Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia - Social and Behavioral Sciences 54 (2012) 240 – 250

Procedia
Social and Behavioral Sciences

EWGT 2012

15th meeting of the EURO Working Group on Transportation

The impact of telework on transport externalities: the case of Brussels Capital Region

Tom van Lier*, Astrid De Witte, Cathy Macharis

Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium

Abstract

Telework is often suggested as an instrument to improve sustainability by reducing environmental and socio-economical impacts of mobility on society. Currently, telework is however not yet implemented as a widespread measure in companies in Belgium. Goal of this paper is to determine if further encouragement of telework is indeed desirable from a sustainable mobility viewpoint and whether it should be supported by future policies.

Based on survey data, an appraisal of the environmental, mobility and socio-economic impacts of telework for companies located in the Brussels Capital Region (BCR) is performed. Traffic on the road network in and around the BCR is heavily congested during peak periods and every additional vehicle causes additional externalities. Congestion, climate change, air pollution, noise, traffic accidents and externalities linked to up- and downstream processes are the most well known transport related externalities, and are taken into account in the calculations. Survey data was generated through a questionnaire that was distributed to both workers and management of six large companies, whose main offices are located in the BCR and where teleworking is already practiced. For these companies, the external costs of trips to the central office are compared to the external costs of trips to satellite offices and the external costs caused by additional distances travelled when teleworking at home. Modal shifts occurring between trips travelled to the central office and trips travelled to the satellite office are taken into account and play an important role in the overall impact on external transport costs. Also receptor density and congestion levels along the routes travelled are taken into account. Results are calculated for the different modal choice scenarios, as well as on an aggregated level.

Keywords: Telework; Sustainable Mobility; External Costs

* Corresponding author. Tel +32 (0)2 629 20 67- Fax +32 (0)2 629 21 86
E-mail address: tom.van.lier@vub.ac.be

1877-0428 © 2012 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of the Program Committee
doi:10.1016/j.sbspro.2012.09.743

1. Introduction

The number of commuters in the Brussels Capital Region has doubled since the 60s. Every day, 359,000 commuters come to work in the Brussels-Capital Region and 56,000 employees move in the opposite direction. In total more than 400,000 people therefore move daily to and from the Brussels Capital Region, where a total of 680,000 persons work.[†]

Consequently the roads in and around the region are increasingly jammed and associated with externalities such as pollution, congestion, noise and road safety hazards. Measures should therefore be taken to reduce the number of trips and/or travel distances, so that the quality of life in the region in terms of mobility, environment and road safety can be safeguarded (Castaigne et al, 2009) [1].

This paper examines whether telework could potentially contribute to reduce these problems. Telework is a form of work where employees can conduct their work activities outside the company headquarters (HQ) and this usually at flexible times. It is a recognized choice for companies that face spatial difficulties caused by a sudden rapid growth or as part of a restructuring phase, allowing more flexible work situations and creating competitive advantages (Illegems &Verbeke, 2003) [2]. Despite the fact that this work form exists already since decades, no clear definition is currently agreed on (Taskin & Walrave, 2010) [3]. However, regardless the differences between the definitions used, some essential elements always appear: the location dimension, the time dimension and the use of information and communication technologies (ICT) (Denolf et al, 2006) [4]. Telework can therefore be described as time and place independent working through employing ICT.

Telework may reduce the home-work trips (if the worker has a closer satellite office) and possibly even avoid them (if the employee can work at home) (Vanoutrive, et al 2010) [5]. Even if the implementation of teleworking through the extended use of ICT's is becoming more economically attractive, telework is as yet not a widespread measure in large companies (> 200 employees) in the Brussels Capital Region. The company transport plans of the Brussels Environmental Agency specify that only 36% of the large companies formally implement telework (BIM, 2010) [6]. Nevertheless telework has risen during the last years and in the statistics of the company transport plans there is an increase of 11% between phase 1 (25%) and phase 2 (36%) of the number of companies that included teleworking in their company transport plan (BIM, 2010) [6].

