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FACULTEIT BEDRIJFSECONOMISCHE WETENSCHAPPEN

master in de verkeerskunde: mobiliteitsmanagement
(Interfacultaire opleiding)

Masterproef

Analysis of influence of work locations on travel behaviour with an activity-based model for Flanders

Promotor :
Prof.dr.ir Tom BELLEMANS

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Masterproef voorgedragen tot het bekomen van de graad van master in de verkeerskunde , afstudeerrichting mobiliteitsmanagement

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Abstract

Activity-based models are often useful when studying the movement of people from regions of origins to destinations. This paper investigates the influence of work locations on the travel behaviour of persons using an activity-based model in 20 selected municipalities in Flanders (Belgium).The activity-based model used is FEATHERS (Forecasting Evolutionary Activity-Travel of Households and their Environmental RepercussionS). A location model is incorporated in FEATHERS to achieve sensitivity to changes in the number of work locations. Basically, increase in the number of work locations is obtained by systematically adding 5% to the original number of employees (null scenario) till a maximum of 20% is reached. For instance a 5% increase in the number of employees in the selected municipalities results in a 5% decrease in the number of employees being applied to the remaining municipalities thereby keeping the number of employees unchanged. On the other hand, to simulate a decrease in the number of work locations, the same process is repeated, but this time a systematic 5% deduction is applied to the null scenario till a maximum value of 20 is attained. The resultant nine scenarios are then simulated in FEATHERS, and the relationship between a change of the number of work locations and travel behaviour of the population is revealed in terms of the following travel indicators: the number of work activities, the trip length, and the number of trips. The results show a change in the stated travel indicators as the number of work locations change.

Keywords : Travel behaviour, Work locations, Work population, FEATHERS, Radiation model, Flanders

1 INTRODUCTION

The demand for travel is influenced by the activities that individuals perform and/or wish to perform. More often than not, these activities are situated in different locations, suggesting an element of travel is involved if persons have to participate in more than one activity. Activities of persons can be classified into fixed and flexible. Examples of fixed activities include work and appointments. Flexible activities include shopping (daily and non-daily), touring, social, as well as recreational activities. For the most part, the choice and spatial context of the type of activity will have an influence on the travel behaviour of the individual.

To be consistent in explaining the variability in persons' travel behaviour, research have shown that, there are a considerable number of variables that need to be taken into account when analysing an individual's travel behaviour. Some of these variables include attitudes, socioeconomic and demographic traits (household structure, age, income, education), residential location, as well as land use and urban forms *[1]*. However the extent, and magnitude by which these variables influence travel behaviour cannot be readily ascertained *[2]*.Therefore, it suffices to say, for one to be consistent in explaining, predicting, and possibly influencing travel behaviour through policies, one needs to understand how these variables inter-act. The role these variables play in the travel behaviour of persons, is explored further in the second part of this paper.

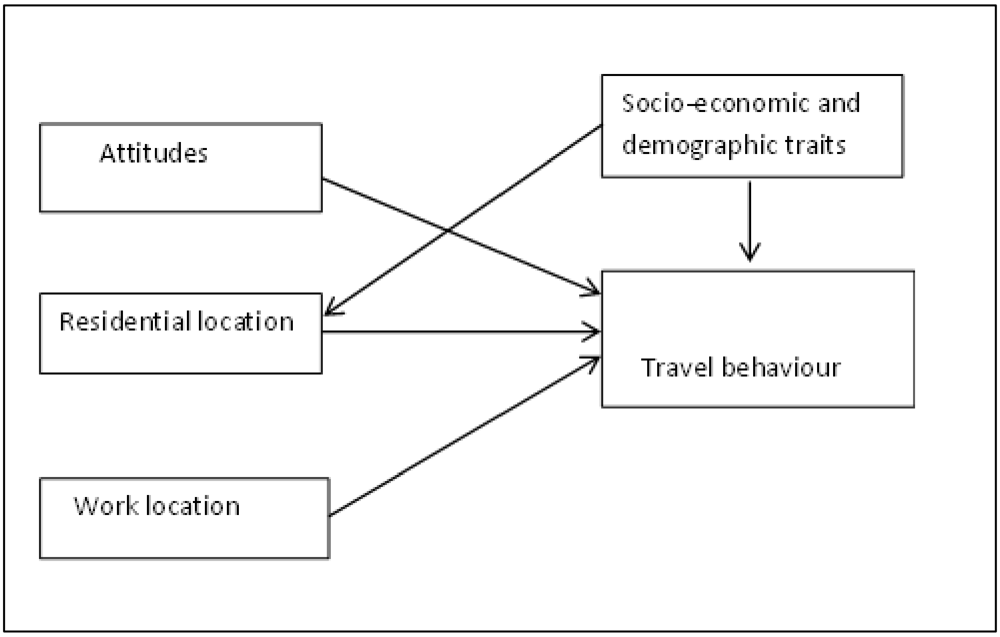

FIGURE 1 Interaction of some variables with travel behaviour

Investigating the impact of changes in the number of work locations on the travel behaviour of persons imply commuting trips are relevant in the context of this paper. The region considered in this study is Flanders (Belgium). 20 municipalities are selected including Brussels-capital region inclusive. The Brussels-capital region is further made up of 19 municipalities, Brussels inclusive (appendix I). The criteria for selection is because they are the largest municipalities in Flanders. The municipalities are comprised of subzones. The centroids of subzones are considered as point locations of activities

