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A user-based approach to urban passenger transport service quality measurement

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Abstract. Within the previous decade, many cities in Russia have introduced major changes in urban passenger transportation (UPT) systems with the aim to increase service quality and make public transport more attractive. The paper develops and tests a new user-oriented approach to UPT service quality measurement. The study is based on user-oriented approaches on service quality borrowed from the marketing field. The proposed approach combines qualitative and quantitative research methods. The data for analysis were collected in May 2024 through three focus groups (21 participants) and an online survey (398 respondents). Contrary to the bulk of literature on this issue, the current study focuses on subjective preferences of the users, where 24 service quality attributes are elicited through the focus groups while their importance and individual levels of satisfaction are measured through the survey. The use of subjective characteristics allows developing a UPT service quality index that can be utilised for longitudinal analysis and comparative studies. Testing of the proposed approach for the transport system of Saint Petersburg (Russia) showed that prioritised development areas for the UPT service quality increase are waiting time and conditions, traffic safety, predictability, transfer conditions, and ride smoothness. The study contributes to the understanding and measurement of UPT service quality and provides a tool for effective decision-making in urban transport system development.

Keywords: urban passenger transport; public transportation; transport service quality; quality measurement; subjective preferences; urban development.

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Пользовательский подход к оценке качества обслуживания городским пассажирским транспортом

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Аннотация. В последнее десятилетие во многих городах России произошли значительные изменения в системе городского пассажирского транспорта (ГПТ), направленные на улучшение качества обслуживания и повышение привлекательности общественного транспорта. Статья посвящена разработке и апробации нового пользовательского подхода к оценке качества транспортного обслуживания в области ГПТ. Методологическая база представлена клиентоцентричным подходом к оценке качества обслуживания, заимствованным из маркетинга. В работе использовались качественные и количественные методы исследования. Данные были собраны в мае 2024 г. в рамках трех фокус-групп (21 участник) и онлайн-опроса (398 респондентов). В отличие от большинства трудов по данной тематике статья акцентирует внимание на субъективных предпочтениях пользователей: 24 атрибута качества обслуживания выявляются посредством фокус-групп, а их важность и уровень удовлетворенности оцениваются с помощью опроса. Применение субъективных характеристик позволяет разработать индекс качества транспортного обслуживания для ГПТ, который может быть использован для лонгитюдного анализа и компаративных исследований. Апробация предложенного подхода на примере транспортной системы г. Санкт-Петербурга показала, что приоритетными направлениями развития являются снижение времени и улучшение условий ожидания транспорта на остановке, повышение предсказуемости времени прибытия в пункт назначения с использованием ГПТ, увеличение безопасности дорожного движения, улучшение простоты пересадок и плавности хода подвижного состава. Исследование вносит вклад в понимание качества транспортного обслуживания и представляет инструмент для его измерения, который может быть полезен в процессе принятия решений о дальнейших направлениях развития городской транспортной системы.

Ключевые слова: городской пассажирский транспорт; общественный транспорт; качество транспортного обслуживания; оценка качества; мнение пользователей; городское развитие.

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INTRODUCTION

Transportation is a key sector in contemporary urban economies. Given that urban space is limited and an object for competition, the development of urban passenger transport (UPT) is justified due to its higher carrying capacity [Vuchic, 1999]. Many cities throughout the world today are UPT-oriented and aim to make it more attractive to the citizens in contrast to private automobiles thus promoting sustainable travel behaviour [Hamidi, Zhao, 2020]. Despite general understanding of policies that facilitate modal shift, the question of their relative effectiveness remains open, considering the variability of urban contexts.

In recent years, many UPT systems in Russia have undergone a set of significant changes. First, the Federal Law No. 220-FZ entered into force in 2015 stipulated the introduction of new contracting models: gross and net contracts. Second, rolling stock renewal and UPT infrastructure development were fostered by the federal project "Development of public transport"[1]. Third, a number of public-private partnership projects have been launched in different cities. Increased financing of the area in couple with new "rules of the game" suggest the need for the changes' effectiveness to be assessed.

UPT-related laws and standards of the Russian Federation generally refer to a set of operational and infrastructural indicators based on which UPT performance is monitored. Thus, the Federal Law No. 220-FZ outlines "the presence of a low floor, air conditioning, equipment for the transportation of passengers with disabilities, an electronic information board, an air temperature control system in the cabin, a cashless fare payment system, equipment for the use of gas engine fuel and other characteristics". The Decree of the RF Government No. 2086[2] delineates indicators related to time and price accessibility, information provision, working hours, traffic and ecological safety, waiting and in-vehicle comfort.

The use of objective indicators raises two questions: to what extent these indicators (1) correspond to the real needs of the UPT users and (2) can be used for comparative analysis considering the variability of urban contexts. These questions have been addressed in the marketing field where comprehensive research on service quality resulted in the development of a set of user-oriented approaches to its estimation (see, e.g. [Parasuraman, Zeithaml, Berry, 1985, 1988; Haywood-Farmer, 1988; Cronin, Taylor, 1992, 1994]).

