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2 **On the environmental and social sustainability of** 3 **urban bus transport practices: the EU case**

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14 **Abstract:** Logistics in urban areas are currently suffering a radical transformation due to
15 increasingly population concentration and the massive use of cars as the preferred transport mode.
16 These issues have resulted in higher pollution levels in urban environments and traffic congestion
17 impacting the world globally. Facilitating the use of sustainable transport modes is widely regarded
18 as a necessity to cope with these adverse effects on citizens' life quality. Hence, some regions, as the
19 European Union, are encouraging bus transport firms to make their business models more
20 environmentally and socially sustainable. The aim of this research is thus to explore how practices
21 adopted by urban bus companies can improve cities' sustainability. With this in mind, a combined
22 Importance Performance Analysis (IPA)-Analytic Hierarchy Process (AHP) method was applied. In
23 this way, both environmental and social sustainability effects of developed practices were
24 represented through hierarchical structures separately. Subsequently, importance and performance
25 ratings of practices in each sustainability dimension were estimated, and thus two IPA grids were
26 generated. These grids support managers in the establishment of more effective action plans to
27 improve logistics sustainability in cities. Findings also provide guidance to governments on the
28 practices that should be promoted in future urban mobility plans.

29 **Keywords:** City logistics; Environmental sustainability; Social sustainability; Urban bus transport;
30 IPA; AHP.

31

32 **1. Introduction**

33 The world population living in urban areas has raised from 33% in the 60's to 55% in 2017
34 (according to the UN). Additionally, this percentage is estimated to raise up to 68% by 2050. This
35 situation is even more accentuated in the European Union, where the percentage of population living
36 in urban areas is 74% (2018) with countries such as Belgium, Denmark, France, Norway or Spain with
37 over 80% of their population living in urban areas. The increasing trend is expected to continue in
38 the European countries as well in years to come reaching a peak of around 82% of urban population
39 in 2050 [1]. This situation generates chronic congestion problems in transportation activities
40 throughout European cities that result in long delay periods for daily journeys. This situation is even
41 worst due to the high percentage of private passenger cars to cover daily short distances (83.1% in
42 2015 according to Eurostat). Dependence on passenger cars is up to 90% in some European countries
43 such as Portugal, Norway or Lithuania.

44 Additionally, the transportation sector represents almost a quarter of Europe's greenhouse gas
45 emissions and is the main cause of air pollution in cities. However, this sector has not showed a

46 declining tendency in emissions as other sectors, quite the contrary, the emissions have increased
47 over 20% in the last 20 years [2]. Road transport in particular accounts for more than 70% of all
48 greenhouse gas emissions from transport in 2014.

49 A final aspect that also plays an important role is the scarcity of urban space due to both, the
50 increase in the urban population and the massive use of passenger cars. Therefore, the current
51 situation calls for the search of new urban mobility programs that merge passengers' expectations
52 and needs, operator's economic requirements and environmental restrictions.

53 A necessary element for the development and success of urban mobility programs is the
54 existence of environmentally and socially friendly modes of transport, such as bus and rail. The
55 European Union (EU) has promoted several projects in order to develop a new generation of buses
56 that will serve for this purpose. Although several projects have focused on the development of new
57 technologies and policies for more environmentally friendly buses, in practice, few of those
58 innovations have been transferred due mainly to economical reasons [3]. Additionally, the European
59 Commission became aware that technology needs to serve, not only to reduce the environmental
60 impact of this mean of transportation, but also to increase its attractiveness, impacting thus, the social
61 sustainability of the mode of transport. However, the impact of the implemented practices in the
62 transportation sector, regarding the bus transportation mode has not been studied so far.

63 In this paper we aim to, first, identify a list of practices that are currently implemented in the
64 urban transportation sector and that have been promoted by the European Commission as a result of
65 different research projects. Additionally, the impact of those practices on environmental and social
66 sustainability dimensions is studied identifying the intensity of those impacts and establishing a
67 hierarchy on the relative impact of each of those practices. This will help managers to optimize their
68 efforts into increasing sustainability and policy makers and governments to better allocate their
69 resources in terms of research funding.

70 This paper is structured as follows. In the following section, definitions for sustainable urban
71 mobility programs are described and the existing literature on the measurement of the impact of
72 transportation policies is analyzed. Section 3 describes the methodology and research procedure in
73 order to assess the main objective of this work. Section 4 presents the results obtained in terms of
74 environmental and social sustainability and finally, the last section presents the most relevant
75 conclusions and limitations of the study.

76

77 2. Literature review

78 2.1. Sustainable Urban Mobility

79 The EU, due to the current situation of continuous mobility congestion in the cities, is especially
80 interested in developing sustainable urban mobility programs in order to palliate the cities' situation.
81 For that purpose, the European Commission has developed the concept of sustainable urban mobility
82 plan with the goal of improving accessibility of urban areas and providing high-quality and
83 sustainable mobility and transport to, through and within the urban area[4].

84 Specifically, the EU Transport Council has defined a sustainable transport system as a system
85 that:

- 86 • allows the basic access and development needs of society to be met safely and in a manner
87 consistent with human and ecosystem health, and promotes equity within and between
88 successive generations.
- 89 • is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a
90 competitive economy, as well as balanced regional development.
- 91 • limits emissions and waste within the planet's ability to absorb them, uses renewable
92 resources at or below their rates of generation and uses non-renewable resources at or below
93 the rates of development of renewable substitutes while minimizing the impact on the use of
94 land and the generation of noise.

95 Additionally, there is a need to develop adequate indicators to measure how sustainable are the
96 implemented urban mobility programs. In this sense, [5] and [6] developed different indicators to

97 evaluate sustainability of transportation networks and urban mobility programs in several European
98 countries.