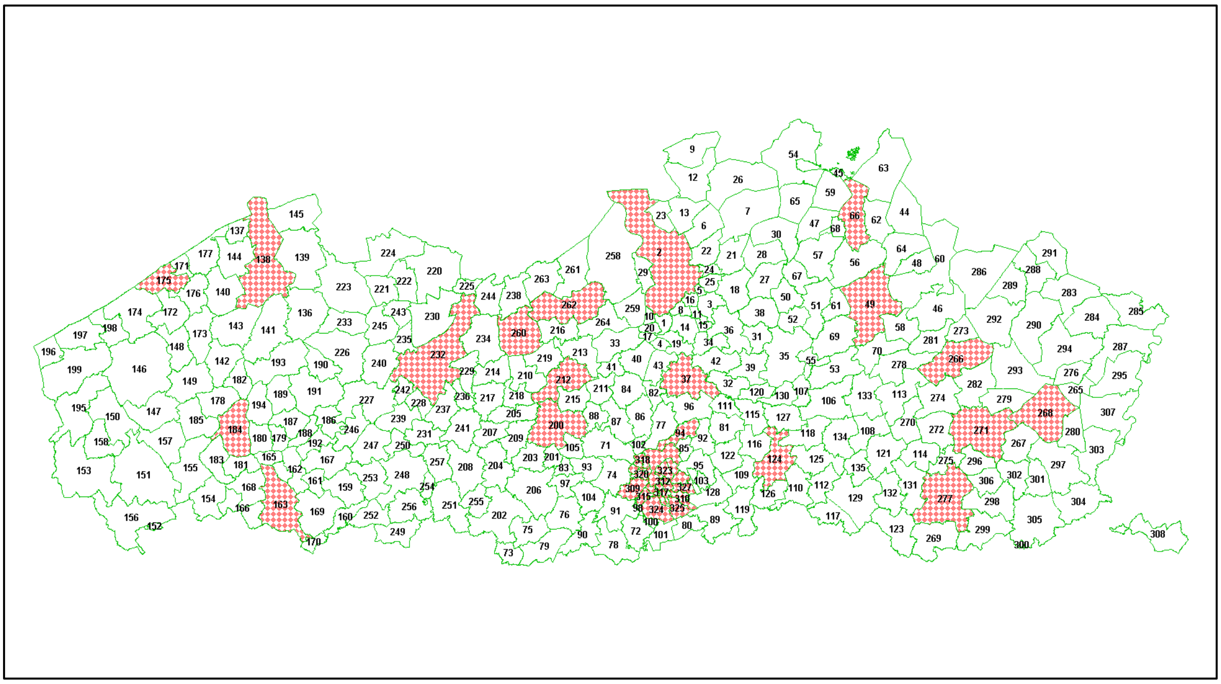

FIGURE 2 Map of Flanders showing selected municipalities

In Flanders, the commute to work is often towards big cities such as Antwerp, Ghent , and Brussels. The amount of traffic often generated during this period (to and back from work) is enormous. A good command and understanding of this situation cannot be over emphasized as there are resultant benefits as well as negative effects from these trips/journeys . Therefore, the knowledge gained can be used as a basis for effective planning decisions. This is in line with the notion that, although these journeys are done by different modes of transportation, for instance the train, bus, bike, a significant percentage is also done with the car.. The benefits often associated with the car as a means of commute is that, in the life of the worker the commute trip is one of the longest trip of the day. More often than not, it is inter-combined with other trips. It can therefore be ascertained that it is an important aspect in the professional life of the commuter. It is time consuming and stress-related *[3,4]*. Subsequently, this will likely have an effect on the travel pattern as well as on the travel behaviour of the individual.

1.1 Purpose of the study

The goal of this research is to analyse travel behaviour of persons in terms of a change in the number of work locations in some selected municipalities in Flanders. The travel behaviour will be revealed in a number of stated indicators. To achieve this, the number of work locations is altered based on a systematic increase or decrease of 5% of the original value.

Upon application of this, the objectives will be to analyse the travel behaviour of persons in terms of :

1) The number of work activities of persons
2) The impact on trip length. Initially, the work trip lengths will be analysed and subsequently the total trip length during the day will be analysed also with respect to changes in the number of work locations

3) The number of trips. Focus will be on the number of car trips, the number of non-motorized trips, the number of public transport trips, and the number of car passenger trips.
4) Additionally, the number of trips per hour is also analysed.

1.2 Structure of the paper

The second part of this research looks at a number of past studies that have examined work locations and travel behaviour. Part 3 describes the radiation model and its benefits in modelling the travel patterns of persons with respect to changes in the number of work locations. The data that is explored is discussed in section 4 (methodology). This is followed by section 5 detailing an in-depth analyses of the results obtained from the experiments. Finally, section 6 will be a presentation of the relevant conclusions and possible recommendations for further research.

2 LITERATURE STUDY ON THE INFLUENCE OF WORK ON TRAVEL BEHAVIOUR

The commuting trip is becoming increasingly important, but never-the-less complex. Its importance is associated to the increasing number of commuters on the road and complexity due to the difficulty in measuring commuting trips *[5]*. This difficulty in measurement is related to the decline of the direct travel to and from work as was the case in the old days. Non-work trips are now linked with commuting trips. This can be noted in the American society today. They include trips that have less frequency such as shopping. Substantial evidence can also be found in Aguilera *[6]*. The study of the three biggest French metropolitan areas (Paris, Lyon and Marseille) suggests that co-location (living and working in the same region) affects only a minority of inhabitants, of whom there were fewer in 1999 than it was the case nine years earlier. The polycentric distribution of jobs and individuals does not necessarily shorten commuting distance.

2.1 Travel differences between workers and rest of the population

As is expected, the time spent and distance travelled by workers is often greater than for non-workers on weekdays. The 2001 US National Household Travel Survey showed workers travelling about 12 miles (approximately 14.5 kilometres) more than non-workers each day *[7]*. In France the Home-to-work trip takes about 30 minutes *[3]* and is the same as in the US *[8]*. The reason for this difference can be explained by the fact that the work locations of most individuals are situated outside the home and away from their areas of residence. Consequently, this group owns more cars and are more motorized than the rest of the population. Thus, the preferred mode of transportation is the car. Thus, they are able to make other trips which are different from home-to-work trips and for which otherwise, would have been difficult if not impossible by public transportation.

2.2 Travel differences among workers

The difference in commute is not only seen between workers and the rest of the population, but there is also noticeable differences among workers. These differences can be expressed in terms of gender, income and professional status, as well as work duration *[9]*. The choice of selecting a work location and consequently the resulting travelling behaviour is different between men and women. However, sociological factors rather than economic are possible explanations why working-class women make shorter commuting trips than working-class men. They often select places of work that are close to their areas of residence *[10]*. Mode choice is affected by the gender role a person assumes in a household *[11]*.This is referred to as the social hypothesis. The same situation is observed in car deficient households (households having more drivers than there are cars). Additionally, females generally have a more 'casual attitude' toward job seeking than their male counter-part. High income earners are more likely to have jobs located far from their area of residence. The same holds for jobs with high professional status. This is also linked to the level of education, with people of higher levels of education having the tendency of seeking jobs located far from their municipalities or area of residence. Referring to work duration, the time spent on work and the commuting distance are positively correlated. In other words, the duration of a certain work can also be a possible explanation for commuting time. Data from the 1998 Dutch National Survey showed that workers spend on average 10.5% of the time available for work on travel or commuting. This refers to about 28 min (for a single trip) in an 8-hour workday *[12]*. Above a certain work duration, commuting time starts to fall. The travel-time ratio is used for the above scenario. It is worth mentioning that the travel-time also varies with other factors such as demographics.

2.3 The impact of demographics on travel behaviour

In different travel categories (business , commuting , leisure) and for all modes (car, rail , and air), after controlling for employment , it is shown that men travel for long distances more than women *[13]*. Individuals over the age of 60 in Great Britain for instance, travel less (except for holiday trips), and in most cases the chosen mode is the coach. Students also travel more but in most cases by coach and rail. The household composition also has an impact on long distance travel; as the number of adults in a household increase, the commute distance decreases. Furthermore, the age of children also affect commute; with households having children under 16 years commuting less. Commute is also more and prominent in areas where the size of municipality and probably population is small (for instance rural areas).

2.4 Trip length

The importance of trip length cannot be over emphasized. This is specifically true for a sustainable city where commuting trip lengths are supposed to decrease over time and not increase *[14]*. Trip length can directly or indirectly influence mode choice. The more time people spend on travelling, the less time they will have for other activities and vice versa. This implies that with all things being equal, people will prefer using a means of transportation that requires less time.

2.5 Trip timing

The journey time to work is an important aspect in the professional life of the commuter. As stated in *[15]*by, the pursuant of activities lead to the consumption of time. This is regardless of the type of activity involved or the time under consideration. In order to arrive at work on time, it is imperative for the worker to take into consideration varying situations such as traffic congestion, peak and off-peak hours, which more often than not are linked to the time of day in which the journey is made. Generally, there is more reliability in arriving on schedule when the journey is made during off-peak hours than when it is made during peak hours. The other two alternatives are either making the journey earlier with the intention of arriving at the work place earlier than your official start time or making it at a later time and thus arriving late at work. Of course, arriving late may have some negative consequences depending on the flexibility of the individual's job description *[16]*

However, rescheduling of trips is possible if congestion time changes. This is subject to the constraint of the particular mode of transportation chosen and also the driving characteristics of the individual.

