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ASSESSMENT OF SERVICE QUALITY IN PUBLIC TRANSPORT USING AN UNDERPERFORMANCE APPROACH: A CASE STUDY OF CONSTANTINE, ALGERIA

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The paper proposes a new approach to evaluating the quality of public transport based on underperformance analysis. This approach aims to identify actual service failures by combining objective data and user perceptions. In this context, the objective of this paper is to offer a more reliable evaluation tool adapted to the contexts of developing countries, where certain service deficiencies tend to be normalized. The proposed approach is applied to a real case study in Constantine public transport; a series of objective and subjective indicators are calculated on the basis of infractions provided by local authorities and user perceptions of the service. This approach thus allows for a better understanding of the sources of quality degradation and supports more effective decisions for improving public transport in order to achieve the overall objectives of sustainable mobility.

Keywords: Underperformance approach, service quality, public transport, objective score, subjective score

1. Introduction

The liberalization of public transport in Algeria, initiated in the mid-1980s, occurred against a background of declining performance and quality of service of public transport companies. Subsidies to these enterprises were increasing at a rate inconsistent with their stated objectives, a situation aggravated by the country's ongoing economic and social crisis (Amarouchene and Boulkroune, 2017). This situation, deemed unsustainable by local authorities, encouraged the emergence of a dynamic private sector composed of numerous micro-operators. While this liberalization has enhanced mobility and made transport more accessible, it remains challenging to guarantee a quality of service that meets sustainable development goals (Bakiri and Guenadez, 2022). Indeed, the performance of these operators is often determined by profitability, an inadequate criterion for evaluating public transport systems, whose objectives are inherently broader and more social than those of purely profit-driven enterprises (OECD/ITF, 2009).

Furthermore, quality of service assessments has been limited to measuring user satisfaction, the majority of studies focusing on the gap between passenger expectations and perceived experiences (Adjeroud *et al.*, 2024; Kelilba and Chaib, 2024; Mimoune and Belaidi, 2024; Zidani *et al.*, 2024; Houria and Farès, 2019). However, these efforts remain insufficient for diagnosing root causes of inefficiencies, as user satisfaction reflects the consequences of effective or ineffective quality management rather than its drivers. To genuinely diagnose and improve services, underlying factors must be analysed (Albors, 1993).

In this context, this study proposes a multidimensional evaluation of public transport service quality in Constantine through an underperformance approach. Key indicators include offenses related to operator compliance, illegal transport activities, and accidents involving public transport buses. Unlike studies that rely on complex data analyses, this work aims to analyse information in a simple and pragmatic manner. This method allows us to focus on the root causes that have the most significant impact on service quality. Thereby, research results can be methodologically, and empirically defensible. Moreover, this study contributes to the understanding of the symmetrical relationships between service quality and underperformance approach, which is rarely found in the literature on public transport service quality. In addition, it presents for the first time a case study on public transport services in Algeria by this approach. The results will enable authorities to monitor not only operational efficiency but also adherence to regulatory standards for delivering quality public transport services.

The remainder of this paper is organized as follows. In the next section, we present the underperformance methodology developed for this study, including the selection of indicators, the mathematical formulation for objective and subjective scores, and the procedure for calculating the final integrated score. Section 3 applies this methodology to the case study of Constantine's public transport system, presenting the results for each performance, along with a comparative analysis of objective and subjective perceptions. Finally, a conclusion will be given in final section.