99 The different transportation modes play a relevant role in order to increase the effectiveness of
100 urban mobility plans. In fact, a recent study made with EU data reveals that the more effective mode
101 of transport will depend on the traffic congestion (peak or off-peak) situations. [7] study different
102 modes of urban transportation –passenger car, motorcycle, bus and rail- on peak and off-peak
103 situations finding that the most effective mode of transport in terms of capacity, cost and
104 environmental performance in peak periods is the public transport. Therefore, there is a clear need
105 for developing transportation policies that encourage the population to use the public transportation
106 system. In order to do that, first, a good public and sustainable transportation system should be put
107 in place. Second, governments should incentivize people to use the public transportation system and
108 therefore should develop the right transportation policies. [8] investigate how to induce population
109 to use sustainable means of transport, finding that public urban transport quality has a direct effect
110 on the intention to use public transport more and private passenger cars less. Therefore, local
111 governments should focus on developing good quality sustainable urban transportation systems in
112 order to incentivize its use.

113 In the search for more sustainable means of transportation, the EU has funded several research
114 projects that aim to develop a new generation of buses, more environmentally friendly and more
115 convenient for passengers. However, even though the technology has evolved to find new engines
116 designed to save fuel and enhance electric vehicles, those are still scarce in practice due mainly to
117 economic reasons [3,9]. For the practices that indeed have been implemented, there is no study that
118 measures their impact on environmental and social sustainability, and thus, that will be the objective
119 of this work.

120

121 2.2. Assessment of transportation policies

122 In order to limit the negative environmental impact of transportation activities, local and
123 national governments are putting several initiatives and policies in place. Evaluating such policies is
124 key to assess the sustainability improvement. [10] evaluate some of the more common regulatory
125 policies put in place by governments in order to establish which ones are more desirable in order to
126 increase sustainability. They propose a method that allows to quantitatively estimate and evaluate
127 system performance, and analyze the behavior in response to regulatory policies, helping in the
128 sustainable transportation planning. [11] also develops a methodology for urban transportation
129 planning that increases sustainability and is based on performance management and system
130 dynamics modeling.

131 Several authors have evaluated current urban transportation strategies all over the world. [12]
132 compare the results of adopting different strategies for urban mobility in achieving more sustainable
133 cities in Newcastle (UK) and Florianopolis (Brazil) and analyzes different indicators for sustainable
134 cities. [13] evaluate the sustainability of urban transport alternatives, including different public bus
135 technologies in the city of Istanbul finding the most appropriate alternatives in order to increase
136 sustainability. [14] investigate how to achieve more sustainable road transportation systems in South
137 Africa. Finding reveal that effectively integrating information and communication technologies in
138 the socio-economic activities will improve sustainability road transportation. An effective use of
139 information and communication technologies will reduce need for travel, traffic volume and will
140 enable appropriate route planning reducing traffic congestion, traffic collisions and travel distance
141 and time. [15] study the influence of different policies in urban transport focusing on environmental,
142 economic and traffic variables in the city of Sao Paulo. They observe that the way in which the policy
143 is implemented will help to reduce existing negative externalities that may appear in the urban
144 transport system. [16] present a decision-making approach that helps managers and policy makers
145 to evaluate and select sustainable configurations for urban freight transportation that is applied in
146 the city of Rio de Janeiro, Brazil.

147 Developing countries, especially in Asia, have even more aggravated environmental problems
148 due to the great scale and speed of urbanization. With the objective of improving city sustainability,

149 [17] develops a combined methodology in order to help in the strategic planning of the urban
150 transportation system. Such strategies are then evaluated based on sustainable development
151 indicators and a priority list is generated, helping city planners to implement good transportation
152 practices. This study is centered in Shahrkord city in Iran. In this country as well but in a different
153 city (Isfahan), [18] evaluate the transportation policies in terms of sustainability and identify which
154 policy is the most important in order to improve city sustainability. Finally, [19] investigate which
155 variables have a greater impact on different transportation models in order to develop new policies
156 focused on those variables. They investigate the Tehran Metropolitan Area with a complex
157 transportation network and complex users concluding that users' behavior is the most significant
158 parameter due to the lack of a public transportation network and its level of comfort.
159

160 3. Data and methods

161 3.1. Research design

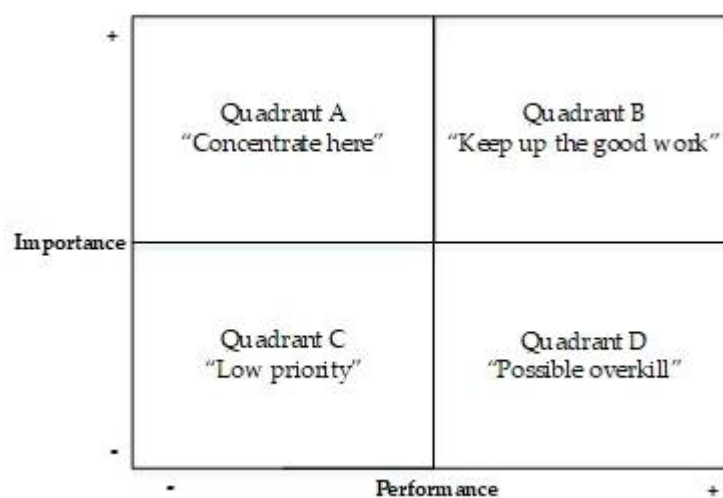
162 The aim of this research is to study those practices adopted by different European companies
163 engaged in bus urban transport in order to increase city's sustainability. The focus of our research is
164 on the European bus transportation sector, due to the patent concern of the EU in reducing
165 greenhouse emissions and improving city logistics from both environmental and social perspectives
166 [20,21]. These concerns have been reflected in the growing policy and funding actions to encourage
167 bus firms to adopt a more sustainable business model, which, in turn, it is expected to result in an
168 improved quality of life for people, communities, governments, and companies. In this respect, it is
169 worth noting that urban bus firms have deployed pioneering contributions in the field of sustainable
170 developments on city logistics within the EU [22–24].

171 Notwithstanding, as Section 2 revealed, little effort has been made in the literature on this matter.
172 The research purpose is therefore eminently exploratory [25], since this study seeks to gain a better
173 understanding about how certain practices carried out by urban transport companies may enhance
174 environmental and social sustainability of cities. In doing so, we propose a hybridized mechanism
175 that integrates Importance-Performance Analysis (IPA) technique with Analytic Hierarchy Process
176 (AHP) [26].