2.6 Mode of commute

The journey to work for the average worker will involve two trips at the least. This refers to the trips to and from work. The travel time to work for the individual is partly influenced by the mode of transportation used to commute. The travel time for the car is relatively less than for public transportation. This is also true when there is a congested situation in both scenarios. In the advent of people owning more cars, there is a likelihood that congestion will always be on the rise, especially if car owners continuously ''have'' a relative advantage of using their cars to work. Many car owners experience more convenience when travelling with their car to work than using public transportation, even under congested conditions *[17]*. In the study made in Leeds, it was found that in order to maintain the same number of commuters travelling by car as now, the number of car owners travelling by car to work would have to be reduced from about 70 per cent now to about 20 per cent in 40 years' time *[18]*. In order to address this issue, various measures have been proposed *[19]* and include: a system of permits or licenses to control the entry of vehicles, a system of pricing the use of road space, parking policy as well as subsidising public transport.

3 FEATHERS RADIATION MODEL

Accurate predictions of population movement is a vital tool for any activity model. The gravity model, in its existing form, has been applied in several domains and for instance, has been widely used to predict the movement of population *[20]*, cargo shipping volume *[21]*, inter-city phone calls *[22]* and bilateral trade flows between nations*[23]*. In summary, the gravity model is given as follows:

$$T_{ij} = \frac{m_i^{\alpha} n_j^{\beta}}{f(r_{ij})}, \qquad (1)$$

Where T_{ij} refers to the number of individuals that move between locations i and j and is proportional to some power of the population of the source(m_i) and destination (n_j) locations, and decays with the distance r_{ij} between them. The parameters α and β are adjustable exponents.

Therefore, for the model to produce reliable results, these parameters that form the base of the model must be adjusted with respect to each region. In this sense, predicting mobility in regions where there is a lack of previous traffic data is a problem. The gravity model also lacks theoretical guidance, lacks rigorous derivation, has systematic predictive discrepancies, and its deterministic property results in it not being able to account for fluctuations in the number of travelers between two locations *[24]*.

In order to take care of these limitations of the gravity model, a proposed extension called the radiation model is adopted *[24]*. The radiation model is able to capture local mobility and require as input only information from population distribution. The radiation model is given as follows:

$$\langle T_{ij} \rangle = T_i \frac{m_i n_j}{(m_i + s_{ij})(m_i + n_j + s_{ij})}, \qquad (2)$$

Where T_{ij} is the average flux from i to j , s_{ij} is the total population in the circle of radius r_{ij} centered at *i* (excluding the source and destination population).

$$T_i \equiv \sum_{j \neq i} T_{ij}$$

Refers to the total number of commuters that start their journey from location *i*, and this is proportional to the population of the source location, hence $T_i = m_i (N_c / \mathrm{N})$, where N_c is the total number of commuters and *N* is the total population in the country. Looking at (1) and (2), it can be seen that the radiation model does not rely on the distance r_{ij} , but rather on s_{ij}. Therefore, the commuting flux depends not only on m_i and n_j but also on the population s_{ij} of the region surrounding the source location.

Therefore, adoption of the radiation model in an activity-based model can be beneficial as shown in the demonstration. Its benefits is seen in both the way it can improve the accuracy of predictive tools in mobility and transport and also how it can predict commuting patterns in areas where previous data is not collected systematically (as a result of its parameter-free advantage). The radiation model can also take further improvements.

Application of the radiation model in FEATHERS results in more sensitivity of the model to changes in the number of work locations. This means predictions of travel patterns of persons in the study area are now comparable to observed values.

4 METHODOLOGY

The data explored in this study is land-use data. Micro-simulations are performed in FEATHERS. In order to study the influence of work location on the travel behaviour of persons, sensitivity analysis is performed on different proportions of the number of employees. This constitutes a change in the number of work locations of the selected municipalities. Initially, a null scenario is obtained based on half of the full population. Half of the full population refers to 1449213 predicted household schedules and this constitutes a representative sample in modeling the travel behavior of persons in Flanders. The null scenario basically consists of the subzone layer without any alteration of the number of work locations. The principle implemented in the simulation is to analyse the travel behaviour of the population by investigating the impact when there is an increase or a decrease in the number of work locations in the study area. Initially, the number of work locations (null scenario) is increased by 5% and we investigate what the effects this will have on the travel indicators. An increase of 5% in the number of work locations in the selected municipalities implies a decrease of 5% is also applied in the remaining municipalities. This process of absorption and dispersion results in the number of employees being kept constant when the number of work locations is altered. Subsequently, this number is increased to 10%, 15%, and finally to 20%, while making sure the remaining municipalities disperse an equal number of employees respectively. However, attention is not only focused on the effects of an increase in the number of work locations. The impact on the travel patterns of the population when there is a decrease in the number of work locations are also studied. For this purpose, a systematic decrease of 5% is applied to the original number of work locations till a maximum value of 20% is reached. Therefore, for a decrease in the number of work locations, the following scenarios are obtained; -5%, -10%, -15% , and -20%. A decrease in the number of employees in the selected municipalities result in an increase in the number of employees in the remaining municipalities, thereby keeping the total number of employees unchanged.

Upon completion of a successful model run simulating a change in the number of work locations, a prediction file is generated. This prediction file contains the activity pattern of agents of the study population. From this pattern, statistics are computed per research question.

5 ANALYSES OF RESULTS

This section of the report presents analyses of the results of the experiments that were carried out in FEATHERS. As expected, nine predictions were done pertaining to the nine different scenarios. The results are realized on tables depicting origins and destinations (home and work location), and presented on graphs to show the effects of changes in the number of work locations when moving from one scenario to another. The following notations for persons category are used to denote the legends for the different graphs.

TABLE 1 Notations used in the graphs

Persons Category	**Description**
HNS-WNS	**H**ome location does **N**ot belong to **S**election of target municipalities and **W**ork location does **N**ot belong to **S**election of target municipalities
HNS-WS	**H**ome location does **N**ot belong to **S**election of target municipalities and **W**ork location belongs to **S**election of target municipalities
HS-WNS	**H**ome location belongs to **S**election of target municipalities and **W**ork location does **N**ot belong to **S**election of target municipalities
HS-WS	**H**ome location belongs to **S**election of target municipalities and **W**ork location belongs to **S**election of target municipalities

5.1 The number of work activities of persons.

Figure 3 shows the number of work activities for the different categories of persons in Flanders. The initial population constitute 55% of persons whose home location does not belong to the selected municipalities and also working in locations not belonging to the selected municipalities, 8.7% of persons whose home locations do not belong to the selected municipalities but whose work locations are within the selected municipalities, 13.7 of persons with home locations belonging in the selection but working out of the selected municipalities, and finally 22.1% of persons whose home and work locations belong to the selected municipalities.

For persons living in both home and work locations not belonging to the selection, increasing the number of work locations by 5% results in a decrease of -0.1 percentage points (pp), 0.1pp increase for persons with home location not belonging to selection but working in selection , -0.3pp for persons with home location belonging to selection but working in locations not belonging to selection, and finally 0.3pp in the number of work activities for persons living and working in the selection.

An increase of 10% in the number of work locations means, the number of work activities of persons with both home and work location not belonging to the selection decrease by 0.3pp. For persons with home location in the selection but working out of the selection, the decrease is 0.7pp. Furthermore, the work activities for persons with both work and home location belonging in the selected municipalities will witness an increase of 0.7pp, and for persons with home location not in the selected municipalities, but work location in the selected municipalities will have an increase in the number of work activities of 0.3pp.

15% increase in the number of work locations, results in -0.5pp and -1.1pp decrease in work activities for persons with home locations not belonging to the selection and work location not belonging to the selection and for persons with home location belonging to the selection but work location not in the respectively. On the other hand, increase in work activities for person categories whose home location do not belong to the selection but working in the selection and persons with both home and work location belong to the selection of municipalities of 0.5pp and 1.1pp respectively.

