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

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

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

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1. Introduction

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

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

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

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

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

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

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

2. Literature review

2.1. Sustainable Urban Mobility

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

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

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

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

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

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

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

2.2. Assessment of transportation policies

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

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

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

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

3. Data and methods

3.1. Research design

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

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

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

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

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

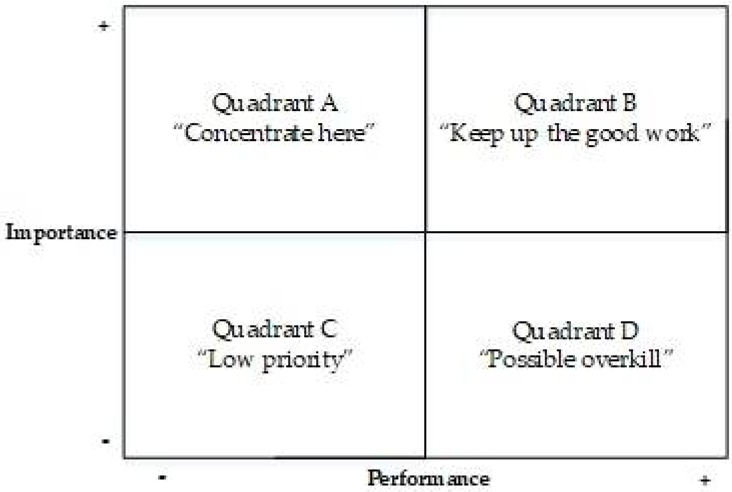

Figure 1. Two-dimensional IPA grid adapted from [27]

3.2. Research procedure

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

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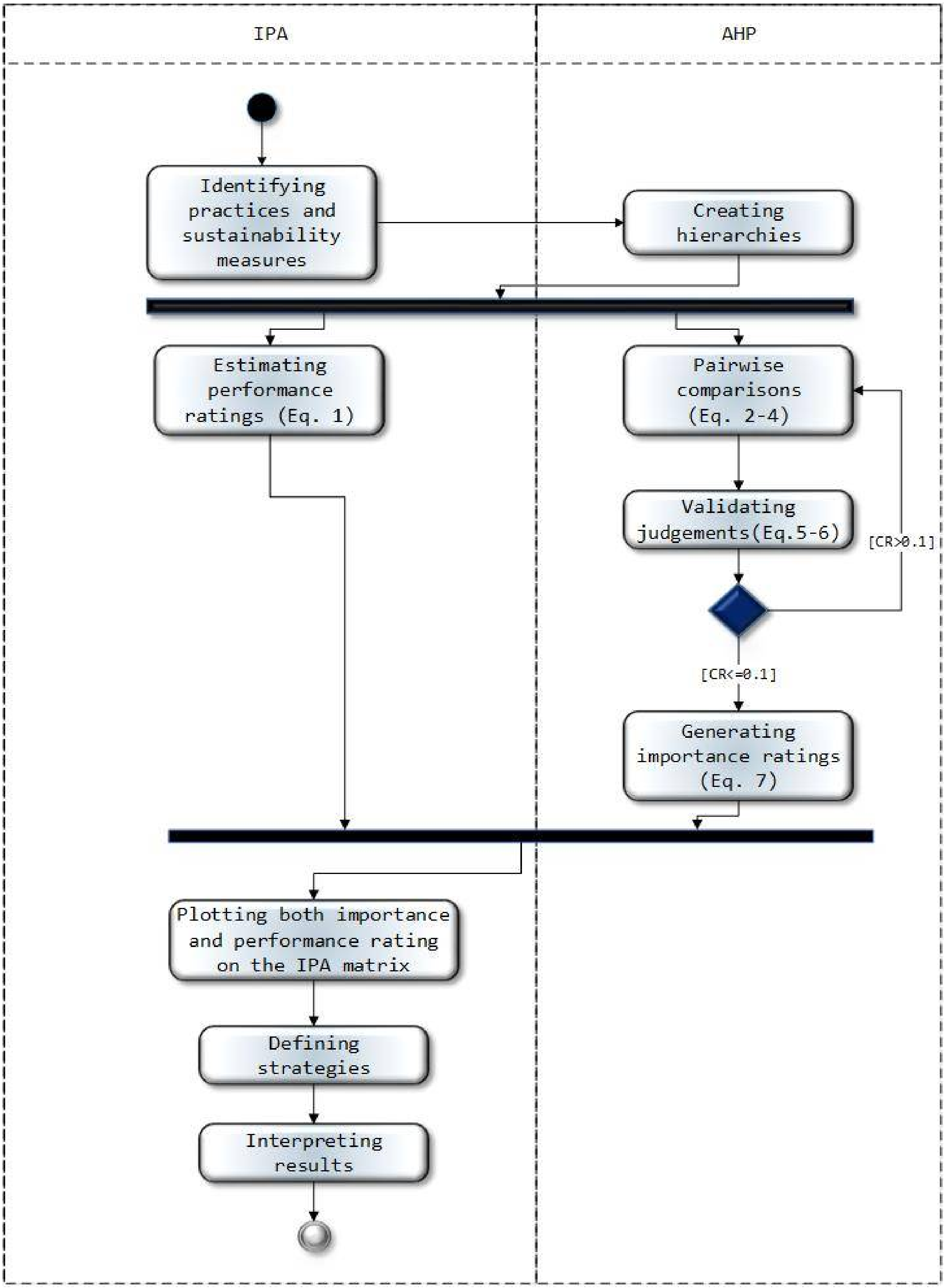