2. Methodology

The objective of the methodology adopted in this study is to evaluate the quality of public transport service in Constantine through an approach based on underperformance. Unlike classical methods focused solely on satisfaction indicators, this approach allows for the identification of actual service malfunctions through the use of concrete data, while considering the real operational conditions of public transport in Algeria. In a first step, the underperformance indicators were selected on the basis of infractions recorded by local authorities, which are regarded as indicators of service quality deficiencies. The evaluation process was then structured into two parts: an objective part and a subjective part (Eboli and Mazzulla, 2011). The objective scores were calculated using a formula specifically developed within the framework of this research, incorporating both the frequency of infractions and their severity. In parallel, a survey was conducted among users to assess whether the selected indicators represented, according to their perception, a disturbance or a real issue. This dual evaluation enables the calculation of a final combined underperformance score, capable of highlighting situations where certain infractions are infrequent but highly disturbing to users, or they may ignore critical invisible or technical aspects that nevertheless determine the actual quality, as they are unaware of regulatory standards. Moreover, in contexts where quality has historically been poor, users tend to normalize structural flaws and consider them as inevitable, which distorts their perception. Thus, this method provides a more balanced and contextualized vision of transport service performance by integrating both measurable data and user perception (Nathanail, 2008).

This methodology aims to develop a new approach for measuring the quality of public transport services in developing countries, based on indicators that yield true and objective results regarding service quality. Indeed, the proposed methodology provides a meaningful measure of service quality because it is based on two fundamental concepts: first, underperformance measurement is equally critical as performance measurement for evaluating service quality, and second, selecting the most reliable indicators directly enhances the efficacy of service quality improvement initiatives.

The following table displays the distribution of underperformance indicators, the objective data utilized in this study are primarily based on all recorded infractions in public transport in Constantine (AFNOR, 2002). These infractions, classified according to their service aspect, were employed as quantitative indicators of underperformance. Additionally, other underperformance indicators were considered:

Table 1. Measurement underperformance indicators

Criteria	**Underperformance Indicators**
Safety and security	1.Accidentology report; 2.Lack of safety equipment in the vehicle; 3.Driving a vehicle with doors open; 4.Driving a vehicle by an unqualified person; 5. Rate of assaults or thefts in vehicles or bus stops.
Accessibility	6. Non-compliance of vehicles with standards for persons with reduced mobility; 7. Excessive distance from residential areas to the nearest public transport stop;
Reliability	8.Failure to complete the assigned route; 9.Failure to stop at designated bus stops; 10.Lane change violation; 11.Failure to adhere to transportation timetables; 12Failure to ensure the continuity of the service.
Availability	13.Unauthorized passenger transport violation; 14.Number of transport lines facing a shortage of operators.
Passenger Care	15.Wearing inappropriate clothing for the driver and assistant; 16.Misbehaving with passengers; 17.Harassment of passengers.
Comfort and cleanliness	18.Non-compliance with vehicle cleanliness regulations; 19.Illegal overloading of passengers; 20.Vehicle in poor condition.

Continuation of Table 1

Criteria	Underperformance Indicators
Information	21. Absence of passenger information systems 22.Failure to provide tickets to passengers and failure to ensure their compliance; 23.Absence of vehicle documents; 24.Failure to display the badge for the driver and the assistant.
Environmental impact	25.Diesel vehicles rate.

2.1. Mathematical formulation

2.1.1. Objective score assessment

For each identified type of infraction, an underperformance score is calculated by combining its annual frequency and its regulatory severity level as defined by current legislation. A calibrated decreasing exponential function is applied to these metrics, ensuring standardized scores within a range of 0 to –10. A score close to zero indicates an infraction that is either infrequent or minor in severity, while a strongly negative score reflects a frequent and/or severe violation. To ensure the statistical stability of this measure, the score is not based on a single year but is aggregated over several years. While this function is specifically suited to regulatory infractions, other types of underperformance indicators included in the analysis may follow different logics and cannot be evaluated through the same formulation. In such cases, adapted quantification approaches are applied to preserve consistency in interpreting service degradation.

$$O_{i,t} = -10 \times (1 - e^{-\alpha . x_{i,t}}), \quad (1)$$

$$x_{i,t} = \left(\frac{C_i}{3}\right) \times \left(\frac{P_{i,t}}{P_{t,total}}\right), \quad (2)$$

$O_{i,t}$: Objective score of the infraction *i* for the year *t*.
C_i: Severity level of the infraction *i*. According to the severity classification defined by the local regulations (first degree: 1, second degree: 2, third degree: 3).
$P_{i,t}$: Number of infractions of type *i* during year *t*.
$P_{t,total}$: Total number of all types of infractions during year *t*.

