

# ELABORATION OF A COMPOSITE SCORE FOR DESIGNING AND CHOOSING SUSTAINABLE “OFFICIAL CAR POLICY”

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## ABSTRACT

A lot of companies provide their employees with official cars in order to get some fiscal advantages while simultaneously satisfying the employee himself. It is a common “win-to-win” situation in most of the cases. However, these official car policies can lead to numerous impacts such as road congestion increase, air pollution as well as climate change. Therefore, it is of key importance to be able to manage that situation in a sustainable way. It is the aim of this paper to develop a methodology for designing and choosing sustainable alternatives in matter of official car policy management. The methodology is based on the elaboration of composite scores integrating the environmental footprints, the costs and the social impacts of proposed alternatives. These scores allow prioritizing official car policies while simultaneous sensitivity analyses make it possible to provide sustainable recommendations.

Keywords: official car policy, sustainable management, composite score.

## 1. INTRODUCTION

When observing the ways of managing commuting of employees, it is obvious that the “official car policies” are very widespread among local, national or international companies. In one hand, it is a fiscal advantage for the company while in the other hand it represents substantial expenses that the employee does not have to take in charge for the use of a private vehicle. It has to be noted that 50% of annual car registrations are made by companies in Belgium. However, the negative impacts of such a situation have to be highlighted: emissions of toxic substances, impacts on climate change, increase of road congestion, etc.

So, it is essential to be able to manage and control “official car policies” in order to minimize the above mentioned impacts.

It is the aim of this paper to propose the elaboration of a composite score to help companies for designing and choosing sustainable official car policies; in other words, cost-, social-, and environmental-friendly policies.

In Section 2, the authors review a number of books, articles, scientific papers and European Directives for elaborating the proposed composite score.

Section 3 describes the structure of the composite score and the underlying aggregation methods. First, major pollutants compose the environmental footprint made up of carbon dioxide, carbon monoxide, sulfur oxides, particle matters and nitrogen oxides. Based on these pollutants, the emissions of current official car policies and alternatives can be evaluated and aggregated in an environmental footprint. Secondly, the global cost is made up of the leasing and fuel costs for official cars while only subscription fees are considered in case of public transport use. Thirdly, the social impact is elaborated on the basis of a qualitative indicator: the comfort, while a second impact is quantified: the travel time. Then, the three above mentioned “super indicators” are aggregated into a final composite score expressing the sustainable performance of current official car policies and alternatives. Based on this score, the various scenarios can be compared and prioritized. Moreover, sensitivity analyses can be performed for testing the robustness of the recommended solutions.

The applicability of this methodology is demonstrated in Section 4 by analyzing and solving a case study.

Finally, some conclusions and perspectives of development are presented in Section 5.

## 2. LITERATURE REVIEW

Number of publications, articles, European directives and other reports were essential for developing the proposed methodology and the study case.

For the elaboration of the composite score, the major literature source is (Rigo et al. 2008) presented during the MAS conference 2008 where the authors developed a similar approach. This approach was improved and adapted to the problem of “official car policy”. Moreover, the authors reviewed number of other references in order to validate the methodology used, such as (Roy and Bouyssou 1993); (Roy 1985); (Rigo, Ndiaye, Dreyer, Zomer, Pinon and Tremeac 2007); (Brans and Mareshal 2005).

For the elaboration of the database used for applying the proposed methodology and solving the study case, (Van Essen et al. 2003) proposes a lot of useful “top-down” data regarding the environmental performances of freight and passenger transport for different modes.

All in all, this review led to the elaboration of the composite score and the demonstration of its applicability in practical situations.

### 3. METHODOLOGY

This section develops in details the scheme used for the elaboration of the sustainable composite score.

This composite score is made up of various types of indicators grouped into three categories respectively linked to the pillars of the sustainable development. For each category, a list of indicators is elaborated. A first aggregation makes it possible to calculate the environmental footprint, the global cost and the social impact via three scores integrating all the information contained in the “first level” indicators.

These “super indicators” can be aggregated into a sustainable composite score providing the actual sustainable performance of the analyzed official car policy and related possible alternatives.

Since the authors use the PROMETHEE method for elaborating the “super” environmental and social indicator as well as the sustainable composite score, the next section recalls the main steps of this pair wise based multi criteria decision aiding method.