With the establishment of consumer society, the quality of goods and services plays the key role in consumer choice [Ilyin, 2024]. UPT is a service, and despite low elasticity of demand [Kholodov et al., 2021], it can be considered as to some extent competing for users with other transportation modes. Additionally, the contemporary paradigms of new public management and good governance imply a pursuit for higher quality in the public sector [Lapuente, van de Walle, 2020; Sari, 2023]. In this regard, service quality can be considered as an integral part measuring UPT system performance [Eboli, Mazzulla, 2011]. Vice versa, UPT system performance improvements cannot imply decrease or no change of service quality.

There is no common approach to define service quality [Parasuraman, Zeithaml, Berry, 1985], but there is a general agreement in marketing field that it is related to customer satisfaction [Oliver, 2010]. Overall service quality is subject to a set of service performance attributes and, therefore, customer satisfaction with these attributes can be used to service quality measurement.

Overall satisfaction of passengers with UPT system performance is by far utilised as an effectiveness indicator in the federal project "Development of public transport" as well as in some regional programs of urban transport development. Even though it can be considered as a viable service quality indicator that allows conducting longitudinal and comparative studies, it is yet insufficient for an in-depth inquiry given that its changes are subject to a large number of factors that might cancel out each other. In this regard, user satisfaction with various attributes of UPT trips might act as a justified measure of the urban passenger transport service quality (UPTSQ). In addition, these attributes can be used as a base for service quality index development.

Numerous approaches have been proposed to measure the UPTSQ, both in Russia [Ivanova, 2016; Ayriev, Kudryashov, 2018; Kudryashov, Ayriev, Prokopenkov, 2019; Zyuzin, 2022; Andreev, 2023] and in other countries [Nathanail, 2008; Eboli, Mazzulla, 2011; de Oña, Eboli, Mazzulla, 2014; dos Santos, Lima, 2021]. However, they are based on either objective characteristics of UPT performance or on user satisfaction with a set of attributes defined by the researcher. There is also no general agreement on the list of UPTSQ attributes as the literature lists thousands of them [Karjalainen, Juhola, 2021].

This study seeks to develop a novel user-based approach to UPTSQ measurement where the latter is based on a perceived user estimation of UPT performance attributes. The current study combines a literature review and a qualitative inquiry to identify and validate a list of UPTSQ attributes and thereupon develops an index that can be used for UPTSQ estimation. In this sense, we follow the Transportation Research Board[3] that suggests eliciting UPTSQ attributes directly from users. The main scientific hypothesis of this study is that the UPTSQ can be characterised through attributes which are defined

[1] UPT rolling stock renewal and infrastructural development is fostered by the federal project "Development of public transport" dated October 28, 2021 as part of the Safe Quality Roads National Project (2019–2030).

[2] Resolution of the Government of the Russian Federation of December 8, 2023 No. 2086 "On approval of requirements to the regional standard of transport services to the population".

[3] The Transportation Research Board. (1999). TCRP Report 47: A handbook for measuring customer satisfaction and service quality. National Research Council, Washington, D.C.

and evaluated by users, thus providing a basis for assessing overall satisfaction with UPT. By identifying the most critical areas of concern, this research aims to highlight key issues for city authorities, enabling targeted improvements. The study also offers actionable recommendations to enhance the development and performance of the UPT system.

The main advantage of the proposed approach is that it allows overcoming contextual peculiarities that act as a barrier for comparative studies in terms of objective or fixed-set service quality attributes. In contrast to the approaches based on objective characteristics of the system, the current one provides grounds for policy prioritization. The approach tested using the case of Saint Petersburg allows giving non-obvious recommendations for UPT policymakers and operators.

LITERATURE REVIEW

Historically, quality was considered from the supplier side as an objective characteristic, being a function of manufacturing and production management. Later scholars adopted a customer-cantered approach, where quality is linked to fulfilment of customer needs and desires, which results in customer satisfaction and repurchase intentions [Oliver, 2010]. This view is reflected in the definition of quality provided by the International Standardization Organization: this is "ability to satisfy customers and the intended and unintended impact on relevant interested parties"[1] and the primary focus of quality management is "to meet customer requirements and to strive to exceed customer expectations"[2].

Quality of services is to a larger extent bound on customers and their expectations considering that customer resources are used as production inputs [Lovelock, 1983]. In addition, quality of services is more difficult to measure considering their heterogeneity, intangibility and inseparability of production and consumption [Parasuraman, Zeithaml, Berry, 1985]. However, numerous authors have developed approaches to service quality measurement based on a set of attributes.