The coefficient α serves as a weighting factor in the calculation of the objective score, allowing the scale of the results to be adjusted in a way that aligns with the perception scale used in the subjective evaluation. In this study, the value $\alpha = 7$ was selected empirically after multiple trials on the available data. This value yields moderately negative scores, generally ranging from 0 to -10, which facilitates comparison and integration with the results from user surveys.

The average of the objective score for years n is calculated as follows:

$$\bar{O}_i = \frac{1}{n} \sum_{t=1}^{n} O_{i,t}. \quad (3)$$

To evaluate the temporal consistency of each objective underperformance indicator, the variance of the objective score is calculated over the observation period. This statistical measure reflects the degree of fluctuation in the annual scores of a given indicator (OECD, 2008). A low variance suggests that the indicator's level of underperformance is relatively stable across years:

$$\mathrm{Var}(e_i^{OBS}) = \frac{1}{n} \sum_{t=1}^{n} (O_{i,t} - \bar{O}_i)^2. \quad (4)$$

This metric enables the ranking of infractions based on their measured impact, thereby guiding authorities in prioritizing interventions. However, these findings must be cross-referenced with user perceptions to identify potential discrepancies between administrative data and on-the-ground experiences.

2.1.2. Subjective score assessment

The subjective measurement of underperformance relies on the evaluation of user experience through two complementary dimensions, allowing to capture both the qualitative and quantitative aspect of the impact of service gaps. This dual approach is based on the integration of user perceptions in the evaluation of the quality of transport services, while specifically adapting it to the context of operational underperformance.

The two fundamental criteria structuring the subjective assessment are:

- **Criterion 1** – Perceived Discomfort (Qualitative Dimension): This dimension measures the degree of subjective nuisance associated with each type of offence or dysfunction. It answers the

question: "To what extent is this deviation from the expected service considered problematic by the user?

- **Criterion 2** – Frequency of suffering (Quantitative dimension): This dimension captures the actual occurrence of the negative experience. It answers the question: "How often is the user concretely confronted with this non-compliance?"

For each underperformance indicator identified in Table 1, respondents successively assess the two dimensions using a standardized scorecard as shown in the following table:

Table 2. Rating grid for the subjective measurement

	Perceived Discomfort	**Frequency of suffering**
0	Not at all awkward	Never
-2	Little awkward	Rarely
-4	Moderately troublesome	Occasionally
-6	Awkward	Often
-8	Very embarrassing	Very often
-10	Extremely awkward	Always

For each indicator *i* and each respondent *j*, the individual subjective score is obtained by arithmetic mean of the two dimensions:

$$S_{i,j} = \frac{Perceived\ discomfort_{i,j} + Frequency\ of\ suffering_{i,j}}{2}. \quad (5)$$

The overall subjective score for indicator *i* is calculated as the average over the entire sample:

$$\overline{S_i} = \frac{1}{n}\sum_{j=1}^{n} S_{i,j}. \quad (6)$$

The variance of subjective scores is estimated for each indicator in order to quantify the heterogeneity of perceptions among the user group (OECD, 2008):

$$\mathrm{Var}(e_i^{PER}) = \frac{1}{n}\sum_{j=1}^{n}(S_{i,j} - \overline{S_i})^2. \quad (7)$$

2.1.3. Final score assessment

The final underperformance score represents a unified measure integrating the objective and subjective dimensions of service quality. This summary indicator aims to provide a balanced assessment that takes into account both the measurable reality of malfunctions and their perception by users. The construction of the final score is based on an optimal weighting approach that assigns a relative weight to each type of measure according to its statistical reliability (Eboli and Mazzulla, 2011). The fundamental principle is that trust in each data source should be proportional to its stability and consistency.