From a policy viewpoint the magnitude of the impact of teleworking on environment, mobility and socio-economic aspects is therefore relevant in order to determine whether a further encouragement of telework is useful and sustainable for the society as a whole. Illegems & Verbeke (2003) [2] estimate that for the Brussels Capital Region the annual avoided external costs of telecommuting amounts to between €215 million and €465 million. Given the still increasing congestion levels in recent years and the fact that additional time losses weigh heavily in the calculation of external costs, external cost figures can be expected to be even higher in 2010.

This paper focuses on the effectiveness of telework by determining the environmental, mobility and socio-economic impacts of teleworking in six major companies in the Brussels Capital Region (BCR), based on self-reporting surveys, both from employees and company management.

2. Methodology

The study was based on a survey conducted in six companies of Brussels with more than 100 employees and in which (part of) the staff teleworks. The companies were selected from the database on company transport plans of large companies provided by the Brussels Environmental Agency. Considering the importance of accessibility to the workplace as a determinant of the commuting behavior of an employee (Van Acker et al, 2007 [7]; Verhetsel et al, 2007 [8]) the selection of the companies also took into account different city areas as well as the existence within the company of mobility measures and a telework policy. A multistage random sample was

---

[†] Actiris (2007). http://www.actiris.be/2009/files/home_fr/Chiffres_emploi_et_chomage.pdf

drawn where a number of homogeneous classes could be distinguished and where subgroups (eg, based on availability) were compared with each other (De Pelsmacker & Van Kenhove, 2006 [9]). The six selected companies differed in geographical location and industry sector. In total 1247 surveys were received from employees of these six companies.

In order to examine the societal impact of telework, external transport costs were calculated based on this survey data for a) transport to HQ, b) transport to the satellite office and c) additional trips (if any) when working at home. Calculation of external transport costs was limited to car transportation, since focus was on identifying the marginal external costs of an additional vehicle that is added to or removed from existing traffic flow. In the case of transportation by train and other public transportation (bus, tram, subway), assumption was made that a change in the number of passengers as a result of teleworking initially has no impact on the frequency, composition and number of public transport options[‡].

3. Transport externalities: theoretical background

"*An external cost arises, when the social or economic activities of one group of persons have an impact on another group and when that impact is not fully accounted, or compensated for, by the first group.*" (Bickel and Friedrich, 2005 [10]). In the transport sector, externalities arise when transport-consumers/producers impose additional costs to the society without having to bear these costs themselves or without having to transfer or pay compensations. Transport externalities are primarily related to the impact of emissions (climate change and air pollution), accidents, noise, soil contamination, disruption of the ecological system, infrastructure damages, visual intrusion and congestion (van Lier et al, 2010 [11]).

In this paper, calculations of relevant external costs are based on best practices for marginal external cost calculations currently available in economic literature[§]. Despite growing consensus on key methodological issues (Maibach et al, 2008 [12]), numerous influencing parameters have to be taken into account when performing a detailed external costs estimation, such as fuel type (petrol, diesel, LPG, biofuels, ...), location (urban, interurban, rural), the driving conditions (peak, offpeak, night) and vehicle characteristics (EURO standards)[**]. In this paper, data from the IMPACT study (Maibach et al, 2008 [12]) was used to obtain key external cost figures. The European Commission also attempts (based on the IMPACT published ratios) to internalize in a short period of time the external costs of transport in order to attain a more sustainable transport system (European Commission, 2011 [13]).

4. Calculation of the external costs: methodology

To calculate the impact of telework on mobility-related external costs, comparison is needed of the external costs related to travel to HQ with the external costs related to working at the satellite office and working at home. Therefore in a first phase the marginal external costs per vehicle kilometer were calculated for each of the three

---

[‡] When the amount of teleworkers reaches a certain threshold, an impact on the frequency, composition and number of public transport options may no longer be excluded. Considering the lack of specific data and the conditional tense of this assumption, this impact was not included in the analysis.

[§] Note that we calculate the impact of additionally avoided units of cars, which means that we are interested in the marginal rather than the average external costs.