Figure 2. Step-by-step procedure.

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

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

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

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

Code	Practice	Description	Source
P1	Fully accessible buses	– Accessible for elders, disabled, tourist, children – Urban quality of life and health	CATS Project Horizon 2020
P2	Stations that integrated intermodality	– 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	– Applications-based traveler information with open access server – Improvement of customers' satisfaction – Innovative public service	TIDE Project Horizon 2020
P4	Machine for traveler information	– User friendly human machine interface (HMI) for traveler information – Improvement of customers' efficiency	TIDE Project Horizon 2020

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P5	Electric buses	– Bus powered by electricity – Deployment of clean vehicles – Sustainable urban logistics	ELIPTIC 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

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

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					

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

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

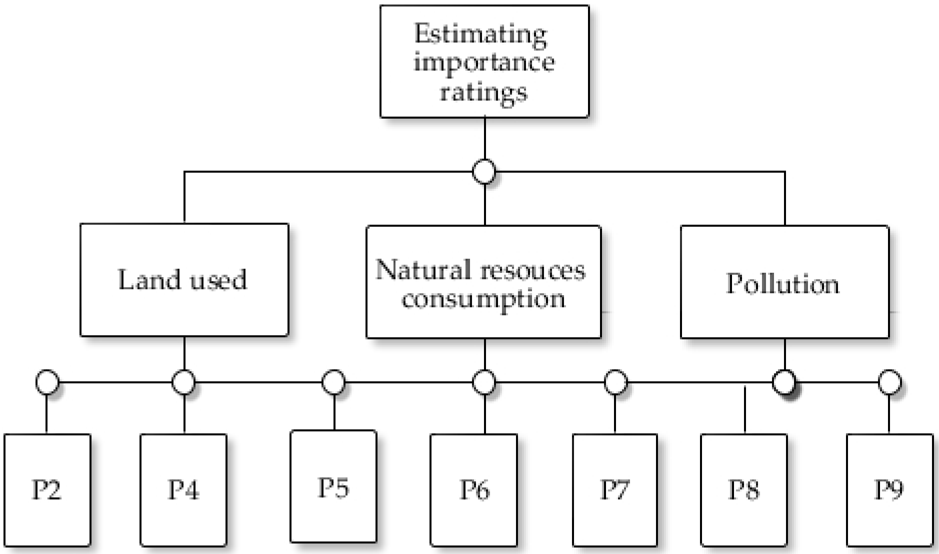

Figure 3. Hierarchical structure to environmental sustainability dimension.