For each indicator *i*, the final score X_i is calculated as follows:

$$X_i = \frac{\frac{\overline{O_i}}{\mathrm{Var}(e_i^{OBS})} + \frac{\overline{S_i}}{\mathrm{Var}(e_i^{PER})}}{\frac{1}{\mathrm{Var}(e_i^{OBS})} + \frac{1}{\mathrm{Var}(e_i^{PER})}}. \quad (8)$$

The final score, on the scale from 0 to -10, allows an immediate ranking of underperformance issues:

Table 3. Final score ranking

Final Score	**Action**
-8 to -10	Critical underperformance requiring urgent intervention
-6 to -8	Significant underperformance justifying a priority action plan
-4 to -6	Moderate underperformance requiring careful monitoring
0 to -4	Acceptable or negligible underperformance

3. Application

3.1. Presentation of the study area

Constantine is a metropolis in the northeast of Algeria, and capital of the eastern region. By its economic and social potential, the city of Constantine is among the most important in the country. It covers an area of 2,297.20 km2 and has more than one million inhabitants (Medjitna, 2023).

Public transport in Constantine has undergone a notable evolution since its creation. The territory served, its organization and management methods have undergone sometimes radical transformations (Cherrad and Benmachiche, 2017). Urban transport networks are denser in the heart of the city due to the narrowness of road infrastructures, which themselves depend on a complex topography and a very constrained urban geography.

Today, public transport in the city of Constantine is essentially dominated by the private sector, composed of micro-enterprises whose buses and taxis are the means of transport most used by citizens. According to the Transport Directorate of the city of Constantine, the urban transport perimeter has 73 urban lines operated by 805 operators with a fleet of 1063 buses, 63 of which are part of the public company ETUSC. In addition, there are 2255 individual taxis and 576 urban collective taxis. However, the city recently adopted a structuring mode of transport with the commissioning of an 18.2 km tramway line, inaugurated in 2013 (Kahlouche and Chaib, 2017). This project marks the return of the State in the exploitation of this strategic sector for urban development but this initiative remains however timid after more than a decade of existence, which was not enough to stop the anarchy prevailing in the operation of urban buses.

3.2. Study case

The practical application of our underperformance assessment methodology was conducted on the Constantine bus network, chosen as a case study because of its strategic importance in urban mobility and the persistent challenges regarding its service quality.

For the objective score, a hybrid approach was adopted: initially, 17 out of 25 underperformance indicators: Lack of safety equipment in the vehicle; Driving a vehicle with doors open; Driving a vehicle by an unqualified person; Failure to complete the assigned route; Failure to stop at designated bus stops; Lane change violation; Failure to adhere to transportation timetables; Failure to ensure the continuity of the service. Unauthorized passenger transport violation; Wearing inappropriate clothing for the driver and assistant; Misbehaving with passengers; Harassment of passengers. non-compliance with vehicle cleanliness regulations; Illegal overloading of passengers; Vehicle in poor condition. Failure to provide tickets to passengers and failure to ensure their compliance; Absence of vehicle documents; Failure to display the badge for the driver and the assistant, were evaluated based on the number of infringements recorded by public authorities over the past seven years, using the objective score calculation formula detailed in the previous section. For the remaining indicators, the objective score was calculated as the direct proportion of the undesirable characteristic within the system. This ratio, naturally bounded between 0 and 1, was then converted to a score between 0 and -10 through multiplication by -10.

It should be noted that three indicators from Table 1: Rate of assaults or thefts in vehicles or bus stops; Non-compliance of vehicles with standards for persons with reduced mobility; Excessive distance from residential areas to the nearest public transport stop, were not included in the quantitative analysis due to insufficient or unreliable data, these omissions limit the scope of the assessment but do not affect the validity of the indicators that could be calculated from available data.