[**] For an overview of the calculation of the external costs, see i.e. INFRAS/IWW (2000 en 2004), ExternE, EC (2005), EX-TREMIS, TRT (2007), Forkenbrock (2001), European Commision (2011), Mauch, Banfi en Rothengatter (1995), Maddison et al. (1996), Kreutzberger et al.(2006), Macharis en Van Mierlo (2006). For a recent overview of the different external cost categories, the most relevant studies in a European context and recently recommended ratios as proposed by the European Commission, see: Handbook on estimation of external cost in the transport sector (Maibach et al, 2008), within the IMPACT study (Internalisation Measures and Policies for All external Cost of Transport).

situations (HQ, satellite office and work at home). By multiplying these values with the car kilometers driven that are reduced or added as a result of satellite office work and work at home, the impact of telework in terms of external costs can be obtained. To reach a realistic and detailed assessment, different telework scenarios were developed based on the results of the survey research which indicated that the telecommuting frequency of most teleworkers is around 1 to 2 times per week.

The modal choice made by employees is another crucial factor. Since external costs will be higher or lower depending on additional car kilometers driven or avoided, the impact of a modal shift in the main transport mode used for travelling to HQ or satellite office on the number of travelled car kilometers will be taken into account.

Also location is an important factor. For air and noise, receptor density plays a decisive role, while congestion is usually the strongest in urban areas (De Nocker et al, 2006 [14]. For some external costs categories, a distinction was therefore made between rural and urban areas. Based on the Strategisch Plan Ruimtelijke Economie Vlaanderen (Cabus & Vanhaverbeke, 2004 [15]), a ratio of 70% urban – 30% rural was assumed reasonable.

The trip distances with the main transport mode to HQ, satellite office and additional kilometers (if any) when working at home came out of the survey differentiated by fuel type.[††] For congestion a further differentiation was applied depending on perceived traffic intensity level (Table 1). This clearly indicates that commuters to HQ are faced with higher congestion levels than commuters to the satellite office.

Table 1: Respondents estimation of morning traffic intensity on the way to HQ and satellite office

Traffic in the morning	**HQ**	**Satellite office**
always fluent, no traffic jams	4,0%	29,8%
usually fluent, little congestion	16,8%	51,3%
reasonably fast, but regular traffic jams	25,3%	15,3%
usually difficult, often traffic jams	28,3%	3,6%
very difficult, almost always traffic jams	25,5%	0,0%
Total	100,0%	100,0%

Source: MOSI-T, 2011

5. External costs per vehicle kilometre

For each relevant external cost category, first the external costs for each different work situation (HQ, satellite office and work at home) were calculated for vehicle kilometers per year, using appropriate key figures from IMPACT (Maibach et al, 2008 [12]). Total external costs were then divided by number of vehicle kilometers in order to obtain key figures expressed per vehicle kilometer. Table 2 summarizes the calculated marginal external costs per vehicle kilometer for the three situations, in 2011€.

[††] The modal choice of pre- and post transport when public transport is chosen as the main mode of transport (e.g. modal choice for trips to and from the train station) was not questioned and could therefore not be included in the analysis.

Table 2: Marginal external costs of the various external costs categories for the three situations, expressed in € ct 2011 per vehicle kilometer

Worksituation	Climate change	Air pollution	Up-and downstream	Noise	Accidents	Congestion
HQ	0,48	0,70	0,56	0,85	2,83	34,04
Satellite office	0,48	0,58	0,56	1,42	2,83	6,65
From home	0,50	0,68	0,58	1,60	3,08	2,31

