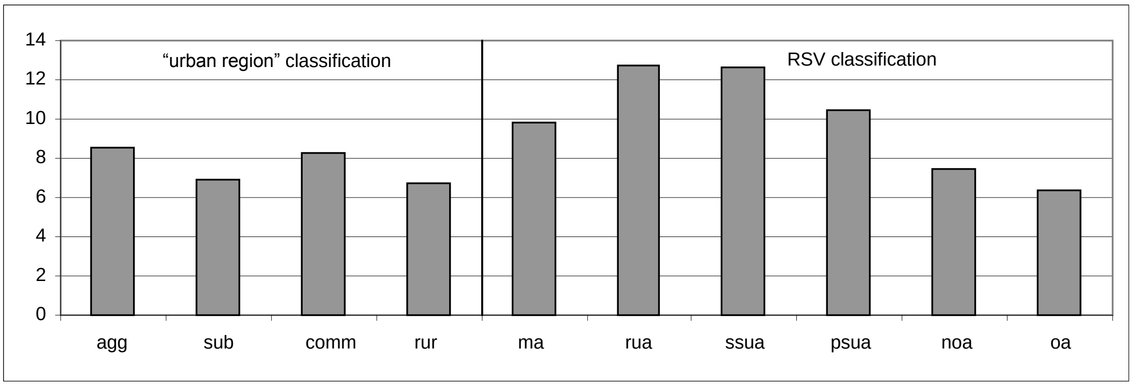


Table 14: Weekly haul excess rate



In Figures 10 and 11 we note for most purposes a systematic downward trend of the excess rate when we watch the various spatial classes in order of decreasing urban nature. In short, this means that a high degree of spatial proximity is only partially reflected in short trip lengths, because the increased choice of possible destinations generates comparatively long journeys. In metropolitan areas the average household goes shopping three times further from home than strictly necessary, while in the outlying area this rate amounts to one and a half only. Thus, a higher degree of spatial proximity creates greater choice, compensating for a significant proportion of the potential gains (in terms of external costs caused by traffic). Noteworthy is that the differences in excess travel between the spatial classes are rather small. This is in contrast to what was found previously in the case of excess commuting (Boussauw et al., 2010), with very high values in urban areas, compared to very low values in rural areas. Regarding differences between purposes, we notice a very high degree of excess travel in leisure trips, where strong personal preferences play. This applies to some extent also for trips to services, although the low visit frequency and the overall high degree of spatial proximity (there is a doctor in every street, so to speak) play their role in the obtained excess rate.

When assessing the excess rate of a combined weekly haul, then the downward trend is not anymore evident. Following the spatial classification according to the RSV, regional and small urban areas report the highest values of excess travel. The rates are much lower in the metropolitan areas. A household in a regional urban area covers a weekly distance that is more than 12 times longer than the minimum distance required by our model. By contrast, a household living in the outlying area covers only 6 times the minimum required distance.

We can interpret the excess rate as a measure that indicates to what extent a travel pattern can be made more efficient, given the spatial context. In this case gaining efficiency means shortening travel distances by choosing similar destinations closer to home, within the existing spatial configuration of housing and facilities. Such an adjustment of households' travel pattern may happen in case transportation would become more expensive, e.g. by a severe congestion or environmental policy, or by energy scarcity. In the outlying areas, distances are relatively high, and the excess rate is low. This means that those areas are most vulnerable to a price increase in transportation. In regional urban and small urban areas, the distances are not only smaller, there is also more margin leaving the possibility to choose destinations closer to home. In the metropolitan areas non-professional trips seem comparatively efficient, apart from being short anyway.

CONCLUSIONS

The excess commuting research framework proves to be very useful in examining the relationship between non-professional trips and spatial structure. By mapping the minimum distance that an average household needs to cover in order to complete its weekly programme, we get an idea of the variation in spatial proximity between housing and facilities. This combined minimum weekly haul varies from 5 km to 392 km, depending on the residence location. This wide range of spatial proximity classes indicates that the distinction between more and less urbanisation is still reality and remains important in terms of mobility. The proximity map we obtained in this way (Figure 3) can be used as a guidance for new developments. Additional densification of areas where the degree of spatial proximity is already high, or areas that are immediately adjacent to these, make an excessive increase of newly generated traffic least likely. In areas with a relatively low degree of spatial proximity, the situation could be improved by planning a better functional mix for the future. Yet, additional housing in areas characterized by a low degree of spatial proximity will generate more traffic. These findings are in line with what Banister (1999, p. 318) suggests: “New development should be of a substantial size and located near to (or within) existing urban areas so that critical size thresholds can be achieved.”

As stated in the introduction, spatial proximity is only one aspect of the overall picture. The degree to which choice behaviour is driven by spatial structure is equally important. Table 9 shows that the relationship between spatial proximity and number of kilometres travelled is not linear. Residents of agglomerations, metropolitan and regional urban areas travel over relatively short distances, but the inhabitants of the suburban and commuter areas and small urban areas appear to have a less sustainable travel pattern than is suggested by the rather urbanized spatial structures in which these people live. What is also surprising is that these variations cannot be explained by differences in family size or income.

From research on spatially disaggregated excess commuting we know that less urbanized areas are characterized by a higher minimum commuting distance along with a higher excess rate. In other words, residents of rural areas go to work further from home than urban residents, but they opt more often for the closest job they can find (Boussauw et al., 2010) than city-dwellers do. By analogy, we expected to find a similar phenomenon in the study of non-professional trips. Based on Table 14 we see that this expectation is only partially confirmed. In particular metropolitan areas, agglomerations and suburban areas are characterized by a relatively low excess rate, indicating that residents of these areas are still heavily influenced by spatial proximity when choosing their non-professional destinations. Possibly, modal choice has to do something with this: in an urban environment more non-professional trips are made on foot or by bike, slow transport modes for which trip length is crucial.

We conclude that spatial structure and degree of urbanization is of great importance to spatial proximity and length of non-professional trips. Particularly in metropolitan areas, but also in regional urban areas or the suburban areas that are adjacent to both urban classes, households look for non-professional activities relatively close to home, especially when it is possible to walk or bike there in a pleasant way. By attributing a role to this aspect in spatial planning practice, generation of additional traffic can be avoided and the vulnerability of spatial developments to more expensive transport (by rising fuel prices, congestion problems and congestion policy) can be reduced.

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