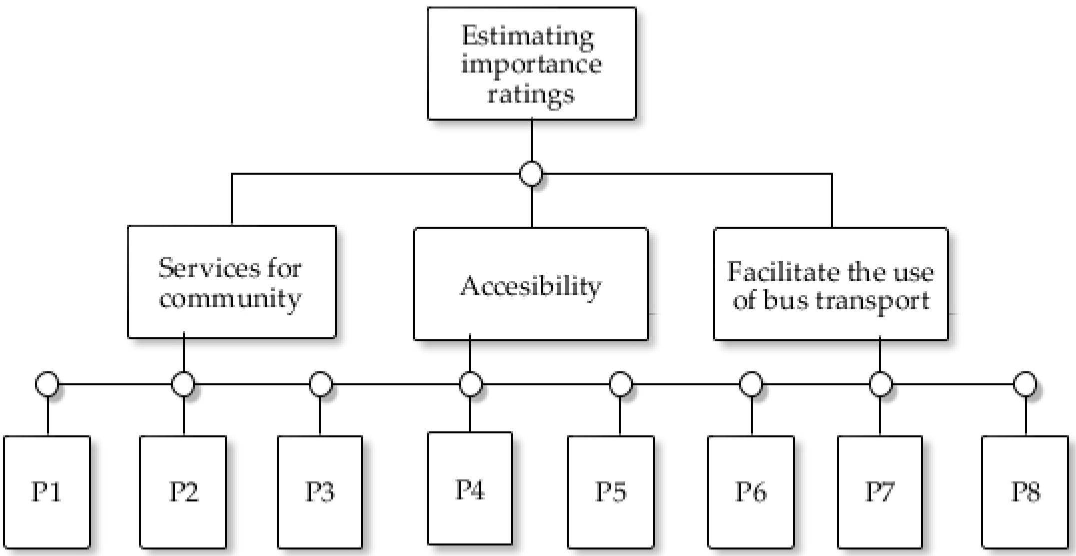

Figure 4. Hierarchical structure to social sustainability dimension.

3.2.3. STEP 3: generating performance ratings of sustainability practices

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

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

$$P_i = {\sum_{i=1}^{n} p_{ij}}/{N} \tag{1}$$

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

3.2.4. STEP 4: estimating importance ratings of sustainability practices

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

$$A = (a_{ij}),\ i, j = 1, \ldots\ldots, n \tag{2}$$

$$A = \begin{pmatrix} 1 & a_{12} & \ldots & \ldots & a_{1n} \\ 1/a_{12} & 1 & \ldots & \ldots & \ldots \\ \ldots & \ldots & 1 & a_{ij} & \ldots \\ \ldots & \ldots & a_{ji} = 1/a_{ij} & 1 & \ldots \\ 1/a_{1n} & \ldots & \ldots & \ldots & 1 \end{pmatrix} \tag{3}$$

where,

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

n is the number of compared elements in the ith level.

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

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

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

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

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

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

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

3.2.5. STEP 5: generating IPA matrices

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

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

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

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

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

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4. Results

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

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

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

4.1. Effects of practices in environmental sustainability

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

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

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

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

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

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

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

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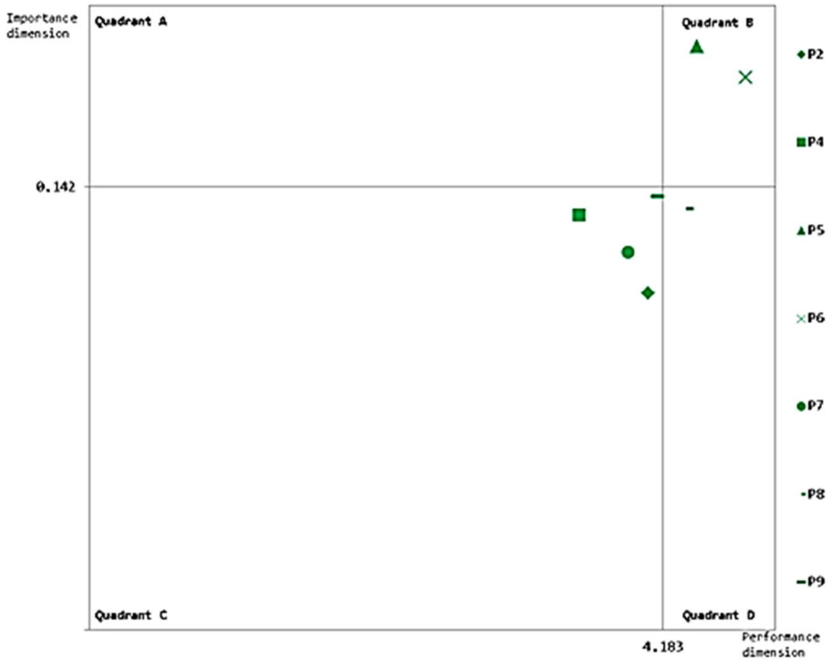