Then, the ways of calculating the impacts on the indicators are detailed as well as the methods used to aggregate them in super indicators.

Finally, the elaboration of the sustainable composite score is explained.

#### 3.1. The PROMETHEE methodology

Since the PROMETHEE method is used for the aggregation of the environmental and social impacts as well as for the elaboration of the composite score, the following modeling is recalled.

First, let us consider a set of criteria,  $\{g_1(\cdot), g_2(\cdot), g_3(\cdot), \dots, g_m(\cdot)\}$  and a set of scenarios to compare  $A = \{a_1, a_2, a_3, \dots, a_n\}$ . Let us define  $g_j(a_i)$  the evaluation of scenario  $a_i$  on the axis  $j$ .

Let us consider the deviation of impacts of two actions on a criterion:

$$d_j(a, b) = g_j(a) - g_j(b); \quad \forall a, b \in A \quad (1)$$

In order to delete the possible scale effects related to the units of criteria, let us define the following function in the case of a criterion  $j$  to maximize,

$$0 < F_j[d_j(a, b)] \leq 1; \quad \forall a, b \in A \quad (2)$$

Where:

$$F_j[d_j(a, b)] > 0 \Rightarrow F_j[d_j(b, a)] = 0; \quad \forall a, b \in A \quad (3)$$

If the criterion  $j$  has to be minimized, the following relation is considered,

$$0 < F_j[-d_j(a, b)] \leq 1; \quad \forall a, b \in A \quad (4)$$

The pair  $\{g_j(\cdot); F_j[d_j(a, b)]\}$  is called the generalized criterion associated to the criterion  $g_j$  or the preference function related to the criterion  $g_j$ .

Various preference functions are available and can be varied to an infinite number of solutions corresponding to the needs of the users. Two examples are described here after:

The usual generalized criterion is defined as follows:

$$F_j[d_j(a, b)] = \begin{cases} 0 & \text{if } d_j(a, b) \leq 0 \\ 1 & \text{if } d_j(a, b) > 0 \end{cases}; \quad \forall a, b \in A \quad (5)$$

The U-shape generalized criterion can be defined as follows:

$$F_j[d_j(a, b)] = \begin{cases} 0 & \text{if } d_j(a, b) \leq q \\ 1 & \text{if } d_j(a, b) > q \end{cases}; \quad \forall a, b \in A \quad (6)$$

Where  $q$  is the preference threshold.

On the basis of these generalized criteria, let us calculate the aggregated preference indices as follow:

$$\begin{cases} \pi(a, b) = \sum_{j=1}^m F_j[d_j(a, b)] \times \omega_j \\ \pi(b, a) = \sum_{j=1}^m F_j[d_j(b, a)] \times \omega_j \end{cases}; \quad \forall a, b \in A \quad (7)$$

Where  $w_j$  is the weight allotted to the criterion  $j$ . Then, the positive and negative outranking flows are calculated as follows:

$$\phi^+(a) = \frac{1}{n-1} \sum_{x \in A} \pi(a, x) \quad (8)$$

$$\phi^-(a) = \frac{1}{n-1} \sum_{x \in A} \pi(x, a) \quad (9)$$

The PROMETHEE II complete ranking is based on the following outranking net flow:

$$\phi(a) = \phi^+(a) - \phi^-(a) \quad (10)$$

#### 3.2. Towards the “super indicators”

Three main fields have to be considered in order to develop a sustainable composite score: the economic aspects focusing on the direct costs for the company, the environmental impacts dedicated to the pollutant

emissions and the social aspects highlighting the well-being of the employee during the journey.

### 3.2.1. The environmental indicators

When looking at the environmental aspects, the authors focus on the air pollution and selected a list of six pollutants usually considered in the frame of transport activities. The “Well to Wheel” framework was chosen in order to depict a global picture of the emissions caused by transport of persons. This means that both “Well to Tank” (*WTT*) and “Tank to Wheels” (*TTW*) emissions are considered.

Among these chemical substances, the carbon dioxide ( $\text{CO}_2$ ) resulting from fuel combustion has a global impact on climate change and is certainly the major greenhouse effect gas. The nitrogen oxides ( $\text{NO}_x$ ) are generated by ‘high-temperature’ combustions and contribute to the creation of ozone impacting on human health and vegetation. The sulfur oxides ( $\text{SO}_x$ ) and among others, the sulfur dioxide originates in the sulfur contained in the fuel.  $\text{SO}_2$  leads to acidification impacting on the public health and the crops. The particle matters (PM) such as soot and ashes, present in oil causes local pollution, impacting seriously on human health. The carbon monoxide (CO) results from an incomplete combustion of fuel and causes a local acidification and the creation of ozone on the ground level.