Source: MOSI-T, 2011

For the external costs of climate change, air pollution and up-and downstream, IMPACT key figures for EURO-4 cars with an engine capacity between 1400 and 2000cc for petrol and diesel were applied[‡‡]. Marginal external costs of up-and downstream processes and marginal external climate costs depend directly on fuel consumption and are therefore of a similar magnitude for the three situations. For marginal external costs of air pollution, also receptor density is crucial. Because this receptor density is greater for movements in metropolitan areas in the vicinity of the HQ than displacements in (medium) urban areas in the vicinity of the satellite office, the marginal external costs of air pollution are on average lower for trips to the satellite office. On the other hand, in the longer trips to both HQ and satellite office, portions of the trip will be traveled on highways in less urbanized or rural area, where local receptor density is lower. When working at home, the additional trips are mainly in urbanized and interurban areas. Receptor density for these additional trips will therefore on average be lower than the receptor density in the (medium) metropolitan areas around the head and satellite office, but on average higher than the receptor density on the parts of the trips to HQ and satellite office through less urbanized or rural areas. Expressed per vehicle kilometer, the marginal external costs of air pollution in case of additional kilometers when working at home are of a similar order of magnitude as those for commuting to HQ and satellite office.

Marginal external noise costs are clearly higher for the work at home and commuting to the satellite office than for commuting to the HQ. Receptor density (and hence the rural-urban division) as well as the existing traffic situation play an important role for noise. During dense traffic conditions, the marginal external noise costs might be relatively low, since an additional vehicle would only add a small additional noise on top of the already existing noise levels caused by the existing traffic. On the opposite, the additional noise is relatively high when an additional vehicle is added to a fluent traffic flow. Taking into account the perceived congestion levels in Table 1, it is clear that commuting to the HQ involves travelling a relatively large number of vehicle kilometers in dense traffic conditions, namely 79% of the total travelled kilometers, while only 21% is travelled in fluent traffic conditions. To commute to the satellite office these ratios are almost reversed: only 19% of the vehicle kilometers are travelled in intense traffic conditions, while the remaining 81% are in fluent traffic conditions.

For the marginal external accident costs, specific key figures for personal car use in Belgium from IMPACT were used, differentiated according to the network level (urban roads, highways, all roads). Since satellite offices are generally also located in urban environments (such as Antwerp, Ghent, Mechelen, Leuven, ...), it was assumed that 70 % of vehicle kilometers are travelled on motorways and 30% on urban roads for both commuting to headquarters and commuting to satellite offices. For working at home, additional vehicle

[‡‡] It is based on the following division of the network types used in the IMPACT study:
• Head office: 10% metropolitan, 20% and 70% inter-urban motorways
• Satellite office: 10% urban, 20% and 70% inter-urban motorways
• Home: 100% average

kilometers are assumed to be driven on the category "other ways". Given that the same assumptions pertain when commuting to the HQ and when commuting to the satellite office the marginal external accident costs per vehicle kilometer for both situations are similar. For any additional kilometers that are travelled by working at home the marginal external accident costs per vehicle kilometer are slightly higher. This is mainly because on motorways (to commute to the HQ and to the satellite office) far fewer accidents happen per vehicle kilometer travelled, but on the other side the severity of these accidents due to the higher speed are usually greater. Taking into account both aspects, the external accident cost per vehicle kilometer for working at home is on a similar order of magnitude.

The marginal external congestion costs are also based on IMPACT key figures (Maibach et al, 2008 [12]). For passenger vehicles a division is made between different network types and congestion levels. As expected, based on the results shown in Table 1, the marginal external congestion costs of commuting to HQ are considerably higher than those of commuting to satellite office. For work at home, the marginal external congestion costs are small.

6. Calculation of the external costs: assessment scenarios

Based on the external costs per vehicle kilometer, the impact of telework for the employees who participated in the survey research was estimated. This has been done for each of the three situations (HQ, satellite office and work at home) by multiplying the marginal external costs per vehicle kilometer (Table 2) with the additional or avoided car kilometers driven according to the survey research.

For each type of telework (work at home and work at the satellite office), the following 4 scenarios were established:

- Scenario 1: No telework (baseline scenario)
- Scenario 2: 1 day / week telework (1/5 scenario)
- Scenario 3: 2 days / week telework (2/5 scenario)
- Scenario 4: always telework (maximum scenario)

The impact of teleworking can then be calculated by comparing the results of scenarios 2 and 3 to the reference scenario with no telework. Scenario 4 is an extreme scenario that was also set up to provide an indication of what the maximum impact would be if telework would be possible at all times.