Regarding the subjective measurement, an in-depth survey was carried out with 348 regular users, interviewed in real-time at bus stops and onboard buses. The questionnaire structured around a dual assessment of perceived discomfort and the frequency of encountering service problems. This field application thus establishes a robust framework for calculating the final underperformance score, effectively balancing measurable data with the actual experiences of users.

3.3. Results and discussions

3.3.1. Safety and security

Safety is a fundamental aspect of the quality of public transport service (Gromule *et al.,* 2017). In our underperformance approach, safety is assessed through four specific indicators, as defined in Table.1:

The indicator of the attribute "Accidentology report' was calculated on the basis of the number of accidents involving public transport buses in which driver incompetence is the main factor of the accident. The indicator of the attribute 'Lack of safety equipment in the vehicle' was calculated on the basis of the number of violations related to the lack of all mandatory safety equipment on board buses (fire extinguisher, first aid kit, hammer breaker, etc.). The indicator of the attribute ‘‘Driving a vehicle with doors open; and driving a vehicle by an unqualified person.’’ was calculated on the basis of the number of violations recorded for these two indicators during the study period.

Table 4. Calculation of safety indicators

Criterion	Indicator	O_i	Var (obj)	Si	Var (Sub)	Xi
Safety	Accidentology report	-6.51	0.38	-7.15	1.23	-6.66
	Lack of safety equipment in the vehicle	-6.15	0.29	-4.07	1.56	-5.83
	Driving a vehicle with doors open	-3.36	0.58	-3.78	0.98	-3.52
	Driving a vehicle by an unqualified person	-2.25	1.12	-5.12	1.26	-3.60

Based on the results obtained, a convergence emerges between objective data and users' perceptions of accident rates, confirming a significant problem. However, the significant discrepancy observed regarding the lack of safety equipment, where a high objective score contrasts with a moderate perception, highlights a latent risk that is underestimated by users. Furthermore, driving by an unqualified person generates marked subjective concern, suggesting a level of mistrust that extends beyond recorded infractions, while remaining acceptable.

3.3.2. Reliability

Reliability represents one of the fundamental pillars of public transport service quality (Soza-Parra *et al.*, 2019); for this criterion, five indicators of underperformance will be measured: Failure to complete the assigned route; Failure to stop at designated bus stops; Lane change violation; Failure to adhere to transportation timetables; Failure to ensure the continuity of the service.

Table 5. Calculation of reliability indicators

Criterion	Indicator	O_i	Var (obj)	Si	Var (Sub)	Xi
Reliability	Failure to complete the assigned route	-7.8	0.35	-9.31	0.78	-8.26
	Failure to stop at designated bus stops	-8.56	0.42	-5.59	1.27	-7.87
	Lane change violation	-5.35	0.61	-4.68	1.05	-5.21
	Failure to adhere to transportation timetables	-2.63	0.28	-7.82	0.69	-4.13
	Failure to ensure the continuity of the service	-2.19	1.23	-5.15	1.34	-3.60

The reliability criterion analysis highlights several significant operational challenges. “Failure to complete the assigned route” constitutes a critical operational failure, the unanimous recognition of which by users and its confirmation by operational data reveal a persistent structural dysfunction. Furthermore, “Failure to stop at designated bus stops” represents a major concern for regulatory authorities, particularly regarding road safety and traffic flow, although this issue appears relatively downplayed in the perception of users, possibly due to a lack of awareness of the real implications. At the same time, “Failure to adhere to transportation timetables” and “Failure to ensure the continuity of the service”, while keenly felt by users, do not benefit from sufficiently reliable objective monitoring, given the limitations of existing control mechanisms.

3.3.3. Availability

The availability of public transportation is a legal obligation of the state towards its citizens (Niewczas *et al.*, 2025). This availability is defined by two concepts: spatial availability and temporal availability. A lack of legal public transportation, according to these two concepts, undermines user confidence, leading to the emergence of an alternative, illegal transportation system.