Then, it is the aim of this paper to evaluate the impacts of “official car policies” on these emissions. Since most of these data are not available from the companies, a top down approach is used in order to provide realistic estimations. So, in one hand data are available for type vehicles: the energy consumption expressed in MJ/km and the emission factors per vehicle in g/km are available for the above-mentioned pollutants. In the other hand, data are also available for refining and electricity production emissions and expressed in g/MJ.

Therefore, “Well to Wheels” emissions can be quantified for official car policies and designed alternatives leading to a detailed estimation of the toxic pollutants emitted in the atmosphere.

Five transport modes are considered in the frame of this paper; namely the cars, buses, trams, metros and trains. If we look at the “Tank to Wheels” emissions, only cars and buses are concerned since trains, metros and trams only lead to electricity production emissions.

So, let us consider the following factors:

- $EF_{p,HW,v}$ , the emission factor of pollutant  $p$  by a vehicle  $v$  of the fleet  $V$  on highway section expressed in g/km;
- $KM_{HW,v}$ , the distance covered on highways by the vehicle  $v$ ;
- $EF_{p,CR,v}$ , the emission factor of pollutant  $p$  on motorway section in g/km;

- $KM_{CR,v}$ , the distance covered on city roads by the vehicle  $v$ ;

In this paper, the authors do not consider car pooling scenarios.

So, the following formulas provide the *TTW* emissions of pollutant  $p$  in g for the fleet  $V$  on highway and city road sections per day:

$$TTW_{p,V,HW} = \sum_{v \in V} (EF_{p,HW,v} * KM_{HW,v}) \quad (11)$$

$$TTW_{p,V,CR} = \sum_{v \in V} (EF_{p,CR,v} * KM_{CR,v}) \quad (12)$$

The authors want to emphasize the rural and urban area and the related pollution impacts. That is why the *TTW* emissions are split between highway and city road sections making it possible to use specific urban and non urban societal costs when elaborating the environmental footprint, as explained at the end of this section.

When applying these equations in a practical case, a specific time window has to be fixed for quantifying the emissions. In the study case developed in this paper, the authors proposed to consider 22 working days equivalent to one month. Therefore, the *TTW* emissions will be multiplied by 22 since the daily covered distance is supposed to be the same.

When looking at the *WTT* emissions, let us consider the following factors for diesel engine vehicles:

- $ER_p$ , the emission of refining pollutant  $p$  in g/MJ;
- $EU_{p,CR,v}$ , the energy use in MJ/km for a vehicle  $v$  on city roads;
- $EU_{p,HW,v}$ , the energy use in MJ/km for a vehicle  $v$  on highways.

Then the next equation provides the *WTT* emissions of a pollutant  $p$  for diesel engine vehicles of the fleet  $V$ :

$$WTT_{p,V} = \sum_{v \in V} (EU_{p,HW,v} * KM_{HW,v} + EU_{p,CR,v} * KM_{CR,v}) * ER_p \quad (13)$$

When evaluating the *WTT* emissions, the authors considered that it is very difficult to emphasize the crossed urban and non urban area since the toxic substances are emitted during the feedstock extraction, storage, distribution and transport of the fuel, tasks taking place far away from the actual transport route used by the employees.

When looking at *WTT* emissions, electric modes have to be considered too. The authors proposed to exclude the nuclear power source of electricity production since the natural human behavior reluctantly

accepts the high risks and waste aspects linked to that electricity source.

Then, let us consider the following factors:

- $EP_{p,v}$ , the emission factor of pollutant  $p$  by a vehicle  $v$  expressed in g/km;
- $ER$ , the energy return more or less equal to 38% regarding the electricity production and distribution rates of 42% and 90%;
- $EU_v$ , the energy use for a vehicle  $v$  expressed in MJ/SKM (Seat Kilometers because of the consideration of electric public transport);
- $KM_v$ , the total distance covered by the vehicle  $v$ .