177 IPA method was initially introduced by [27] for supporting the development of effective
178 marketing strategies in the automobile service sector. Then, this technique allowed measuring
179 individually a set of descriptive attributes of customers' satisfaction in accordance to their
180 corresponding perceived importance and performance. The obtained ratings were plotted in a two-
181 dimensional importance-performance grid (Figure 1), so that four strategies could be established
182 from each one of the four grid areas. Because of its multiples advantages derived from its simplicity,
183 effectiveness, utility and easy execution [28–30], IPA has been widely spreading to a great variety of
184 literature fields. Focusing our attention in the sustainability field, several studies have been recently
185 developed with this technique. [31,32] examine how tourism initiatives enable sustainable
186 developments on the residents' experience. [33] explore clients' perceptions on green practices
187 applied in the food services sector. [34] compare the importance and performance of economic, social
188 and green sustainability practices in dyadic relationships at three supply chain levels: upstream,
189 downstream and the overall. On the other side of the coin, [35] determine what lean, green and
190 resilient practices are critical to improve sustainability in the aerospace manufacturing supply chain.
191 These studies highlight that the IPA method has been successfully applied in reaching similar
192 purposes.

193 Notwithstanding, it must be also pointed out that IPA method itself is not exempt of weaknesses
194 [36,37]. [38] already stated that one of these concerns lies in the way in which performance and
195 importance ratings are estimated. According to [39], the problematic does not lie in the scale of

196 performance perceptions but rather at importance perceptions. Previous studies have successfully
 197 overcome this issue by adding comparability in the scales through coupling IPA with AHP [40–42].
 198 This method reinforces the IPA approach in several aspects. On the one hand, AHP allows measuring
 199 importance of specific practices by means of multiple attributes. Thus, the effects of adopted practices
 200 by bus transport firms will be accurately measured based on concrete social and green sustainability
 201 measures. For this purpose, as suggested in [43], direct pairwise comparison between measures will
 202 be carried out to determine the importance of each practice from the city's sustainability point of
 203 view. On the other hand, AHP allows checking the consistency of expert judgements by calculating
 204 a consistency ratio (CR). If these proved to be inconsistent, judgements would have to be reviewed
 205 and the experiment repeated [44]. Thus, the construction of the IPA grid will be also reinforced. The
 206 next subsection explains step-by-step how the combined IPA- AHP method has been applied in the
 207 present study.
 208
 209



210
 211 **Figure 1.** Two-dimensional IPA grid adapted from [27]

212 3.2. Research procedure

213 The procedure presented here is a combination of the IPA and AHP methods. This will help to
 214 gain a better understanding on how further business models may make city logistics more
 215 sustainable. That hybridization was used in the past in different sustainability studies with very
 216 interesting results, as we explained before. However, each generic step must perfectly fit with the
 217 study requirements. Figure 2 provides an overview of the IPA-AHP approach applied in this
 218 research. This is divided into five steps, which are described as follows.