The indicator for the attribute " Unauthorized passenger transport violation;" was calculated based on the number of offenses concerning the illegal transport of persons per year. The indicator for the attribute "Number of transport lines facing a shortage of operators" was calculated based on the ratio of the number of lines experiencing insufficient service and the number of missing lines to the total number of lines within the urban transport area.

Table 6. Calculation of availability indicators

Criterion	Indicator	Oi	Var (obj)	Si	Var (Sub)	Xi
Availability	Unauthorized passenger transport violation	-9.2	0.31	-4.15	1.56	-8.46
	Number of transport lines facing a shortage of operators	-5.2	1.2	-7.85	1.39	-6.44

Analysis of the availability criterion reveals deep structural challenges in the transport system. Illegal transport appears to be a major concern for the authorities, although its perception remains muted among users who potentially see it as a substitute for an insufficient formal service, despite some users

criticizing its high fares compared to authorized transport. At the same time, the shortage of operators on certain routes poses a significant problem for service continuity, generating marked dissatisfaction among users who directly bear the brunt of this service limitation.

3.3.4. Passenger care

Passenger Care was assessed based on personnel appearance, misbehaviour with passengers, and harassment of passengers (Eboli and Mazzulla, 2011). Personnel appearance was evaluated by the number of violations related to driver and assistant attire, while misbehaviour with passengers and harassment of passengers were calculated based on passenger complaints.

Table 7. Calculation of passenger care indicators

Criterion	Indicator	Oi	Var (obj)	Si	Var (Sub)	Xi
Passenger Care	Wearing inappropriate clothing for the driver and assistant	-5.31	0.72	-5.17	1.26	-5.25
	Misbehaving with passengers	-1.58	0.23	-6.25	1.03	-2.43
	harassment of passengers	-1.15	0.92	-7.62	1.27	-3.83

Analysis of the "Passenger Care" criterion reveals remarkable consistency between objective and subjective assessments of staff appearance, as this visual aspect is directly observable and verifiable by all users. In contrast, pronounced heterogeneity characterizes the other two indicators—inappropriate behaviour and harassment—where the subjectivity of individual experiences and the absence of a formal complaint culture create a gap between lived reality and its representation in official data.

3.3.5. Comfort and cleanliness

Comfort on board buses depends on many factors; in this study, underperformance was assessed based on violations related to passenger overloading and the overall condition of the vehicle (seats, bodywork, windows, etc.). Cleanliness was also assessed based on violations related to cleanliness inside the buses.

Table 8. Calculation of comfort and cleanliness indicators

Criterion	Indicator	Oi	Var (obj)	Si	Var (Sub)	Xi
Comfort and cleanliness	Non-compliance with vehicle cleanliness regulations	-6.77	0.82	-7.21	1.52	-6.91
	Illegal overloading of passengers	-2.25	1.34	-7.24	1.02	-5.08
	Vehicle in poor condition	-5.28	0.91	-7.26	1.07	-6.02

Analysis of the "Comfort and Cleanliness" criterion highlights a discrepancy between objective measurements and user experience. While the cleanliness and overall condition of the vehicles receive average objective scores, users perceive them as being in a severely degraded state, revealing a gap between acceptable maintenance standards and passenger expectations. Furthermore, illegal overcrowding, although rarely recorded in official data due to the lack of regulations limiting the number of passengers per bus in urban areas, is a major concern from a subjective point of view.

3.3.6. Information

The quality of the information service for users was assessed by considering shortcomings related to the availability and provision of mandatory information, both on board vehicles and at stations. These shortcomings create an information asymmetry between the operator and the user, which constitutes a form of underperformance.