Finally , an increase of 20% in the number of work locations , results in increase of 0.6pp and 1.5pp for persons with home location not belong to the selection but working in the selection and for persons with home and work location belonging to the selection respectively, and decrease in the number of work activities for persons with home and work location not belong to the selection and for persons with home location belonging to selection but working out of the selection of municipalities by -0.6pp and 1.5pp respectively.

Simulating a 5% decrease in the number of work locations result in increase of 0.1pp and 0.4pp for persons with home and work location not belonging to selection and persons with home location belonging to selection but work location not belonging to selection respectively. On the other hand there is a decrease of 0.2pp in the number of work activities for persons with home location not belonging to selection but working in the selection and also a decrease of -0.4pp in the number of work activities for persons whose home and work locations belong to the selection of municipalities.

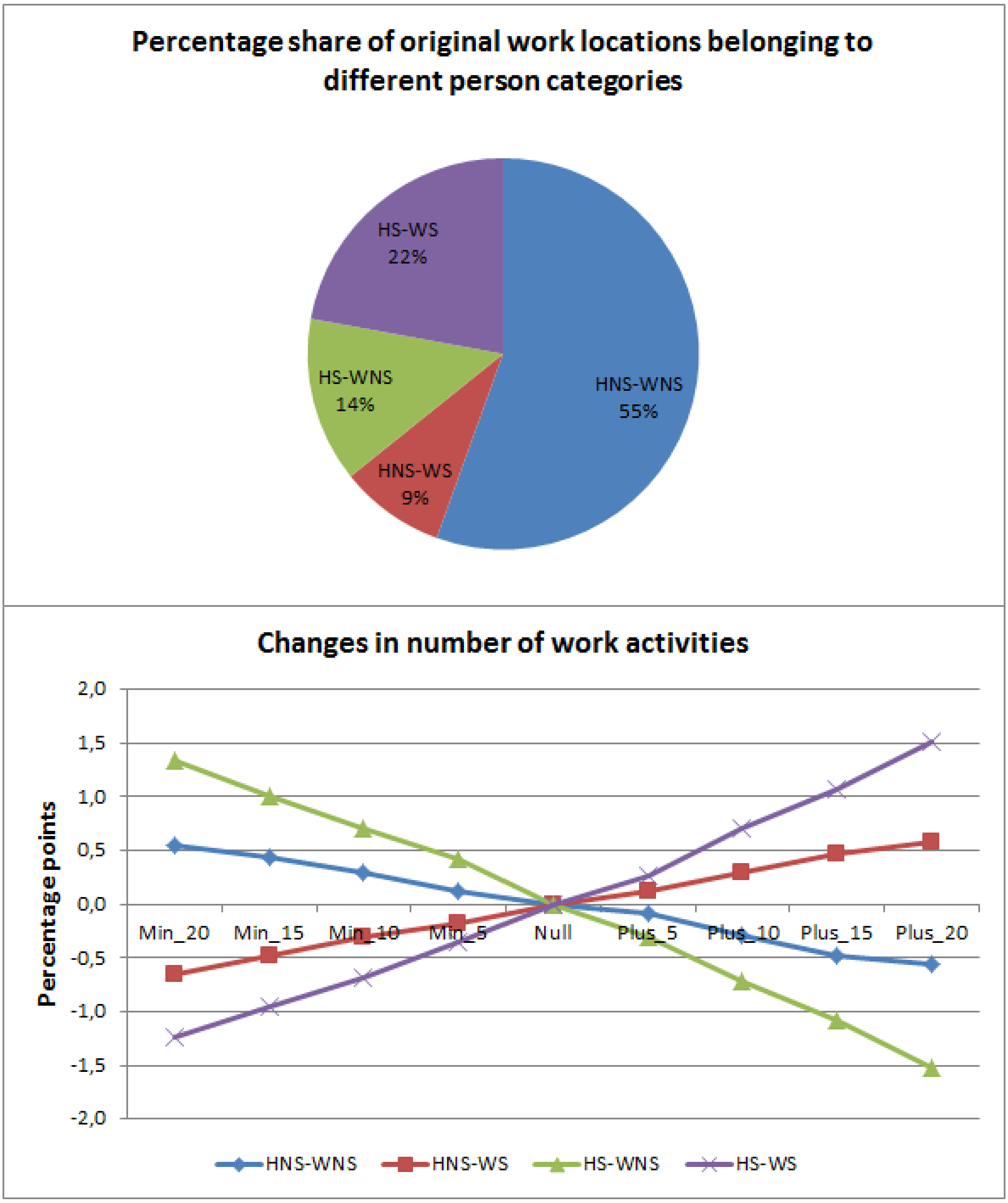

FIGURE 3 Changes in the number of work activities

5.2 Work trip length

Figures 4a and 4b show respectively the work trip length and the total trip length during the day when the number of work locations is either increased or decreased. locations do not belong to the selected municipalities, but working in the selected municipalities. Table 2 shows the work trip length and the total trip length for the different categories of persons. Table 3 show the percentage changes in the work trip length for different person categories. The increase or decrease is with respect to the null scenario

The work trip lengths increase for persons whose work location belong to the selected municipalities irrespective of their home location, when the number of work locations increase and decrease for these groups of persons when the number of work locations decrease. This means they have to cover more distance to get to their place of work, which can mean the new work locations are further than the previous locations. For persons with work locations not belonging to the selected municipalities, the reverse is true. In other words, persons working outside the selected municipalities experience a decrease in their work trip length when the number of work locations increase, and an increase in their work trip length when the number of work locations decrease irrespective of the home location. To summarise, persons either living or working in the selected municipalities will always experience an increase in their trip length when the number of work locations increase, and a decrease otherwise. The only group of persons that experience a decrease in their work trip length when the number of work locations is increase, are persons with home and work locations not belonging to the selected municipalities.

TABLE 2 Changes in work trip length

	Work trip length Null scenario(km/day)
HNS-WNS	7,78
HNS-WS	12,67
HS-WNS	18,06
HS-WS	9,17

TABLE 3 Changes in work trip length

	Min_20	Min_15	Min_10	Min_5	Null	Plus_5	Plus_10	Plus_15	Plus_20
HNS-WNS	1,84	1,57	0,88	0,34	0,00	-0,72	-1,59	-1,84	-2,41
HNS-WS	-2,05	-0,48	-0,14	0,17	0,00	0,26	0,16	0,75	1,19
HS-WNS	-5,55	-4,46	-3,04	-1,45	0,00	1,07	1,94	2,91	4,23
HS-WS	-15,52	-11,79	-7,95	-3,95	0,00	3,97	9,28	13,36	18,93