6.1. Satellite office work

The survey results indicated that a large number of modal shifts occurs when the employees commute to the satellite office in comparison with the mode of transport they use to commute to the HQ. Table 3 shows the main modal shifts of the principal transportation mode that occur when commuting to the satellite office in relation to commuting to the HQ and provides for these categories the respective average commuting distances to the HQ and the satellite office (one-way trip). It is important to note that only the main transport mode was considered: pre- and post trajectories (i.e. to and from railway stations) are not included.

Table 3: Modal shift, number of respondents (total and percentage) and average number of vehicle kilometers at one-way trip for commuting to the HQ and to the satellite office by the satellite office employees

			Average number of km	
Modal Shift	Number	%	HQ	Satellite office
Train to car	84	34,6%	75	21
Car to car	58	23,9%	73	28
Train to train	36	14,8%	83	26
Train to bicycle	16	6,6%	73	7

Train to walk	8	3,3%	70	1
Car to train	6	2,5%	60	35
Car to bicycle	6	2,5%	48	10
Train to bus	6	2,5%	86	10
Others	23	9,5%		
	243			

Source: MOSI-T, 2011

When commuting five days by car to HQ the employee will be confronted with high external costs, mainly due to the high external costs of congestion encountered in the morning and evening in and around Brussels. Since these congestion costs are much lower for commuting by car to the satellite office, and as the distances are also shorter (which in addition has an effect on the environmental costs), the external costs generated by one and two days satellite work are respectively 17.6% and 35.1% lower compared to the baseline scenario. If it would be possible to work at the satellite office all the time, maximum savings can even reach 87.8%.

The situation is however completely different when a modal shift occurs from train or public transport to car when commuting to the satellite office. Based on the survey research, this modal shift occurs in 34% of the cases. Assuming that working at the satellite office has no impact on the timetables of the railways, no marginal external costs occur when commuting by train to the office. Commuting by car to the satellite office however does impose marginal external transportation costs. This type of modal shift therefore causes a significant increase of the external transport costs in the case of satellite work.

Approximately 2.5% of the satellite office employees drive by car to HQ but use the bike to reach the satellite office, another 2.5% use the car to get to HQ but travel by train to reach the satellite office (again, no immediate impact on the timetables of the railways is assumed). In both cases there is a significant external cost saving when working in satellite offices, since savings here involve avoiding the densely congested commuter route to and from Brussels. In addition, there are also external health benefits associated with cycling which are not included.

14.8% of the satellite office employees make both trips (to HQ and satellite office) by train. 6.6% and 3.3% of the satellite office employees commute by train to HQ but travel with bike and by walking to the satellite office. 2.5% take the train to reach HQ and commute by bus to the satellite office. For these categories, no changes in external transport costs are assumed.

To get the overall effect of working at the satellite office on the basis of the survey result, a weighted value was calculated taking into account the relative weights of the various modal categories, including the categories in which no external costs take place. This calculation is shown in Table 4, and clearly shows an external cost save in terms of mobility when working at the satellite office. Taking into account all the employees working in satellite offices, and the modal shifts that may occur, the average external cost saving of 1 day satellite office work and 4 days at the HQ compared with 5 days work at the HQ is on average 15.6 %, while it rises to 31.2% when working 2 days at the satellite office. This has mainly two reasons: the shorter commuting distance to the satellite office, which has a positive impact on all of the external cost categories, and the much lower levels of congestion when commuting to the satellite office. If we look at scenario 4, with five days working at the satellite office, external costs savings reach up to 78%.