The indicator for the attribute "Absence of passenger information systems" was calculated as the ratio between the number of vehicles equipped with a functional onboard information system and the total number of vehicles. Furthermore, this indicator was also evaluated based on a score assigned to each stop on the line that lacked timetables and maps. The final score represents the average of these two calculations.

The indicator for the attribute " Absence of vehicle documents" was calculated based on the number of violations related to the absence of mandatory on-board documents (transportation card, insurance, vehicle control certificate). The indicator "Failure to display badge for driver and assistant" was quantified by the number of checks that noted the absence of an identification badge. The indicator " Failure to provide tickets to passengers and failure to ensure their compliance " was measured by the number of violations for not providing tickets.

Table 9. Calculation of information indicators

Criterion	Indicator	Oi	Var (obj)	Si	Var (Sub)	Xi
Information	Absence of passenger information systems	-8.23	0.66	-7.86	1.08	-8.10
	Absence of vehicle documents	-4.25	1.04	-1.14	1.02	-2.92
	Failure to display badge for driver and assistant	-4.28	0.89	-1.05	0.93	-2.70
	Failure to provide tickets to passengers and failure to ensure their compliance	-3.15	0.55	-4.18	1.19	-3.48

The absence of passenger information systems is unanimously recognized as a major deficiency, both objectively measured and subjectively perceived, highlighting the urgent need to improve access to essential information. Conversely, administrative shortcomings, such as the absence of required documents or identification badges, while objectively observed, are undervalued in the perception of users, likely due to their less visible nature and indirect impact on service quality. Ticket issuance presents a relative balance between objective measurement and perception, reflecting a tangible problem in the user-operator interaction.

3.3.7. Environmental impact

The environmental impact of underperformance service quality was assessed by considering the use of diesel vehicles. The objective score was calculated as the ratio between the number of vehicles per line using energy sources not compliant with environmental protection standards and the total number of vehicles on the line. Conversely, the subjective score was calculated based on users' sensitivity to the unpleasant scents of engine emissions.

Table 10. Calculation of environmental impact indicator

Criterion	Indicator	Oi	Var (obj)	Si	Var (Sub)	Xi
Environmental impact	Diesel vehicles rate	-9.25	0.23	-7.28	0.64	-8.73

Analysis of the environmental indicator "Diesel vehicles rate" reveals a critical underperformance with a final score of -8.73, ranking it among the most serious problems in Constantine's public transport system. Indeed, the lack of a sustainable bus transport system based on renewable energy represents a health and environmental emergency requiring a coordinated and immediate response from local and national authorities.

3.3.8. Comparison between indicators

Analysis of the average objective scores reveals shortcomings within the Constantine public transport network, with an average objective score of -5.12. Two criteria exhibit significant underperformance, with objective scores below -6.0 “Availability and environmental impact”. Considering only objective indicators as measures of underperformance, four indicators appear to be severely deficient: " Failure to stop at designated bus stops "," Unauthorized passenger transport violation ", and " Absence of passenger information systems " and "Diesel vehicles rate", which reveal serious systemic problems. Regarding the stability and consistency of these problems, there is slight variability in the objective measurements across the different indicators. The variances of the objective scores range from 0.23 to 1.34, with an average variance of 0.71. The indicators showing the most consistent objective measurements are precisely those that display the most significant underperformance, suggesting persistent service failures rather than sporadic problems.

Analysis of the average values of subjective indicators reveals that users perceive a general decline in service quality, with an average score of -5.38 indicating marked dissatisfaction across all aspects of Constantine's public transport. Five criteria are considered a significant problem by users, with subjective scores below -6.0. If we consider only subjective indicators as measures of underperformance, only one indicator can be considered critical: " Failure to complete the assigned route " is deemed very detrimental. Regarding the variability of user satisfaction, we observe some heterogeneity in judgments about perceived inconvenience; indeed, the standard deviations of satisfaction scores for service attributes vary from 0.69 to 1.58, with an average of 1.15. The indicators that elicit the most consistent judgments are those that are the most and least inconvenient for users. However, the other indicators are subject to heterogeneous judgments. Indeed, this heterogeneity is strongly influenced by the culture and personality of the users and the acceptance of certain substandard practices.