So, the  $WTT$  emissions of the electric public transport used for one seat  $s$  can be expressed as follows:

$$WTT_{p,s} = \sum_{v \in V} EP_{p,v} * ER * EU_v * KM_v \quad (14)$$

Then, by multiplying this figure by the number of seats occupied by the new employees using public transport, we obtain the marginal emission due to the public transport use.

The assessment of the abovementioned indicators for each pollutant makes it possible to elaborate the evaluation table used to calculate the environmental footprint. This evaluation table is based on the results of equations (11), (12), (13) and (14).

Since the authors used the PROMETHEE method for aggregating these impacts, and as explained in Section 3.1, weights have to be defined.

The authors propose to use the societal costs in urban and non urban sections for the  $TTW$  emissions while the average of the urban and non urban costs are considered for the  $WTT$  emissions.

It has to be noted that no urban/rural distinction is available for  $CO_2$  and  $SO_2$ .

Table 1: Societal costs of toxic substances

Substance	Societal cost (E/ton)
$CO_2$	50
$SO_2$	3000
$NO_x$ (urban)	7000
$NO_x$ (Non urban)	5000
PM10 (Urban)	225000
PM10 (Non urban)	50000
CO (Urban)	500
CO (Non urban)	100

### 3.2.2. The costs

In the frame of this paper, direct costs falling to the company namely the leasing and the fuel consumption are considered. The leasing covers the depreciation and the insurance costs as well as repairs and maintenance

including tires. In the case of public transport, only subscription fees are taken into account.

Then, the total cost of the fleet can be evaluated and expressed in € per month. This does not require specific modelling. It is detailed in the analysis of the proposed case study.

### 3.2.3. The social aspects

The third main pillar of the sustainable development is the social aspects. Comfort and time gains can vary strongly due to the congestion of the road network.

First, the comfort is considered and evaluated on the following qualitative scale: High, Medium and Low.

The time gain can be quantified. It is quite easy to estimate the average time for travelling by cars or by using public transport in usual situations (excluding strikes or exceptional accidents). All in all, these indicators are aggregated into one social score by using the PROMETHEE method allowing the user to combine quantitative and qualitative approaches. This is detailed in the analysis of the study case.

### 3.3. Towards the sustainable composite score

The composite score is made up of the three previous super indicators related to the costs, the pollution and the social aspects aggregated by using PROMETHEE.

Based on this composite score, current official car policies can be compared with new designed alternatives as it is demonstrated in the study case. Moreover, this composite indicator makes it possible to perform sensitivity analyses ensuring robust recommendations.

The above mentioned aggregations are implemented in a software based solution used in the case study while the actual evaluations are performed in spreadsheets and directly imported into the software.

## 4. STUDY CASE

The case studied in the frame of this paper revolves around a small company located in Brussels, providing official cars to their 20 senior executives. The monthly fees include the vehicle hiring as well as the insurances, the repair and maintenance. For the fleet currently used, the monthly fee is about €432,- per vehicle.

Among the senior executives, five come from Tienen to the company headquartered in the center of Brussels, 10 come from Gent and 5 from Borgworm. The routes are characterized as follows:

Table 2: Route description, Scenario 0

Routes	Highway	City road	Total
Tienen – Brussels	38 km	9 km	47 km
Borgworm – Brussels	68 km	10 km	78 km
Gent - Brussels	45 km	11 km	56 km

Two alternatives are considered. Firstly, it is proposed to replace the current fleet by new vehicles emitting less toxic substances. This alternative is characterized by the same route as Scenario 0 and the monthly related fees are about €451,- per vehicle.

The second alternative aims at convincing the senior executives coming from Tienen and Borgworm to use rail mode since a door-to-door service is provided by rail network between Tienen, Borgworm and Brussels while the vehicles used for “Gent-Brussels” are replaced by new vehicles with lower emissions.

Regarding this alternative, the route lengths are as follows:

Table 3: Route description, scenario 2

Routes	Highway	City roads	Total
Tienen – Brussels	50 km		50 km
Borgworm – Brussels	80 km		80 km
Gent - Brussels	45 km	11 km	56 km

Since the authors did not emphasize the urban and non urban sections for the *TTW* emissions, it is not necessary to split the length of the routes Tienen - Brussels and Borgworm - Brussels.