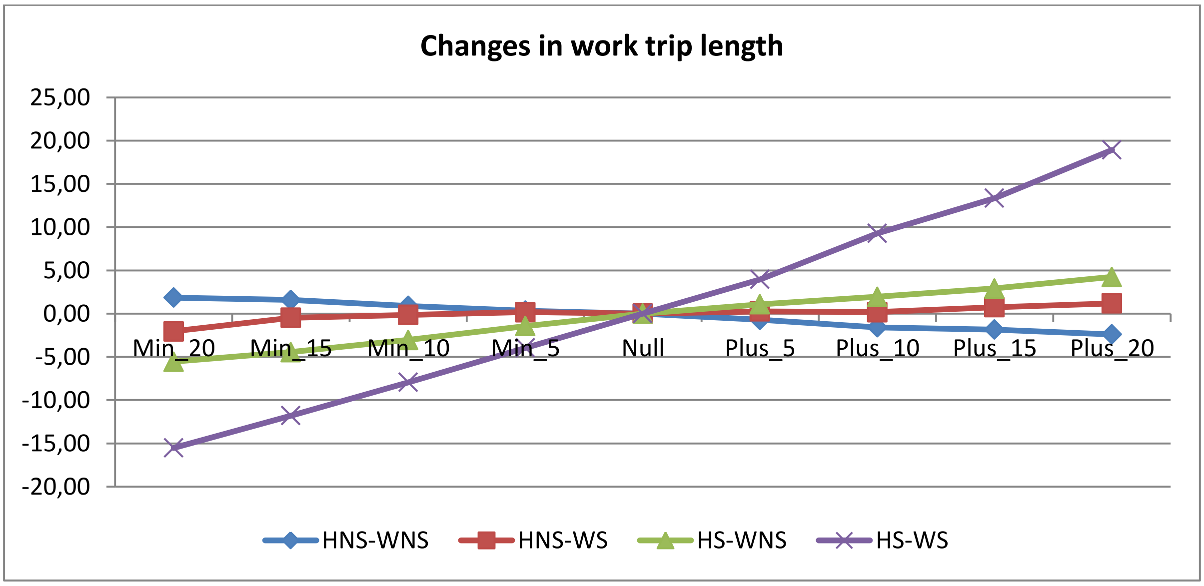

FIGURE 4a Changes in work trip length

The total daily trip length follows a similar pattern as the work trip length. However, the total trip length is larger for the different categories of persons because it includes more than one category of trips (not only work trip length). Additionally, it can be observed that the total trip length will increase for all persons when the number of work locations increase. When the number of work locations is also decreased, the trip lengths for all person categories will also decrease. However persons with home not in the selection but working in the selection will have a slight increase in their total trip length of 0.34% and 0.22% when the number of work locations decreases by 5% and 10% respectively This is shown is table 5

TABLE 4 Changes in total trip length

	Total trip length Null scenario(km/day)
HNS-WNS	71,44
HNS-WS	39,49
HS-WNS	129,36
HS-WS	28,82

TABLE 5 Changes in total trip length

	Min_20	Min_15	Min_10	Min_5	Null	Plus_5	Plus_10	Plus_15	Plus_20
HNS-WNS	-1,15	-0,74	-0,56	-0,34	0,00	0,25	0,65	1,32	2,04
HNS-WS	-1,29	-0,18	0,22	0,34	0,00	0,46	0,46	1,34	1,97
HS-WNS	-6,78	-5,19	-3,56	-1,78	0,00	2,02	4,28	6,09	9,12
HS-WS	-10,07	-7,45	-5,08	-2,65	0,00	2,55	5,65	8,04	12,10

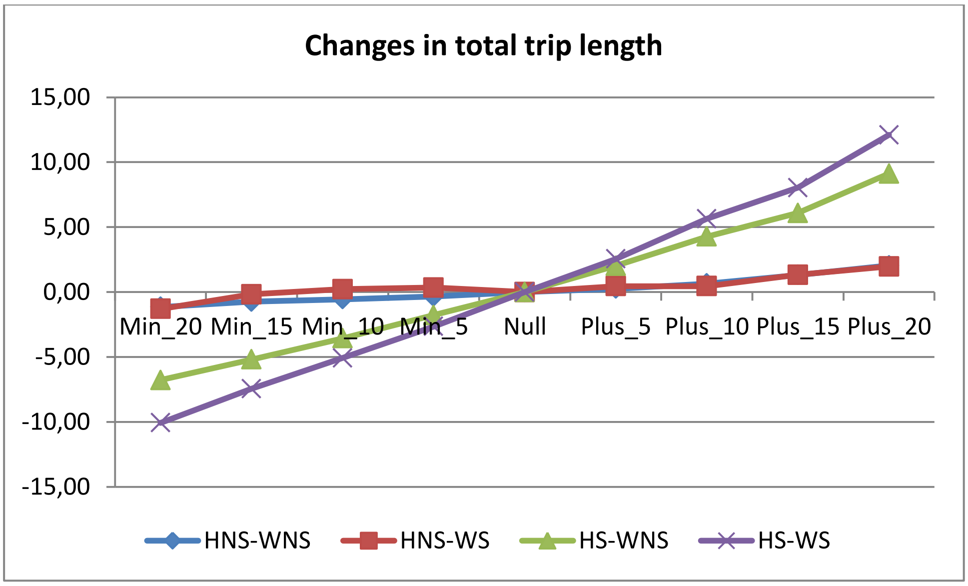

FIGURE 4b Total trip length during the day

5.3 The number of trips by modes

The number of trips are classified under four modes of transportation which include; car trips, non-motorized trips, public transport trips, and car passenger trips. Figure 5 shows the percentage share per mode for the different categories of persons.

For all modes and per person category, persons with both home and work location not belonging to the selected municipalities, make the highest number of trips. This is followed by persons living and working in the selected municipalities, persons living but working out of the selected municipalities, and at the bottom, persons with home location not belonging to the selected municipalities, but working in the selected municipalities.

For car mode, an increase in the number of work locations result in an increase in the number of trips for persons working in the selection irrespective of home location. Non-motorized trips of persons with work location in the selection, will experience an increase. Public transport persons with work location belonging to the selection will experience an increase in the number of trips. Car passenger users with work location belonging to the selected municipalities will also experience an increase in their number of trips.