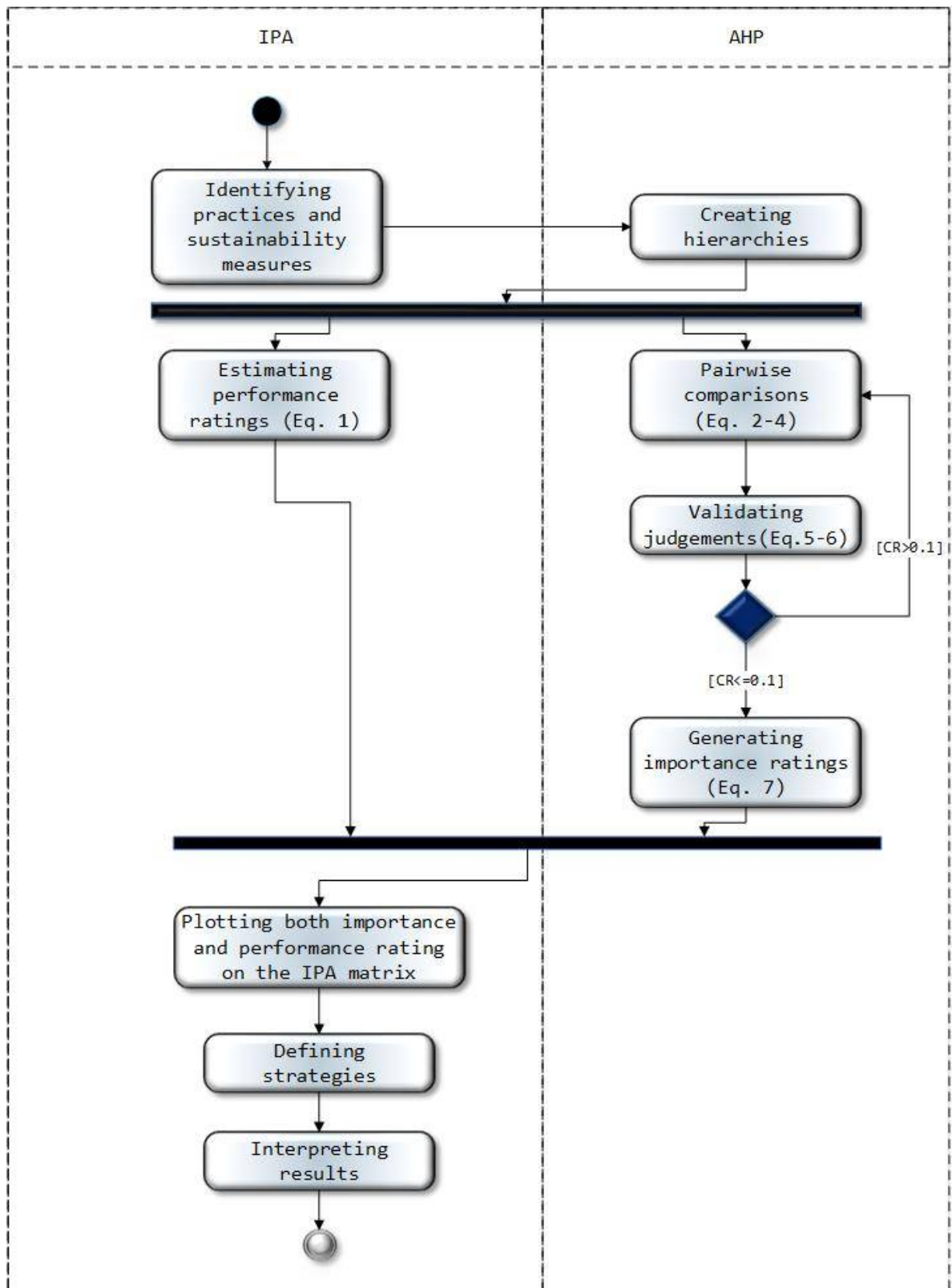


Figure 2. Step-by-step procedure.

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220

221 3.2.1. STEP 1: identifying the practices and sustainability measures in the European urban bus
222 transport sector

223 The research began by exploring how urban bus firms in the EU have adjusted their business
224 models to make city logistics more sustainable. With this purpose in mind, two elements were
225 identified.

226 Firstly, those innovative practices which have been undertaken by European companies of
 227 urban bus transport need to be identified. For that purpose, multiple sources of secondary data were
 228 consulted from the European Commission, firms of urban bus transport and other related organisms.
 229 Many public reports, studies, programs and projects were found reporting on the website. By means
 230 of conducting a comprehensive content analysis [45], these documents were revised in depth so as to
 231 clearly identify what practices have been developed over the past years. These practices and their
 232 descriptions were coded and included in a database, together with the relevant information about
 233 the companies and the European projects that have adopted and funded them respectively. Criterion
 234 for inclusion into the database was that each practice was at least promoted by innovative projects
 235 related to public transport and energy saving. Table 1 depicts the list of sustainability practices
 236 identified in the research.

237 **Table 1.** List of sustainability practices in the transportation sector.

Code	Practice	Description	Source
P1	Fully accessible buses	<ul style="list-style-type: none"> – Accessible for elders, disabled, tourist, children – Urban quality of life and health 	CATS Project Horizon 2020
P2	Stations that integrated intermodality	<ul style="list-style-type: none"> – Stations design and building integrating all aspects of intermodality (infrastructure, localization, comfort, effectiveness, communication). – Adapted to urban environment – Communication between cities – Integrated network management – Enabling infrastructure to support sustainable urban mobility 	CATS Project Horizon 2020
P3	Application with information	<ul style="list-style-type: none"> – Applications-based traveler information with open access server – Improvement of customers' satisfaction – Innovative public service 	TIDE Project Horizon 2020
P4	Machine for traveler information	<ul style="list-style-type: none"> – User friendly human machine interface (HMI) for traveler information – Improvement of customers' efficiency 	TIDE Project Horizon 2020

P5	Electric buses	– Bus powered by electricity – Deployment of clean vehicles – Sustainable urban logistics	ELLIPTIC Project Horizon 2020
P6	Emission free buses	– Zero greenhouse emission buses – Deployment of clean vehicles	ZEEUS Project Horizon 2020
P7	Quiet buses	– Quiet operation against noisy pollution – Sustainable urban logistics	ZEEUS Project Horizon 2020
P8	Hydrogen-powered bus	– Bus that uses hydrogen fuel cell as its power source – Sustainable urban logistics	ÖBB (Austrian Postbus)
P9	Fast charge electric station	– Fast charge station for electric and hybrid buses – Innovate service	Opbrid

238

239 Second, those social and environmental sustainability measures that have been improved
 240 thanks to the implemented practices need to be identified. For that purpose, four senior academicians
 241 were consulted. They were selected according to his/her recognized knowledge in logistics
 242 sustainability and business models. Individual face-to-face interviews were conducted. First, the list
 243 of the practices identified in the first stage was explained to the academician. They identified the
 244 specific social and environmental sustainability measures in city logistics that may be affected by
 245 those practices and the practices that may lead to improvements in each of the measures (influences).
 246 Thus, a specific model per academician was extracted. Once all the interviews were finished, only
 247 matching elements (measures and practices' influences) were added in one unique final model.
 248 Moreover, all influences were corroborated through data collected in the previous content analysis.
 249 Table 2 depicts the final list of environmental and social sustainability measures and the practices
 250 impacting on each one.

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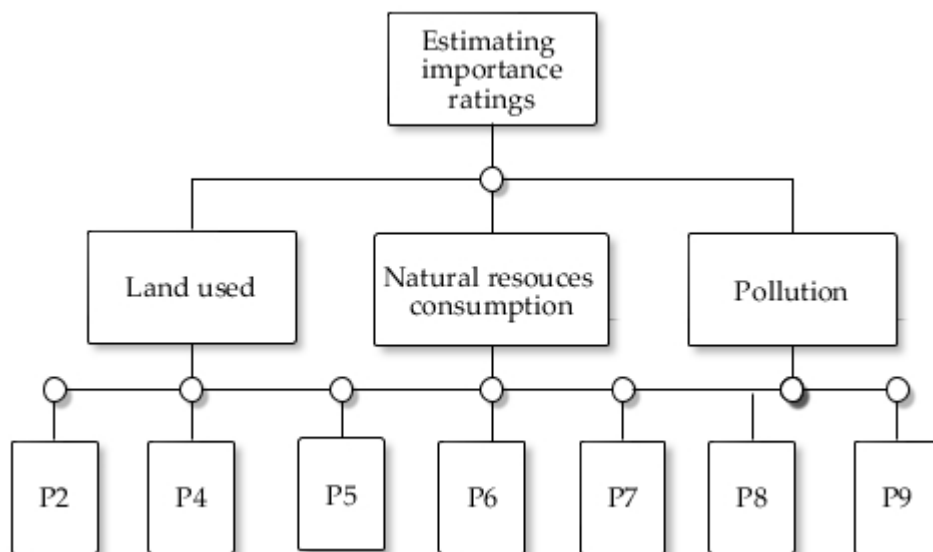
Table 2. List of environmental and social sustainability measures