#### 4.1. The environmental footprint

Based upon the data presented in (Van Essen et al., 2003), the authors performed the calculations for evaluating the *WTT* as well as the *TTW* emissions in urban and non urban sections by using the equations detailed in Section 3.2.1.

The next tables present the data used for performing the environmental evaluations.

Table 4: Data base, Current Fleet, *TTW* emissions

	Current Fleet	
	City Road	Highways
CO <sub>2</sub> [g/km]	222	154
NO <sub>x</sub> [g/km]	0,86	0,52
CO [g/km]	1,31	0,19
SO <sub>x</sub> [g/km]	0,048	0,032
PM [g/km]	0,144	0,071
Energy Use [MJ/km]	3,03	1,75

Table 5: Data base, New Fleet, *TTW* emissions

	New Fleet	
	City Road	Highways
CO <sub>2</sub> [g/km]	192	111
NO <sub>x</sub> [g/km]	0,41	0,25
CO [g/km]	0,33	0,05
SO <sub>x</sub> [g/km]	0,006	0,004
PM [g/km]	0,046	0,031
Energy Use [MJ/km]	2,62	1,51

Table 6: Data base, Diesel engine, *WTT* emissions

Emissions of Refining (g/MJ)					
	CO <sub>2</sub>	NO <sub>x</sub>	CO	SO <sub>2</sub>	PM <sub>10</sub>
Diesel	6,8	0,036	0,005	0,052	0,001

Table 7: Data base, Electric engine, *WTT* emissions

Electric engines	
CO <sub>2</sub> [g/MJ]	178
NO <sub>x</sub> [g/MJ]	0,45
CO [g/MJ]	0,03
SO <sub>x</sub> [g/MJ]	1,04
PM [g/MJ]	0,05
Energy Return	0,38
Energy Use [MJ/SKM]	0,31

Table 8 and Table 9 present the valuation of *TTW* and *WTT* emissions for Scenario 0 revolving around the use of the present fleet. It has to be noted that the total emissions are obtained by considering the round trip. HW states for Highways and CR for City roads.

Table 8: Scenario 0, *TTW* emissions [g]

	Gent Brussels	Tienen Brussels	Borgworm Brussels	TOTAL (x2)[g]
CO <sub>2</sub> HW	1524600	643720	1151920	6640480
CO <sub>2</sub> CR	537240	219780	244200	2002440
CO HW	1881	794,2	1421,2	8192,8
CO CR	3170,2	1296,9	1441	11816,2
NO <sub>x</sub> HW	5148	2173,6	3889,6	22422,4
NO <sub>x</sub> CR	2081,2	851,4	946	7757,2
SO <sub>x</sub> HW	316,8	133,76	239,36	1379,84
SO <sub>x</sub> CR	116,16	47,52	52,8	432,96
PM HW	702,9	296,78	531,08	3061,52
PM CR	348,48	142,56	158,4	1298,88

Table 9: Scenario 0, *WTT* emissions [g]

	Gent Brussels	Tienen Brussels	Borgworm Brussels	TOTAL (x2)[g]
CO <sub>2</sub>	117843,33	49769,27	89042,3	513309,8
CO	119,955	63,845	95,75	559,1
NO <sub>x</sub>	657,03	290,61	501,54	2898,36
SO <sub>x</sub>	934,23	407,65	710,98	4105,72
PM	50,655	34,585	43,39	257,26

The *TTW* and *WTT* emissions of Scenario 1 are presented on Table 10 and Table 11. The use of stricter emission standard engines leads to an important pollution reduction.

Table 10: Scenario 1, TTW emissions [g]

	Gent Brussels	Tienen Brussels	Borgworm Brussels	TOTAL (x2)[g]
CO2 HW	1098900	463980	830280	4786320
CO2 CR	464640	190080	211200	1731840
CO HW	495	209	374	2156
CO CR	798,6	326,7	363	2976,6
NOx HW	2475	1045	1870	10780
NOx CR	992,2	405,9	451	3698,2
SOx HW	39,6	16,72	29,92	172,48
SOx CR	14,52	5,94	6,6	54,12
PM HW	306,9	129,58	231,88	1336,72
PM CR	111,32	44,54	50,6	412,92

Table 11: Scenario 1, WTT emissions [g]

	Gent Brussels	Tienen Brussels	Borgworm Brussels	TOTAL (x2)[g]
CO2	101682,02	42943,82	76830,84	442913,36
CO	103,565	55,139	82,674	482,756
NOx	566,984	250,8048	432,8128	2501,2032
SOx	806,168	351,7936	613,5296	3542,9824
PM	43,769	29,8918	37,4948	222,3112

Finally, the *TTW* and *WTT* emissions of Scenario 2 are presented in Table 12 and Table 13. It has to be noted that the *TTW* emissions are only due to the route Gent-Brussels since the railway is used by the employees coming from Tienen and Borgworm.