Figure 5. IPA grid to improve environmental sustainability

4.2. Effects of practices in social sustainability

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

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

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

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

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

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

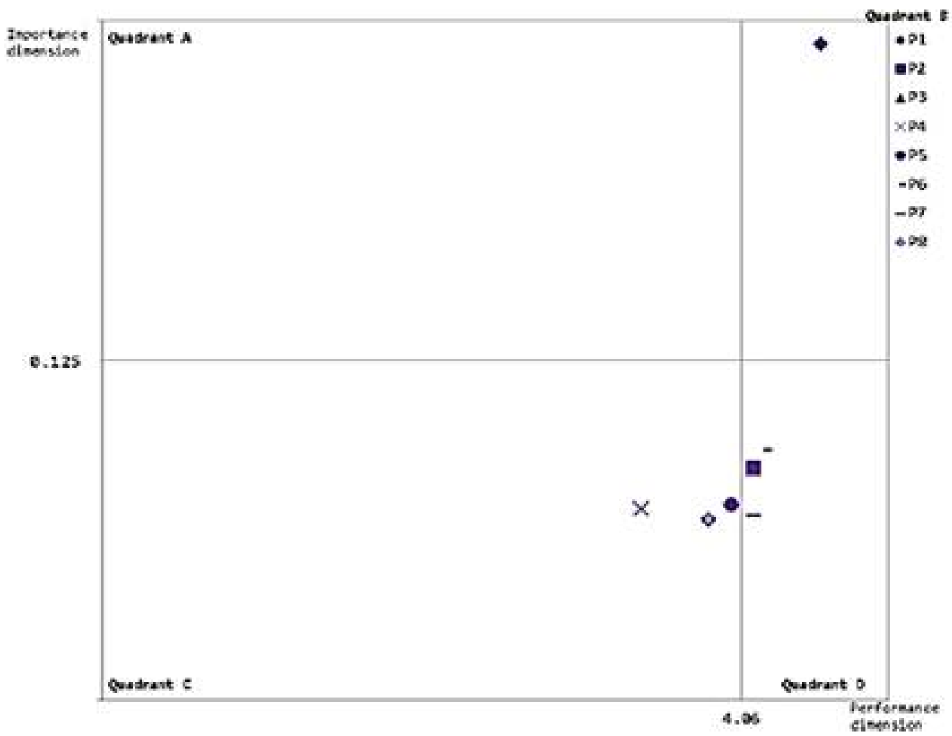

Figure 6. IPA grid to improve social sustainability

5. Conclusions

The whole globe is facing a situation of overcrowded cities and this is only getting more accentuated with time. There is an urgent need to increase cities' sustainability and not only at the environmental level. One of the main activities that is currently aggravating this situation is the transportation sector. Urban transportation worsens cities environmental and social sustainability. In order to overcome these problems, several countries all over the world have started to implement new policies and practices in urban mobility systems. In particular, the EU has financed several research projects with the aim to improve urban transportation systems. Some of those projects were focused on the improvement of the bus mobility mode and have developed the technology to generate more environmentally and socially friendly buses. Measuring how effective in the improvement of sustainability those developed measures are becomes critical as bus transportation companies normally face economical restrictions and need to choose which practices to implement in their buses fleets.

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

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

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

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