Sustainability measures	Dimension	P1	P2	P3	P4	P5	P6	P7	P8	P9
Land used	Environmental		X		X					
Pollution	Environmental		X							
Natural resources consumption	Environmental		X		X	X	X	X	X	X
Services for community	Social	X	X			X			X	
Accessibility	Social	X				X	X	X	X	
Facilitate the use of bus transport	Social	X	X	X	X					

252

253 3.2.2. STEP 2: creating hierarchies in environmental and social dimensions

254 Since the classical AHP method was used in [46] to estimate importance ratings, a hierarchical
 255 structure needs to be developed. It represents complex decision problems through the identification
 256 of the goal, criteria, sub-criteria, and available alternatives. For that purpose, the impact of the
 257 identified practice on the sustainability measures (Table 2) was taken into account. This research
 258 required creating two hierarchies, one per sustainability dimension under study. Each entire
 259 hierarchy is represented in three levels, as illustrated in Figures 3 and 4. In the top level, we place the
 260 aim of the decision problem. The elements in the second levels are the sustainability measures
 261 considered in environmental and social dimensions, respectively. The bottom level contains those
 262 practices that may lead to any improvement in each sustainability dimension.

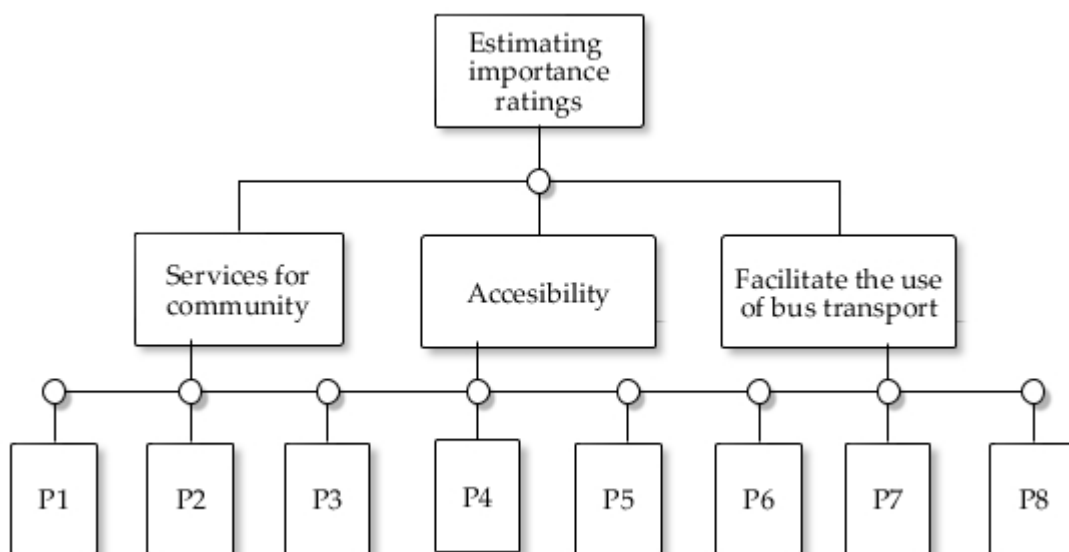


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264

Figure 3. Hierarchical structure to environmental sustainability dimension.

265



266

267

Figure 4. Hierarchical structure to social sustainability dimension.

268 3.2.3. STEP 3: generating performance ratings of sustainability practices

269 With the goal of generating performance ratings, a panel of 14 experts on urban transport was
 270 created. In order to guarantee the results' validity, the participants should pertain to a wide variety
 271 of managerial positions and backgrounds [47]. They were selected for having an minimum
 272 experience of 4 years on the bus transportation field, and all of them were still in direct and daily
 273 contact with the field. Fourteen participants is also considered a good panel size to provide reliable
 274 findings as the literature suggests [48–50].

275 Experts' panels were consulted during the months March and April of 2017. Data was gathered
 276 using a structured online questionnaire. This began with a brief description of the research goal as
 277 well as detailed instructions to answer each part. The first part exclusively included questions on the
 278 experts' profile (professional experience, current position, company and academic studies). The
 279 second and third parts requested information on importance and performance perceived of each
 280 practice in accordance to the hierarchical structure of environmental and social sustainability
 281 dimensions (Figure 3 and 4), respectively. Concerning the performance rating, we added a question
 282 per practice included in the respective hierarchy. In each question, experts had to measure perceived
 283 performance on environmental sustainability and social sustainability in the second and third part,
 284 respectively. In this way, a symmetrical 5-point Likert scale was used (1 = insignificant, 2 = low
 285 performance, 3 = moderate performance, 4 = high performance, 5 = very high performance). Once all
 286 the questionnaires were received, performance ratings of sustainability practices (P_i) were generated
 287 by applying Eq. (1) [27].

$$288 \quad P_i = \frac{\sum_{j=1}^n p_{ij}}{N} \quad (1)$$

289 where p_{ij} represents the performance score that expert j assigned to practice i and N
 290 represents the number of participants.

291 3.2.4. STEP 4: estimating importance ratings of sustainability practices

292 The questionnaire also included in the second and third parts, specific questions to estimate
 293 importance ratings of each practice. Experts were asked about the importance of each element with
 294 respect to each of the others at each level of the hierarchy. Their judgements were gathered using the
 295 nine-point scale presented in [51]. The pairwise $n \times n$ matrix A may be directly built using Eqs. (2)
 296 and (3):

$$297 \quad A = (a_{ij}), \quad i, j = 1, \dots, n \quad (2)$$

$$298 \quad A = \begin{pmatrix} 1 & a_{12} & \dots & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & \dots & \dots \\ \dots & \dots & 1 & a_{ij} & \dots \\ \dots & \dots & a_{ji} = 1/a_{ij} & 1 & \dots \\ 1/a_{1n} & \dots & \dots & \dots & 1 \end{pmatrix} \quad (3)$$

299 where,

300 a_{ij} is how much element i is more important than element j .