Table 12: Scenario 2, TTW emissions [g]

	Gent Brussels	TOTAL (x2)[g]
CO2 HW	1098900	2197800
CO2 CR	464640	929280
CO HW	495	990
CO CR	798,6	1597,2
NOx HW	2475	4950
NOx CR	992,2	1984,4
SOx HW	39,6	79,2
SOx CR	14,52	29,04
PM HW	306,9	613,8
PM CR	111,32	222,64

Table 13: Scenario 2, WTT emissions, [g]

	Gent Brussels	Tienen Brussels	Borgworm Brussels	TOTAL (x2)[g]
CO2	101682,02	5242,1	8387,36	230622,96
CO	103,565	0,8835	1,4136	211,7242
NOx	566,984	13,2525	21,204	1202,881
SOx	806,168	30,628	49,0048	1771,6016
PM	43,769	1,4725	2,356	95,195

Tables 12 and 13 highlight the really substantial impacts of using electric public transport.

Then, the authors used the developed related software to elaborate the environmental footprint on the basis of these evaluations and the societal weights. Regarding the preference functions, the authors propose to use the usual function for conserving all the information during the decision process. The next figure presents the environmental footprint of each alternative.

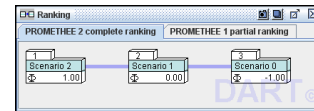


Figure 1: The environmental footprint

Scenario 2 obtains the best environmental footprint expressed by an outranking net flow equal to 1.

#### 4.2. The global cost

The monthly leasing cost is about €432,- per vehicle for the current fleet while it is equal to €451,- per new vehicle. Then, the monthly leasing cost of the current scenario is about €8640,- while the monthly leasing cost of the proposed new fleet would be about €9020,- since 20 vehicles are concerned.

Regarding the second alternative, the price of a monthly subscription is about €146,- for those coming from Tienen and Borgworm since the travelled distances are in a same price category.

Then, the cost of Scenario 2 would be equal to €5970,- per month.

The global cost is made up of another compound; namely the fuel cost. The fuel consumption of the two fleets is shown on the next table:

Table 14: Fuel consumption

	Urban area	Non urban area
S0 (current fleet)	7,5 l/100km	4,6 l/100km
S1 and S2 (new fleet)	6,5 l/100km	4,3 l/100km

Then, regarding the route description detailed in Table 2 and Table 3, the monthly consumption of the current fleet is about 2660,02l while the monthly consumption of the proposed new fleet is about 2440,46l. Scenario 2 is characterized by a monthly fuel consumption of 1166 liters.

When observing the current situation, we can use an average of the fuel price based on the last two years such as €1,2 per liter while some estimations lead to a weak fuel price increase in the coming years, compared to the present situation, to €1,- per liter. Indeed, the possible replacement of the fleet requires some time for its actual implementation so that one can consider that the fuel price would be changed by that horizon.

So, the fuel cost of the current scenario is about €3192,03 per month and the fuel cost of Scenario 1 is about €2928,55 per month due to the fuel consumption and fuel price decrease. The fuel price of Scenario 2 is about €1166,-.

All in all, the global cost of the current scenario is about €11832,03 per month while the monthly cost of Scenario 1 is about €11948,55 and Scenario 2 is about €7136,-. Therefore, Scenario 2 is the cheapest scenario due to the low price of public transport subscription in this particular case characterized by a door-to-door service ensured by train.

### 4.3. The social score

Regarding the social indicator integrating the travel time as well as the comfort during the journey, the authors proposed to use the PROMETHEE method since it allows combining qualitative and quantitative assessments. The comfort is based on a qualitative “three levels” scale while the travel time is well known for both train and road transport modes. It has to be noted that for road transport, an additional travel time of 30 minutes is considered compared to the usual travel time due to rush hours in the morning and in the afternoon.