Table 4: Marginal external costs for working at the satellite office per employee per week (€ 2011): weighted average of the modal categories

SATELLITE weighted	**Climate**	**Air**	**Up- & down**	**Noise**	**Environment**	difference from Sc 1	**Accidents**	**Congestion**	**TOT incl C**	difference from Sc 1
€/employee/wk										
Scenario 1 (5d HK)	0,97	1,41	1,12	1,71	5,21		5,68	68,38	**79,27**	

Scenario 2 (1d SK + 4d HK)	0,91	1,29	1,05	1,77	5,01	-0,20 (-3,7%)	5,33	56,56	**66,91**	-12,36 (-15,6%)
Scenario 3 (2d SK + 3d HK)	0,85	1,17	0,98	1,82	4,82	-0,39 (-7,4%)	4,99	44,74	**54,54**	-24,72 (-31,2%)
Scenario 4 (5d SK)	0,67	0,81	0,79	1,98	4,25	-0,96 (-18,4%)	3,94	9,27	**17,46**	-61,81 (-78,0%)

Source: MOSI-T, 2011

The only external cost category that increases when working at the satellite office is noise. Because the marginal external noise costs are much higher in less dense traffic, even the lower commuting distance to the satellite office cannot prevent that these costs are slightly higher for scenarios with one or two days of working at the satellite office. However, adding all the external environmental costs together (climate change, air pollution, upstream and downstream processes and noise), working at the satellite office still results in a cost saving of 3.7% (1 day telework/week) and 7.4% (2 days telework/week). In the case of five days working at the satellite office, the marginal external environmental costs could be reduced by 18.4%.

Overall we can conclude that external costs will initially depend on the proportion of commuter trips to the HQ that take place with the car and in second instance on the modal shifts that occur when working at the satellite office. The more car trips to the HQ can be replaced by trips to the satellite office (either by car or with other transport modes), the greater the external cost saving will be.

6.2. Work at home

To calculate the impact of telecommuting on external costs, a comparison is needed between transport behaviour to HQ and transport behaviour during an average day working at home in order to gain insight into the number of additional avoided car kilometers. Similar as with the calculations regarding work at the satellite office, modal choice data collected as part of the survey research was used.

The survey results show that people who work at home commute in different ways to the HQ on days when they go to work there. This naturally affects the calculation of the impact of the external transport costs of working at home. If one commutes to the HQ by car, the external cost saves of teleworking are significant. If one, however, commutes with the train, then any additional vehicle kilometers by car that are made during working at home will have negative impacts. Table 5 shows the categories for the respective average commuting distance to the HQ.

For employees working at home, additional private vehicle kilometers driven when working at home that would not have been driven when working at HQ should be taken into account. Survey results show that only 13% of the employees working at home use the car when working at home. Of these 13% only 42% travel additional private vehicle kilometers with an average displacement of 12.3 km per employee involved.

Table 5: Modal choice, number of respondents (total and percentage) and average number of vehicle kilometers from the main mode of transportation to commute to the office by one-way trip for employees that work at home

Modal choice to headquarter	Number	%	Average number of miles to headquarters
Car	232	51,3%	40
Train	177	39,2%	62
Motorcycle / moped	10	2,2%	31

Tram	10	2,2%	11
Subway	5	1,1%	28
Walk	2	0,4%	3
Bicycle	9	2,0%	14
Bus	7	1,5%	26
	452	100,0%	

Source: MOSI-T, 2011

About half of the work at home employees (51%) commute by car to the HQ over an average commuting distance of 40 kilometers. Compared to commuting to the satellite office, the external transport costs for 5 days commuting to the HQ for employees working at home is lower due to the lower average commuting distance. With five home working days, no marginal external transport costs occur if the car is not being used for additional kilometers. If there are additional kilometers, the marginal external transport costs will be very limited considering the low trip distances.

This is of course quite different when teleworkers commute to the headquarter office using the train. Assuming again that commuting to the HQ by employees working at home has no impact on the supply-side of the railways, there are no marginal external costs of commuting by train to the HQ. If during the work at home no additional vehicle kilometers are driven, no marginal external costs occur in both scenario's. However, when additional vehicle kilometers are driven during the work at home, a negative external cost impact will occur. Even in a scenario with five days work at home, these additional external costs are however limited by the relatively low distances of the additional trips when working at home. Moreover, it is a very small group of employees that travel additional kilometers (2.3% of the survey), so the overall impact of this category on the external costs remains relatively limited.