301 n is the number of compared elements in the i th level.

302 Each entry in the main diagonal is always equal to 1, since a_{ii} indicates the importance of
 303 element i compared to itself. If $a_{ij} = 1$, the importance of elements i and j is the same. If $a_{ij} > 1$,
 304 the importance of element i is considered higher than the importance of element j . If $a_{ij} < 1$, the
 305 importance of element i is considered lower than that one of element j . Matrix A is therefore
 306 reciprocal, and the number of required pairwise comparisons (NPC) is computed using Eq. 4.

307

$$308 \quad NPC = (n^2 - n)/2 \quad (4)$$

309 Subsequently, the consistency of experts' judgments must be checked using the principal
310 eigenvalue (λ_{max}). This allows to estimate CR (5) and the consistency index (CI) (6) [52]:

311

$$312 \quad CR = CI/RI \quad (5)$$

$$313 \quad CI = (\lambda_{max} - n)/(n - 1) \quad (6)$$

314

315 where RI is the random consistency index [26]. If $CR > 0.1$, the judgements provided by the
316 experts are not considered consistent. The implication of this is that the pairwise comparison must
317 be verified and repeated by experts. If $CR \leq 0.1$, then the experts' judgements are considered
318 consistent and the vector of importance rating (ω) can be already generated by applying (7). The
319 calculations were made by expert choice software in this study. CR values were 0.04 and 0.03 to
320 environmental and social sustainability dimension respectively, and therefore pairwise comparison
321 did not have to be repeated.

$$322 \quad A\omega = \lambda_{max}\omega \quad (7)$$

323 3.2.5. STEP 5: generating IPA matrices

324 Once the importance and performance ratings had been obtained, the IPA matrix was generated.
325 On one hand, the importance rating of each practice was plotted in the Y-axis and the performance
326 rating of each practice was plotted in the X-axis as coordinates (x,y) in a graph. On the other hand,
327 the grand mean of importance ratings (cutting point of Y-axis) and the grand mean of performance
328 ratings (cutting point of X-axis) were represented [53]. Thus, the graph was converted into a two-
329 dimensional grid with a division into four quadrants with the following meaning:

330 **Quadrant A** (Concentrate here). Practices plotted in this quadrant present a high level of
331 importance and a low level of performance. Hence, this quadrant is known as the preferential
332 improvement area. Even though these practices enable improvements in either social or
333 environmental sustainability of city logistics, scarce efforts and resources have been allocated for their
334 implementation. Managers ought to prioritize the development of these practices.

335 **Quadrant B** (Keep up the good work). Practices represented in this quadrant show a high level
336 of importance and a high level of performance. Managers' firms of urban bus transport should
337 maintain current efforts and resources allocated to them, because these practices have proven to
338 improve sustainability in city logistics.

339 **Quadrant C** (low priority). Practices represented in this quadrant show a low level of importance
340 and a low level of performance. These do not require assignment of additional resources and efforts
341 since those practices do not provide enough improvements in either social or environmental
342 sustainability of city logistics.

343 **Quadrant D** (possible overkill). Practices plotted in this quadrant present a low level of
344 importance and a high level of performance. Urban bus transport companies have addressed
345 excessive efforts and resources in developing these practices when they do not provide enough
346 improvements in sustainability of city logistics. Therefore, managers should cut down on resources
347 and efforts for these practices' development.

348 4. Results

349 One of the specific strengths of coupling IPA with AHP lies in the fact that the effects of practices
 350 are measured considering multiple weighted measures of environmental and social sustainability.
 351 Table 3 displays a summary of local weights assigned to sustainability measures. It can be observed
 352 that pollution presents the highest value in the environmental dimensions. Indeed, its local weight
 353 (0.466) was from 0.12 to 2.95 times greater than the one for other environmental sustainability
 354 measures. Natural resource consumption reached a local weight of 0.377, in the second place, which
 355 make these measures agglutinating 84.3% of the total weight in the environmental dimension. This
 356 fact should be translated into a stronger commitment on improving these measures from urban bus
 357 transport companies, governments and society in general. Even though the land used achieved the
 358 lowest value with a local weight of 0.158, all entities should take it into account in their future
 359 decisions as it bears some significance. Thus, environmental sustainability in city logistics will be able
 360 to be enhanced in a more effective way.

361 Concerning social sustainability measures, their local weights were very close among
 362 themselves. The accessibility reached the highest local weight of 0.422. This score was from 1.22 to
 363 1.83 times greater than the other social sustainability measures. Services for community and facilitate
 364 the use of bus transport were ranked in the second and third place, with a local weight of 0.346 and
 365 0.231 respectively. The importance of these three benefit criteria amounted to 93.8% of the total global
 366 weight. Therefore, these three measures should be encouraged with equal priority.

367

Table 3. Local weights of sustainability measures

Sustainability measures	Dimension	Local weights
Land used	Environmental	0.158
Pollution	Environmental	0.466
Natural resources consumption	Environmental	0.377
Services for community	Social	0.346
Accessibility	Social	0.422
Facilitate the use of bus transport	Social	0.231

368

369 4.1. Effects of practices in environmental sustainability

370 In order to explore the effects of the implemented practices by urban bus firms in the
 371 environmental sustainability, a specific IPA grid is generated by applying the steps indicated in
 372 Section 3.2. The obtained importance ratings (Y-axis) and performance ratings (Y-axis) are shown in
 373 Table 4. These points comprise the specific coordinates (x,y) of each practice into the IPA grid. In
 374 addition, cutting points of Y-axis and X-axis were 0.142 and 4.183 respectively. The obtained IPA grid
 375 in the environmental dimension is given in Figure 5.

376 **Quadrant A** is considered as the preferential improvement area since it agglutinates practices
 377 with high level of importance and low level of performance. In this research, no practices were
 378 classified in this quadrant. This indicates that none of the developed practices should be encouraged
 379 to a larger extent than action plans currently state.