70 minutes are necessary to reach Brussels from Tienen while 85 minutes are required from Borgworm and 77 minutes from Gent. Regarding the public transport, 38 and 58 minutes are needed for reaching Brussels from Tienen and Borgworm respectively.

Regarding the second indicator, three linguistic levels are proposed: Low, Medium and High. The authors supposed that comfort – inversely proportional to stress levels - is high when using train since the employee does not need to concentrate himself on road traffic, congestion or risk of accidents while it is only low when driving his car.

The next figure illustrates the social evaluation table while the social composite score is highlighted on Figure 3.

	Confort T-B	Confort B-B	Confort G-B	Time T-B	Time B-B	Time G-B
Scenario 0	Low	Low	Low	70.0	85.0	77.0
Scenario 1	Low	Low	Low	70.0	85.0	77.0
Scenario 2	High	High	Low	38.0	58.0	77.0

Figure 2: Social evaluation table

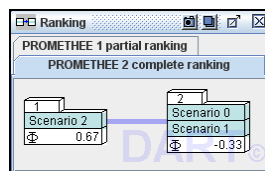


Figure 3: Social ranking

It has to be noted that the authors allotted the same weight to each of the 6 social criteria since it is impossible to give more or less importance to employees of the three different sections. Scenario 2 is the best alternative regarding the well-being of the employees with a social score about 0,67.

### 4.4. Towards the sustainability

Based upon the three above calculated “super-indicators”, the authors proposed to go a step further by aggregating them into a final composite score integrating the three major pillars of the sustainable development.

So, the next figure summarizes the three “macro evaluations” leading to the final ranking based on a composite sustainable score.

	ENV	ECO	SOC
Scenario 0	-1.0	11693.82	-0.33333333
Scenario 1	0.0	11331.76	-0.33333333
Scenario 2	1.0	7136.0	0.66666666

Figure 4: The final evaluation table

After using once again the PROMETHEE method, the authors obtained the following final ranking integrating all the above mentioned information. Scenario 2 obtains the best sustainable composite score. This means that scenario 2 is the best alternative regarding the sustainable management of this particular official car policy.

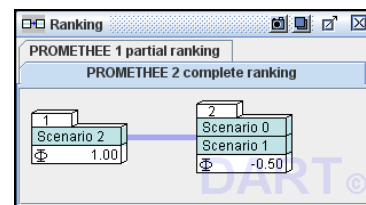


Figure 5: Sustainable composite score

The authors performed sensitivity analyses to test the robustness of the recommendations based on Figure 5. In this particular case, and as already observed in the three super indicators, Scenario 2 is the best alternative whatever the allotted weights or preference functions are since it is the best regarding all the indicators.

However, it is interesting to observe that no distinction is made between Scenario 0 and Scenario 1. It is due to the usual preference function used in the last aggregation step for the macro economic indicator. Indeed, if the U-shape function is used for the global cost with a preference threshold equal to €200,- which is slightly bigger than the deviation between the global costs of S0 and S1, the following composite scores are obtained.

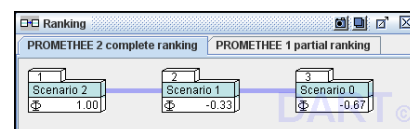


Figure 6: Modified sustainable composite score

This means that moving the preference thresholds could lead to different recommendations according to the preferences of the decision makers.



## 5. CONCLUSION

The goal of this paper was to elaborate a composite score for helping decision makers in designing and choosing sustainable official car policies. Such a score would help each company during the decision process. Moreover, the idea was to develop a software based solution able to support the use of such a score in order to perform automatically all the calculations and providing graphs for helping the communication.

To achieve this goal, the authors review many books, articles and EU directives in order to define precisely the framework and the objectives to meet.

Then the composite score was elaborated on the basis of the three main pillars of the sustainable development, namely the costs, the pollution and the social aspects. A top down approach was used to evaluate the impacts of “official car policy” since actual data are not systematically available in companies. This led to a demonstration of the applicability of the elaborated composite score and the related software.

Finally, it has to be noted that perspectives of development are identified in the frame of this paper. Indeed, in (Maibach et al. 2007), a handbook on the estimation of external costs of transport activities is presented. Then, it would be useful to incorporate these external costs such as road congestion, traffic safety, etc in the proposed composite score to provide a more global picture of the official car policy impacts.

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