For the other categories, the impact will always be comparable to one of the preceding categories. When commuting with the tram, the subway or the bus to the HQ, the impact will be similar to the pathway mentioned above. When commuting to the HQ by walk or by bicycle even health benefits could occur, but since these modal choice categories are relatively small, the impact will be limited. The use of motorcycle/moped to commute to the HQ represents 2.2% of the telecommuters in the survey. Here the external costs are generally higher than by using the car (due to the increased emissions and accident risks), but because this group is relatively small, they were included within the car category in the calculation of the average external cost of the work at home scenarios.

Summary

In order to obtain the overall effect of working at home on the basis of the survey results, a weighted value was calculated, taking into account the relative weights of the various modal types, including the categories in which no external costs may occur. This calculation is shown in Table 6.

Table 6: Marginal external costs by working at home per employee per week (€ 2011): weighted average of the modal categories

HOME weighted	**Climate**	**Air**	**Up- & down**	**Noise**	**TOT Environment**	difference from Sc1	**Accidents**	**Congestion**	**TOT incl C**	difference from Sc1
€/employee/wk										

Scenario 1 (5d HK)	1,04	1,50	1,19	1,83	**5,56**		6,07	73,03	**84,65**	
Scenario 2 (1d TW + 4d HK)	0,83	1,21	0,96	1,47	**4,47**	-1,09 (-19,6%)	4,88	58,79	**67,79**	-16,87 (-19,9%)
Scenario 3 (2d TW + 3d HK)	0,63	0,91	0,72	1,12	**3,38**	-2,18 (-39,1%)	3,68	44,54	**50,92**	-33,74 (-39,9%)
Scenario 4 (5d TW)	0,02	0,02	0,02	0,06	**0,12**	-5,44 (-97,8%)	0,11	0,08	**0,31**	-84,34 (-99,6%)

Source: MOSI-T, 2011

Table 6 clearly shows that even when working at home a significant external cost savings in terms of mobility is realized. Taking into account the views of all the employees participating in working at home, the external cost saving of 1 day working at home and 4 days commuting to HQ compared with 5 days working at HQ is on average 19.9%, while with two days working at home this rises to 39.9 %. For five days working at home, the marginal external transport costs are almost negligible and the external transport costs savings amount to 99.6%.

There are two main reasons: avoidance of commuting distances when working at home, which has a positive impact on all the external cost categories, including noise, and the much lower levels of congestion in additional vehicle kilometers that are travelled during telework at home. Adding the external environmental costs together (climate change, air pollution, upstream and downstream processes and noise) shows that by working at home an external cost saving of 19.6% and 39.1% respectively is realized in one and two days working at home. In case of five days working at home, this would even reach 97.8%. These percentages are much higher than for working at the satellite office, since when working at home a lot more vehicle distance and consequently fuel consumption is avoided. The external costs saved by teleworking at home are therefore relatively larger than when working at the satellite office.

Conclusion

This paper was based on data coming from a survey, estimating the impact of teleworking on the external costs linked to the mobility of employees. Focus was primarily on external environmental transport costs (climate change, air pollution, up and downstream processes and noise) and secondly on external socio-economic transport costs (accidents and congestion). The analysis of the external costs indicates clearly that telework in companies in the Brussels Capital Region could provide a significant external transport costs saving. Especially in terms of marginal external congestion costs the savings in avoiding commuting by car to the capital increase strongly. The travels to the HQ are indeed often associated with congestion, which could totally or partly be avoided by teleworking.

The largest gains can be realized when working at home, since the commuting travel could completely be avoided. However, there are also scenario's where teleworking at home may increase marginal external transport costs, namely when the trip to the HQ occurs by public transport or a soft mode and when additional vehicle kilometers are driven in the context of private trips. Typically, this category of employees is relatively small (2.3% in our survey) and its impact is relatively limited (only 12.3 km / day on average per employee that travel additional vehicle kilometers), so the impact on the total external cost is very small.

Considering working at the satellite office, the relatively common modal shift from public transport (commuting to the HQ) to the car (to commute to the satellite office) is a disadvantageous situation for external transport costs. The impact of this modal shift is however too limited to increase the total external costs rather

than to decrease them, as the congestion levels of commuting by car to the satellite office is much lower than when commuting by car to the HQ, and this category also remains relatively high.