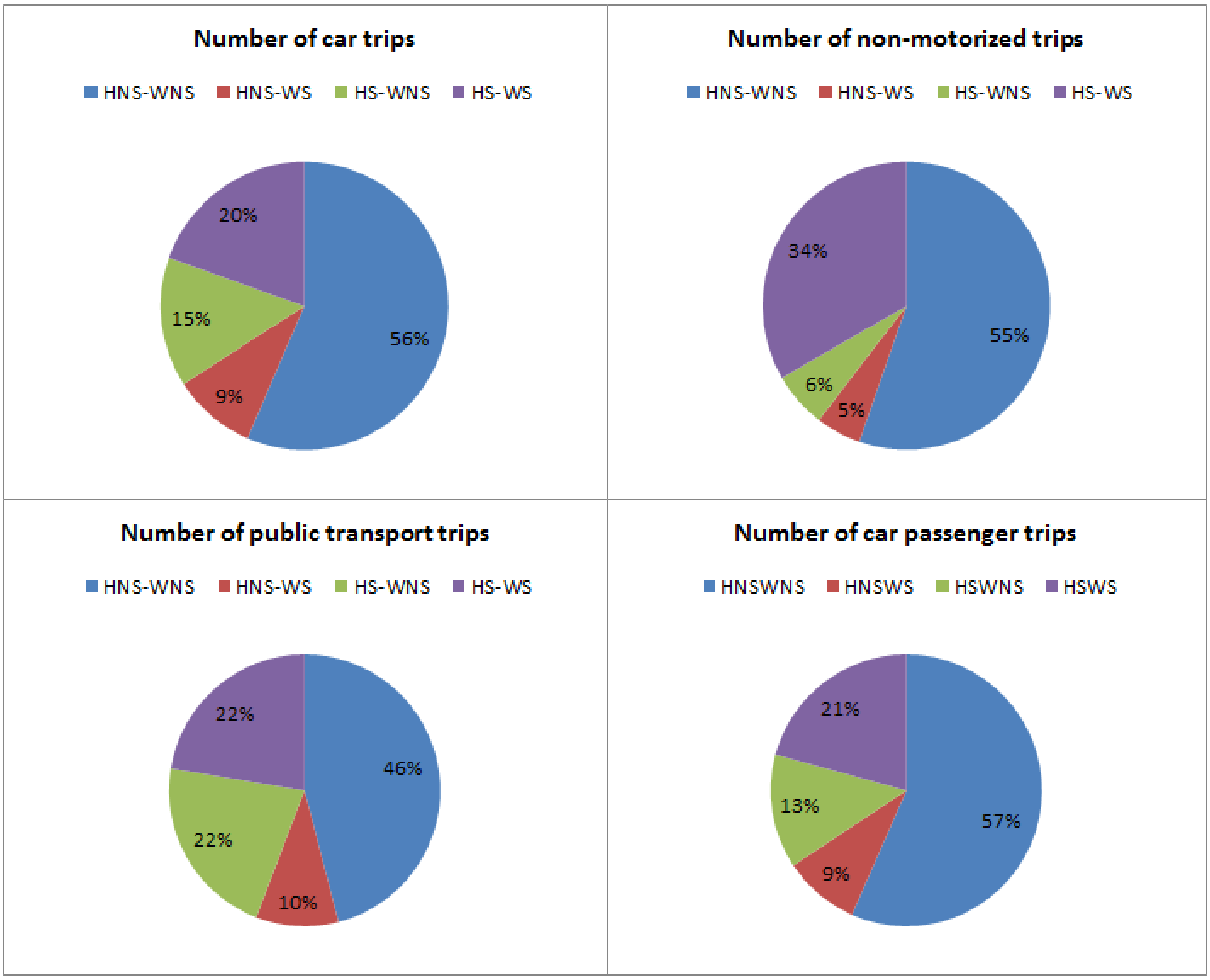

FIGURE 5 Number of trips by modes for the different categories of persons

TABLE 6 Changes in number of trips by modes (in percent)

Car trips									
	Min_20	Min_15	Min_10	Min_5	Null	Plus_5	Plus_10	Plus_15	Plus_20
HNS-WNS	1,13	0,89	0,67	0,29	0,00	-0,24	-0,68	-0,94	-1,09
HNS-WS	-7,72	-6,16	-3,68	-2,49	0,00	1,43	3,52	5,50	6,74
HS-WNS	9,85	7,29	5,13	3,06	0,00	-2,46	-5,48	-8,15	-11,35
HS-WS	-6,90	-5,05	-3,97	-1,92	0,00	1,85	4,36	6,16	8,38
Non-motorized trips									
	Min_20	Min_15	Min_10	Min_5	Null	Plus_5	Plus_10	Plus_15	Plus_20
HNS-WNS	-0,11	0,10	0,08	-0,04	0,00	0,26	0,79	0,31	0,47
HNS-WS	-4,27	-3,13	-0,77	1,14	0,00	1,13	4,00	5,69	6,50
HS-WNS	11,88	8,02	4,09	3,25	0,00	-1,26	-5,14	-8,55	-10,87
HS-WS	-1,38	-1,18	-0,78	-0,72	0,00	-0,37	-0,96	0,21	0,26
Public transport									
	Min_20	Min_15	Min_10	Min_5	Null	Plus_5	Plus_10	Plus_15	Plus_20
HNS-WNS	2,98	2,47	0,89	0,73	0,00	-0,49	-1,81	-3,15	-4,11
HNS-WS	-6,53	-4,30	-3,57	-1,09	0,00	1,42	1,67	4,34	5,96
HS-WNS	8,12	6,69	5,29	2,36	0,00	-0,98	-5,01	-6,36	-10,70
HS-WS	-11,14	-9,69	-5,41	-3,30	0,00	1,34	7,85	10,74	16,21
Car passenger									
	Min_20	Min_15	Min_10	Min_5	Null	Plus_5	Plus_10	Plus_15	Plus_20
HNS-WNS	0,04	-0,74	-0,36	-0,52	0,00	0,41	-0,77	-0,38	-0,64
HNS-WS	-10,18	-3,39	-5,55	-3,89	0,00	0,81	4,29	4,55	6,83
HS-WNS	12,66	9,96	7,28	4,88	0,00	-4,22	-2,89	-8,11	-12,11
HS-WS	-3,90	-2,99	-1,33	-0,07	0,00	1,28	2,10	4,34	6,64

5.4 The number of trips per hour.

The ‘camel-back’ shapes depicted in figures 6a, 6b, 6c, and 6d show the number of trips per hour for different person categories beginning from 3am till the next day.

For persons with home location not in the selection of municipalities but working in the selected municipalities (figure 6a), the number of trips is constant between the hours of 3 and 4 in the morning. This could be seen interpreted as the period when different activities are at their minimum. A continuous increase is observed from 5 till 7 am where the number of trips reaches one of its highest values. Many trips are being(for instance people going to work). The number of trips then falls till 10 am , and then starts rising till it reaches its peak value at 17 o’clock. A lot of persons have finished with their jobs and are now returning home thereby increasing the number of trips per hour. The peak of the graph then slowly declines.

The scenario shown in figure 6b, illustrates the number of trips for persons with home and work location belonging to the selection of municipalities. The number of trips per hour follows a similar pattern as described in the previous group of persons, but having a higher proportion in number of trips per hour.

Persons with home location belonging to the selected municipalities but working out of the selected municipalities have peaks at 7, 11, 15 and 17 o'clock where the number of trips per hour increase sharply. 7 o'clock is seen as the time when work trip begins, 11 o'clock when persons have breaks and 15 and 17 o'clock, time for late shifts and/or time when day work ends, thus increasing the number of trips per hour.

For persons who nether live nor work in the selected municipalities, they have increasing and decreasing peaks indicating a rise and fall in the number of trips per hour. The second highest number of trips for this category of people is recorded 18 o'clock.

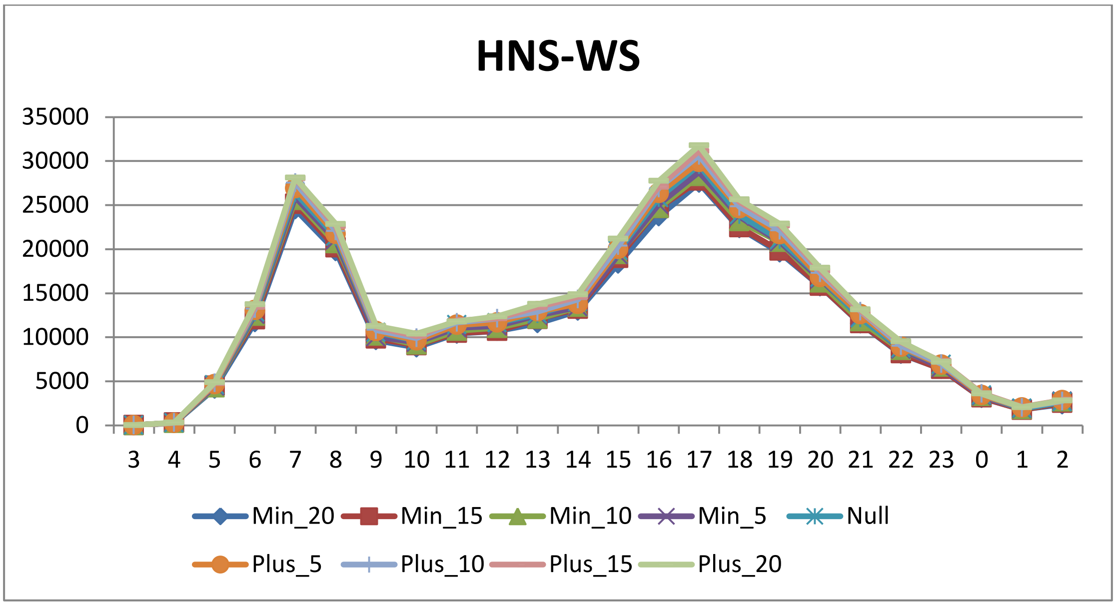

FIGURE 6a The number of trips per hour for persons with home location not in the selected municipalities but working in the selected municipalities