380 **Quadrant B** includes 2 out of 7 practices developed by urban bus companies. Findings reveals
 381 that both P5 (Electric buses) and P6 (Emission free buses) are considered highly important to improve
 382 environmental sustainability of cities. These practices may reduce natural resource consumption and

383 pollution in cities. At the same time, P5 and P6 reached a higher performance level by those European
 384 firms which had already implemented them. These companies therefore should continue extending
 385 and renewing their fleets with electric and emission free buses. Additionally, those organizations,
 386 which have not implemented these practices yet, ought to prioritize them so as to make its business
 387 model more environmentally sustainable.

388 **Quadrant C** brings together the highest number of implemented practices in the European urban
 389 bus transport sector. These are P2 (Stations that integrated intermodality), P4 (Machine for traveller
 390 information), P7 (Quiet buses) and P9 (Fast charge electric station), which represents 57.14% of the
 391 total implemented practices. These four initiatives showed a low importance level to improve
 392 environmental sustainability in cities. Results also reveal that companies that have already
 393 implemented P2, P4, P7 and P9 reached a low performance level from the environmental perspective.
 394 Consequently, it is recommended not to plan and invest further resources and efforts in developing
 395 those practices. In the same line, those organizations that have not developed these practices yet,
 396 should not incorporate them into their business models.

397 **Quadrant D** only contains a practice out of 7 under study. P8 (Hydrogen-powered bus) showed
 398 a low importance level in enhancing environmental sustainability in city logistics. In spite of this, the
 399 practice presented a high performance level. This is due to organizations that have carried out
 400 excessive efforts and resources in implementing P8 from the environmental perspective. Hence,
 401 managers should reduce the efforts and resources invested in this practice. For those firms that have
 402 not extended and renewed their fleets with hydrogen-powered bus yet, they should not prioritize it.

403

Table 4. Findings of IPA-AHP method in the environmental dimension

Practice	Importance ratings	Performance ratings	Quadrant
P2	0.108	4.071	C
P4	0.133	3.571	C
P5	0.187	4.428	B
P6	0.177	4.785	B
P7	0.121	3.928	C
P8	0.135	4.357	D
P9	0.139	4.142	C

404

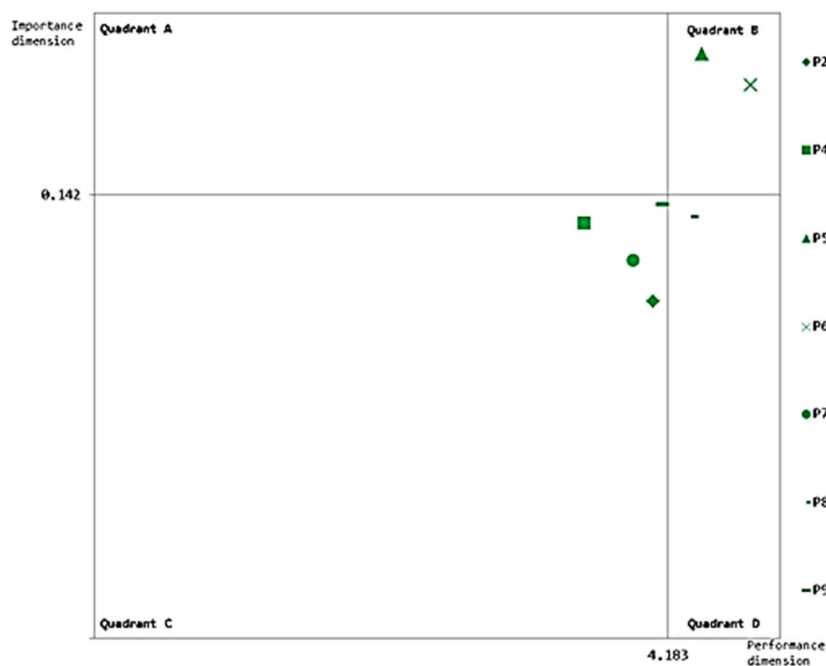


Figure 5. IPA grid to improve environmental sustainability

405

406

407 4.2. Effects of practices in social sustainability

408 In addition to the IPA grid for the environmental sustainability in city logistics, another IPA grid
 409 was built to specifically explore the effects of practices in the social sustainability. Table 5 depicts the
 410 importance ratings (Y-axis) and performance ratings (Y-axis) of all practices. These coordinates
 411 determine in which position of the IPA grid each practice should be plotted. Moreover, the cutting
 412 points of the Y-axis and the X-axis were 0.125 and 4.06 respectively. Figure 6 illustrates the specific
 413 IPA grid for the social dimension.

414 As in the IPA grid for the environmental sustainability, **Quadrant A** does not included any
 415 practice. This area classifies those practices that present high importance level and low performance
 416 level. Therefore, if companies seek to make their business models more socially sustainable, they
 417 ought to prioritize practices included in Quadrant A in their action plans. However, since no practices
 418 in this quadrant were included, one could infer that there is a further need for developing new
 419 socially sustainable practices in the sector.

420 **Quadrant B** solely incorporates one practice of all the ones developed by urban bus companies.
 421 P1 (Fully accessible buses) obtained a high importance level to enhance social sustainability. Indeed,
 422 this practice might directly make the use of bus transport and its accessibility easier. P1 also achieved
 423 a high performance level by those European firms which had already implemented it. For this reason,
 424 it is suggested that these organizations maintain concrete actions in their business model to continue
 425 making their fleet fully accessible. Additionally, P1 should be a priority action to those companies
 426 that have not developed it yet.

427 **Quadrant C** contains 3 out of 8 practices analysed in the social sustainability dimension. P4
 428 (Machine for traveller information), P5 (Electric buses) and P8 (Hydrogen-powered bus) reached both
 429 low importance and performance levels from the social sustainability perspective. This implies that
 430 these practices provide little or no improvements in the social sustainability of city logistics. Hence,
 431 managers of urban bus transport firms should not allocate further efforts and resources into develop
 432 P4, P5 and P8.