General we can say that the size of the external cost depends on the proportion of the commuting trips to the HQ that are travelled by car. The more of those trips may be replaced by working at home or in the satellite office, the greater the external cost saving will be.

References

[1] Castaigne, M., Cornelis, E., De Witte, A., Macharis, C., Pauly, X., Ramaekers, K., Toint, P., & Wets, G. (2009). PROMOCO: Professional Mobility and Company Car Ownership. Final report Science for a sustainable development of the federal authorities.

[2] Illegems, V., & Verbeke, A. (2003). Moving Towards the Virtual Workplace. Managerial and Societal Perspectives on Telework, Cheltenham (UK) – Northampton (MA-USA): Edward Elgar.

[3] Taskin L., & Walrave, M. (2010). Teleworking: Survey Results 2010. Presentatie op Nationale Thuiswerk Dag 2010, 28 oktober, 2010.

[4] Denolf, C., Bletek, H., Vandenbossche, M., & Walrave, M., (2006). Anders Werken Handleiding, Brussels: Nito & Markant.

[5] Vanoutrive, T., Van Malderen, L., Jourquin, B., Thomas, I., Verhetsel, A., & Witlox, F. (2010). Mobility Management Measures by Employers: Overview and Exploratory Analysis for Belgium. EJTIR. 10(2) (pp. 121-141).

[6] BIM (2010). Analyse van de fases 2 van de bedrijfsvervoerplannen. Stand van zaken van het mobiliteitsmanagement in de grote Brusselse bedrijven. Brussels: Leefmilieu Brussel.
http://documentatie.leefmilieubrussel.be/documents/Mobiliteit_BVP_Analysehase2_NL.PDF

[7] Van Acker, V., Witlox, F., & Van Wee, B. (2007). The effects of the land use system on travel behavior: a structural equation modeling approach. Transportation planning and technology. 30(4). (pp. 331-353).

[8] Verhetsel, A., Thomas, I., Van Hecker, E., Beelen, M. (2007). Pendelen in België. Deel I: de woon-werkverplaatsingen. Brussel: FOD Economie, K.M.O., Middenstand en Energie.

[9] De Pelsmacker, P., & Van Kenhove, P. (2006). Marktonderzoek. Methoden en toepassingen. (2nd ed.). Pearson Education Benelux, Prentrice Hall.(pp. 515).

[10] Bickel, P., & Friedrich, R. (2005). ExternE. Externalities of Energy. methodology 2005 Update, European Commission, Luxembourg, (pp. 270).

[11] van Lier, T., Macharis, C., Van Hoeck, E., & Pekin, E. (2010). Comparing the effect of fuel price increases with the internalization of external costs: a decision analysis framework for intermodal transport. In: Witlox, F. & S. Weijers (eds.) Vervoerslogistieke werkdagen 2010. 18 en 19 november, Antwerpen, België. (pp. 267-280).

[12] Maibach, M., Schreyer, C., Sutter, D., (INFRAS), Van Essen, H. P., Boon, B. H., Smokers, R., Schroten, A., (CE Delft), Doll, C., (Fraunhofer Gesellschaft-ISI), Pawlowska, B., Bak M., (University of Gdansk), 2008, Handbook on Estimation of External Cost in the Transport Sector. Internalisation Measures and Policies for All external Cost of Transport (IMPACT), Version 1.1., European Commission DG TREN, Delft, CE, The Netherlands.

[13] European Commission (2011). White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. Brussels.

[14] De Nocker, L., Int Panis, L., & Mayeres, I. (2006). De externe kosten van personenvervoer. In: Mobiliteit en (groot)steden beleid. Vlaams Wetenschappelijk Economisch Congres - VWEC - 2006 - Editors: M. Despontin & C. Macharis. (pp. 381-415).

[15] Cabus, P. & Vanhaverbeke, W. (2004). Strategisch Plan Ruimtelijke Economie; Eindrapport: Ruimte en economie in Vlaanderen. Brussels (pp. 408)