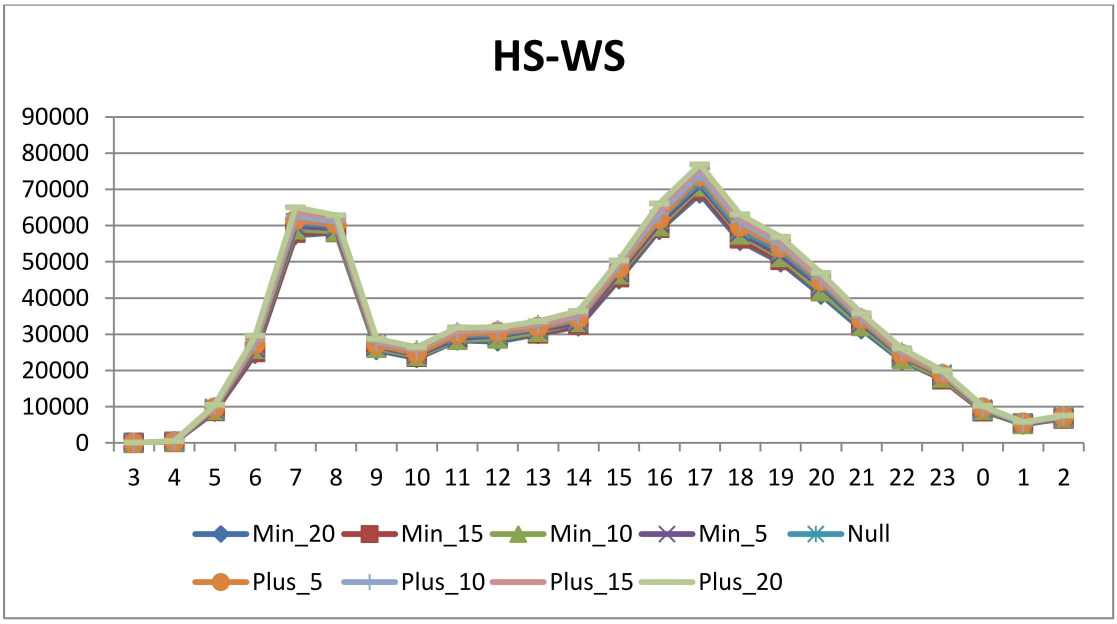

FIGURE 6b The number of trips per hour for persons with home and work location belonging to the selected municipalities

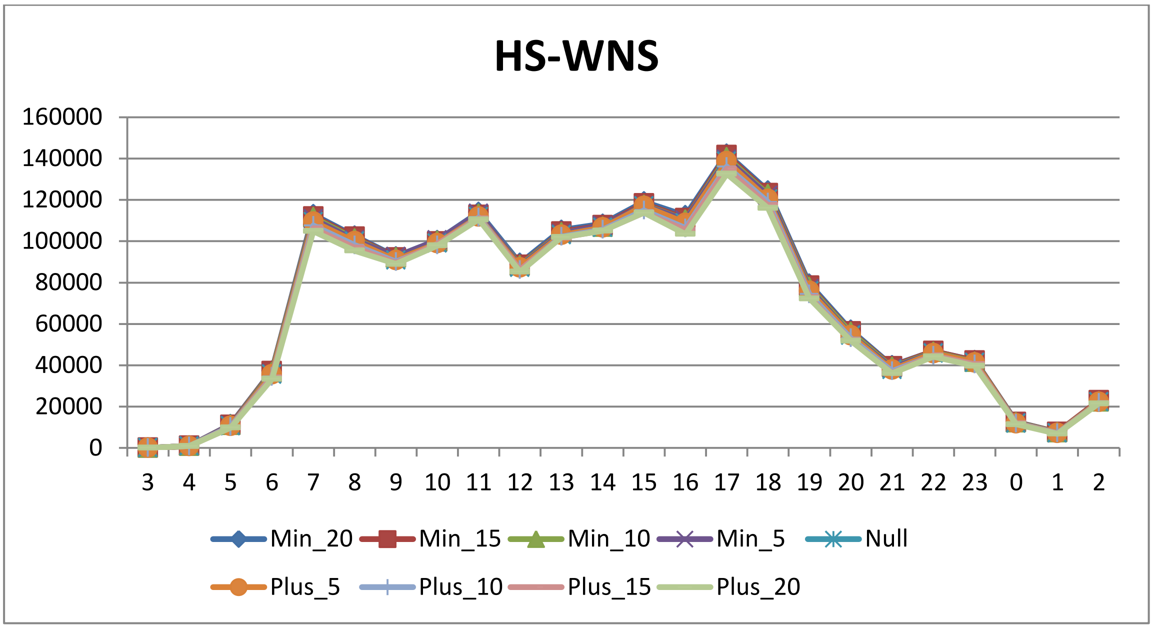

FIGURE 6c The number of trips per hour for persons with home location belonging in the selected municipalities, but working out of the selected municipalities

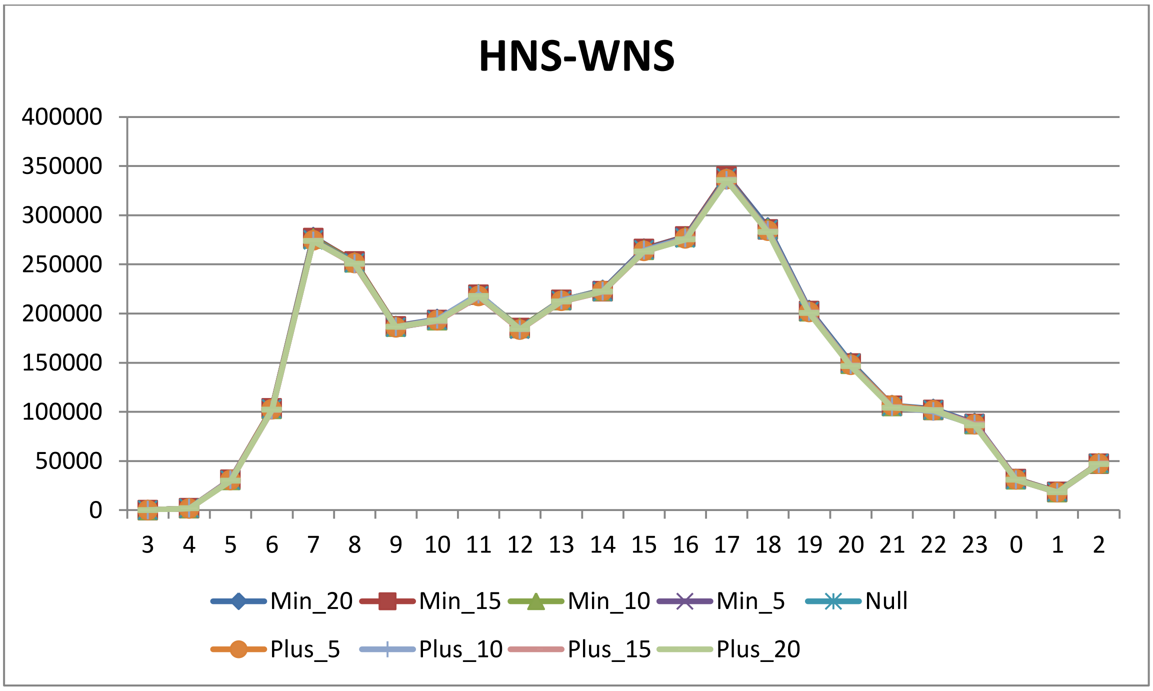

FIGURE 6d The number of trips per hour for persons with both home and work location not belonging to the selected municipalities

It is interesting to look specifically at the two periods which register the highest number of trips per hour for the different person categories (table 7). These periods are 7 o'clock and 17 o'clock. An increase in the number of work locations result in an increase in the number of trips per hour for persons with work locations in the selected municipalities, irrespective of their home locations. A decrease in the number of work locations result in a decrease in the number of trips for these groups of persons.