The description of the final results is carried out by graphically comparing the values of the objective and subjective indicators with the final indicator values, as shown in the following Figure 1. Analysis of

the final scores reveals four critical indicators requiring urgent intervention: illegal transport, route abandonment, the absence of passenger information systems, and the predominance of diesel vehicles. These structural deficiencies, characterized by scores below the critical threshold of -8.0, highlight systemic dysfunctions that compromise the emergence of a quality transport system.

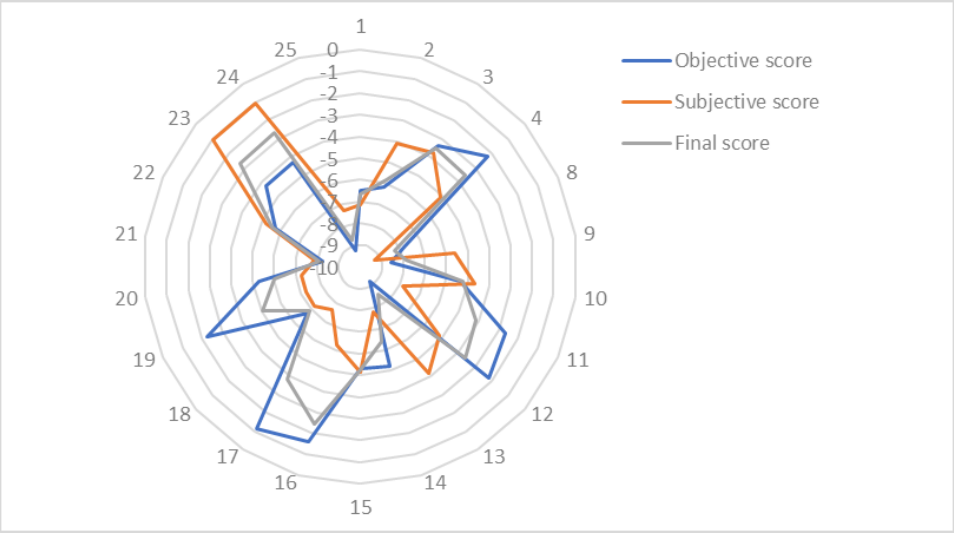

Figure 1. Comparative distribution of objective (Oi), subjective (Si) and final (Xi) scores for the 22 underperformance indicators

4. Conclusion

In this work, an assessment of service quality in liberalized public transport has been made. The objective has been to contribute to the proposal and implementation of an innovative approach to evaluating the quality of public transport services through underperformance. By integrating objective data from regulatory violations and subjective perceptions gathered from users, the developed methodology offers a nuanced and contextualized view of service failures.

The results obtained from our case study on public transport in the city of Constantine demonstrate the usefulness of this dual approach for identifying and prioritizing structural problems. They reveal not only critical objective deficiencies, notably the predominance of diesel vehicles, illegal transport, and the lack of information systems, but also highlight significant discrepancies in perception. Some serious regulatory shortcomings (safety equipment) are underestimated by users, while other subjectively intolerable malfunctions (route abandonment, overcrowding) are not fully captured by objective data.

This research contributes to the literature by providing an analytical framework adapted to liberalized transport systems in developing countries, where traditional satisfaction indicators struggle to capture the complexity of operational and regulatory issues.

For the local authorities of Constantine, the integrated final scores constitute a valuable decision-making tool for targeting the most urgent interventions and allocating resources efficiently, simultaneously impacting the reality of the service and user confidence.

Declaration of Generative AI and AI-assisted technologies in the writing process:

- During the preparation of this manuscript the author(s) used Reverso in order to assist with language translation and phrasing. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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