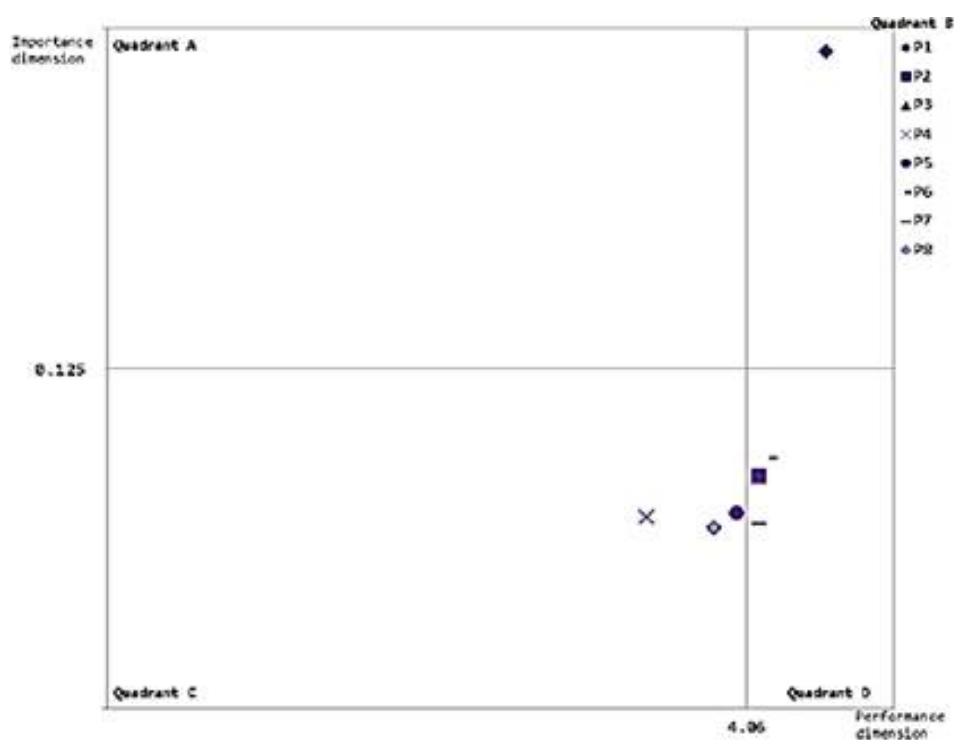
433 **Quadrant D** brings together the highest number of practices included in the social dimension.
 434 P2 (Stations that integrated intermodality), P3 (Application with information), P6 (Emission free
 435 buses) and P7 (Quiet buses) also obtained a low importance level for improving social sustainability
 436 although a high performance level. This fact highlights that firms that have already implemented
 437 these practices should cut down the resources and efforts in their future action plans. With regard to
 438 those companies that have not developed these practices yet, the recommendation is to not focus
 439 their efforts on them.

440

Table 5. Findings of IPA-AHP method in the social dimension

Practice	Importance ratings	Performance ratings	Quadrant
P1	0.309	4.571	B
P2	0.11	4.142	D
P3	0.109	4.142	D
P4	0.09	3.428	C
P5	0.092	4	C
P6	0.118	4.214	D
P7	0.087	4.142	D
P8	0.085	3.857	C

441



442

443

Figure 6. IPA grid to improve social sustainability

444 5. Conclusions

445 The whole globe is facing a situation of overcrowded cities and this is only getting more
 446 accentuated with time. There is an urgent need to increase cities' sustainability and not only at the
 447 environmental level. One of the main activities that is currently aggravating this situation is the
 448 transportation sector. Urban transportation worsens cities environmental and social sustainability. In
 449 order to overcome these problems, several countries all over the world have started to implement

450 new policies and practices in urban mobility systems. In particular, the EU has financed several
451 research projects with the aim to improve urban transportation systems. Some of those projects were
452 focused on the improvement of the bus mobility mode and have developed the technology to
453 generate more environmentally and socially friendly buses. Measuring how effective in the
454 improvement of sustainability those developed measures are becomes critical as bus transportation
455 companies normally face economical restrictions and need to choose which practices to implement
456 in their buses fleets.

457 In order to identify which practices are the most successful ones in order to increase both,
458 environmental and social sustainability, a methodology that combines IPA an AHP is implemented.
459 Results show that in order to increase environmental sustainability, the practices that achieve a
460 greater impact are *Electric buses* and *Emission free buses*. Therefore, those strategies are the ones that
461 should be prioritized in order to achieve a greater performance in the environmental dimension. In
462 parallel, in order to increase social sustainability, *Fully accessible buses* is the practice that will achieve
463 a greater performance in the social dimension and therefore should be prioritized as well.
464 Additionally, this method also identifies the practices that show a great performance rating but the
465 relative importance in improving each of the sustainability dimensions is limited. This is the case of
466 *Hydrogen-powered bus* for the case of the environmental dimension and *Stations that integrated*
467 *intermodality, Application with information, Emission free buses and Quiet buses* for the case of the social
468 dimension. As a consequence, managers working on urban bus transport firms should not allocate
469 further efforts and resources to develop those practices.

470 These results guide managers in order to choose the practices that should be followed in their
471 companies in order to obtain a better sustainability performance. Additionally, the results also help
472 policy makers and governments in order to induce and incentivize companies to implement the right
473 practices to improve sustainability in the cities through urban mobility plans. Findings also reveal
474 what are the research projects that should be funded and where the research efforts should be made.

475 The present research has not been developed without limitations, particularly when focusing
476 our attention only in the European sector of bus transport. A possible extension that would enrich
477 this study would be to carry out a similar one in less-developed regions and compare results.
478 Findings will presumably lead to demand different actions and prioritization of practices. It might
479 even considerably increase the number of practices agglutinated in the preferential improvement
480 area. In addition, perceptions of different actors (users, companies, local authorities...etc.) involved
481 on sustainability in city logistics should be also contemplated in order to generate a much richer and
482 generalizable model. At the methodological level, in the case that new and closely related measures
483 had to be incorporated, it would be advisable to replace AHP with Analytic Network Process (ANP)
484 in the proposed approach.

485

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