Additionally, an increase in the number of work locations, will have the following effects; a decrease in the number of trips per hour for persons with work locations outside the selected municipalities irrespective of their home location. A decrease in the number of work locations will result in an increase in the number of trips for these groups of persons. This is illustrated in figure 7.

TABLE 7 changes in number of trips per hour(in percent)

7 o'clock									
	Min_20	Min_15	Min_10	Min_5	Null	Plus_5	Plus_10	Plus_15	Plus_20
HNS-WNS	0,82	0,63	0,32	0,10	0,00	-0,33	-0,38	-0,44	-0,46
HS-WNS	2,99	2,17	1,75	1,11	0,00	-0,16	-1,69	-3,10	-4,25
HNS-WS	-7,31	-4,86	-3,28	-1,97	0,00	1,78	4,31	6,00	6,41
HS-WS	-5,93	-4,63	-3,18	-1,59	0,00	1,02	2,89	4,96	6,96
17 o'clock									
HNS-WNS	0,53	0,42	0,06	0,15	0,00	-0,47	-0,44	-0,49	-0,43
HS-WNS	2,62	2,07	1,64	0,84	0,00	-0,08	-1,56	-2,68	-4,14
HNS-WS	-6,86	-6,05	-4,01	-2,65	0,00	1,05	3,94	5,31	7,80
HS-WS	-4,69	-3,47	-1,79	-1,23	0,00	1,90	3,46	5,27	6,76

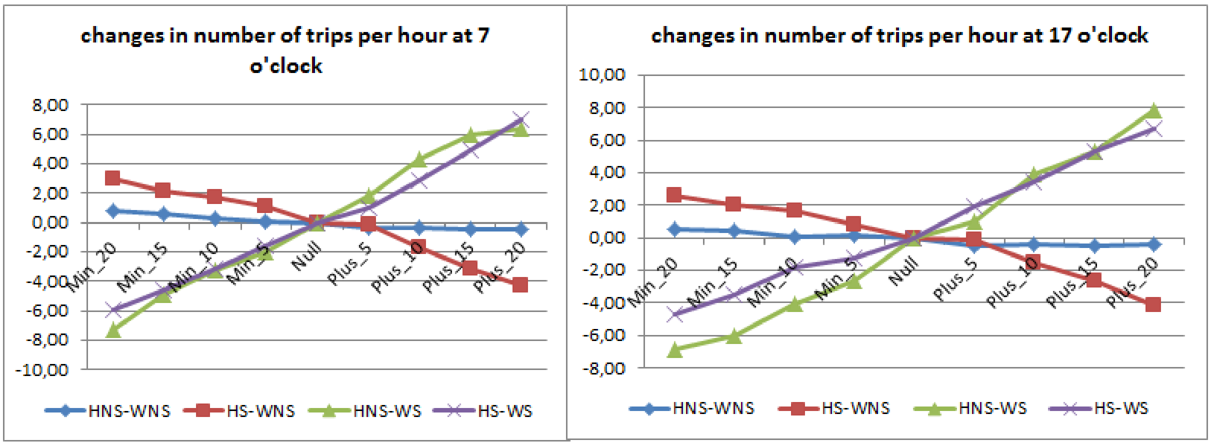

FIGURE 7 The number of trips per hour for persons at 7 and 17o'clock (in percent)

6 CONCLUSIONS

Activity-based models when provided with the required inputs and enough, the predictions they provide can be very useful in forecasting transport events. The FEATHERS framework is used to investigate the impact of a change in the number of work locations on the travel behavior of persons. The travel behavior is expressed in a number of stated travel indicators.

The results show a number of changes on the calculated travel indices when the number of work locations change. Comparison between different category of persons for the different scenarios is expressed in terms percentage points. This is very useful when comparing changes between the different scenarios (changes in the number of work locations).

A decrease in the number of work locations result in an increase in the number of work activities for persons whose work locations belong to the selected municipalities irrespective of whether the home location belongs to the selection or not. On the other hand, an increase in the number of work locations result in an increase in the number of work activities for persons working in selected municipalities irrespective of the home location. Therefore, decreasing the number of work locations in the selected municipalities

The model clearly demonstrates increasing the number of work locations is not beneficial for persons working in the selected municipalities irrespective of whether they live in the selected municipalities or not. For these groups of persons ,the trip lengths increase (both work and total trip length) when the number of work locations increase and decrease otherwise. This implies persons working in the selected municipalities will spend more time on trips. Time spent on other activities would witness a decrease. Therefore, if the goal is to see a decline in the trip length of persons working in the selection, the ideal situation will be a decrease in the number of work locations.

The number of trips evidently increase as the number of work locations increase for persons working in the selected municipalities and decrease as the number of work locations is decreased. However, this pattern is not repeated when non-motorized mode is taken into consideration. It is observed that when the number of work locations increases by 5% and 10%, the number of trips for persons living in the selected municipalities decrease, and when the number of work locations decrease by 5% and 10%, the number of non-motorized trips for persons whose home locations do not belong to the selected municipalities instead rise. Therefore, it can be said that these changes (increase or decrease of 5% and 10% and 15% in some cases) are considered small and as such breaks the pattern.

Further research can be carried out in the domain of measuring the degree of sensitivity of the model to changes in the number of work locations. Desired levels of outputs can be stated in order to achieve certain goals. For instance if the measure is to increase sustainability, what percentage in the number of work locations should be altered to reduce car trips, increase non-motorized trips, increase passenger car trips , and increase public transport trips?

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8 APPENDICES

ID	**NAME**
2	Antwerpen
37	Mechelen
49	Geel
66	Turnhout
94	Vilvoorde
124	Leuven
138	Brugge
163	Kortrijk
175	Oostende
184	Roeselare
200	Aalst
212	Dendermonde
232	Gent
260	Lokeren
262	Sint-Niklaas
266	Beringen
268	Genk
271	Hasselt
277	Sint-Truiden
309	Anderlecht
310	Auderghem
311	Berchem-Sainte-Agathe
312	Bruxelles
313	Etterbeek
314	Evere
315	Forest
316	Ganshoren

317	Ixelles
318	Jette
319	Koekelberg
320	Molenbeek-Saint-Jean
321	Saint-Gilles
322	Saint-Josse-ten-Noode
323	Schaerbeek
324	Uccle
325	Watermael-Boitsfort
326	Woluwe-Saint-Lambert
327	Woluwe-Saint-Pierre

Appendix I List of selected municipalities

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Analysis of influence of work locations on travel behaviour with an activity-based model for Flanders

Richting: **master in de verkeerskunde-mobiliteitsmanagement**
Jaar: **2013**

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