In service sector, SERVQUAL is the most commonly used approach to quality measurement [Caruana, Ewing, Ramaseshan, 2000; Wider et al., 2024]. It is based on 22 attributes grouped in five dimensions: tangibles, reliability, responsiveness, assurance, and empathy. The attributes are measured two-fold via customer satisfaction surveys (CSS): their perceived performance is compared with the customer expectations. Cronin and Taylor [1992] found that the perceived performance can be sufficient to estimate service quality and developed a one-dimensional SERVPERF approach that is based solely on the perceived performance. Considering the generic character of these approaches, industry-specific adaptations were proposed for the transportation area [Randheer, AL-Motawa, Prince Vijay, 2011; de Oña, Eboli, Mazzulla, 2014; Sam, Hamidu, Daniels, 2018].

Defining the UPTSQ is more difficult considering the opposition between individual and social utility [Vuchic, 1999] that characterises public sector. There is neither a commonly accepted definition of the UPT service quality nor of its attributes. Following the bulk of marketing research, we consider the UPTSQ as the function of how the explicit and implicit needs and desires of users are satisfied. Hence, UPTSQ attributes might be viewed as the characteristics of the system that to a certain degree can satisfy user needs and desires. Prioni and Hensher [2000] state that identification and specification of attributes is a complex task. Numerous studies sought to address this issue and relied on various ways to measure the UPT service quality.

Studies differ in terms of using objective and subjective indicators to measure UPTSQ attributes. The used attributes include various indicators of UPT trip time, accessibility, convenience, comfort, reliability, customer service, and safety / security. In most studies, these attributes are operationalised thorough objective [Carter, Lomax, 1992; Vuchic, 2007; Güner, 2018], subjective [de Oña et al., 2016; Guirao, García-Pastor, López-Lambas, 2016; dos Santos, Lima, 2021], or mixed [Nathanail, 2008; Eboli, Mazzulla, 2011; Zak, 2011] sets of indicators.

Redman et al. [2013] present a systematic literature review on objective and subjective indicators used for UPTSQ measurement which they group into physical and perceived attributes. Physical attributes include reliability, frequency, speed, accessibility, price, information provision, ease of transfers, and vehicle condition which can be objectively measured without UPT users' involvement and assumptions are made about how they impact user satisfaction. Perceived attributes are subjective characteristics that cannot be objectively measured, such as comfort, safety, convenience, aesthetics.

Examples of objective indicators for trip time might include average headway measured in minutes and average speed measured in kilometres per hour. These are measured automatically or experimentally by expert groups. Subjective indicators, in contrast, imply asking users about their perception of various revelations of trip time: access, waiting, in-vehicle, and egress time and are often measured through satisfaction. For subjective analysis, the data are collected via CSS.

The Transportation Research Board proposed an alternative method that implies eliciting UPTSQ attributes from the population via focus groups and measuring their satisfaction via survey. Further researchers have also called for the use of this approach to validate the list of UPTSQ attributes [dell'Olio et al., 2010]. In addition to the satisfaction level, attributes might differ in terms of importance for the users. Thus, trip time is often considered

[1] International Organization for Standardization. (2015). Quality Management Systems – Requirements (ISO standard no. 9001:2015). P. 2.

[2] Ibid., p. 3.

as being in general more important than UPT rolling stock appearance. CSS can be used to measure both importance and satisfaction of service quality attributes.

The UPT area is complex due to the multiplicity of actors involved in service delivery. There are multiple organisational forms of UPT delivery with various degrees of state intervention, but the two main actors are the public body as the regulator and the public or private body as the operator [van de Velde, 1999; Ryzhkov, 2016]. Their interaction implies agency and justifies the need to incentivise the operator to deliver good service. In this regard, the "voice of the customer" can be used for UPTSQ estimation to monitor operator's service performance.

URBAN PASSENGER TRANSPORT: AN EVIDENCE FROM SAINT PETERSBURG

Saint Petersburg is the second largest transport hub in Russia after Moscow that has a multimodal UPT system which as of 2024 included such modes as metro (five lines and 72 stations), tram (42 lines), trolleybus (47 lines), and bus / e-bus (449). In addition, some parts of the city are covered by suburban railways and buses. In 2023, around 1.6 billion trips were made on UPT[1]. As of 2022, metro was the most popular mode that accounts for 42.2% of trips followed by bus / e-bus with 37.6% of passengers and trams / trolleybuses with 16.4%. Land rail transport is a poorly integrated mode in UPT which is proved by its low modal share – 3.8%[2].

From the organisational standpoint, multiple public and private bodies are involved in UPT service delivery. The Local Committee for Transport Infrastructure Development accounts for physical infrastructure while the Committee for Transport is responsible for route network organisation and service delivery regulation. The market of operators consists of both public (all metro, tram, and trolleybus lines as well as 103 bus lines) and private companies (346 bus lines). Suburban rail and bus networks are out of the Committee for Transport Regulation.

Since 2022, the system has undergone major changes in route network, introduction of gross contracts regulatory model, payment harmonization, large-scale rolling stock renewal, introduction of free transfers for land transport, and unified colouring for urban buses. In practice, these changes led to a withdrawal of commercial bus lines ("marshrutka"). Their main goal was to improve the UPTSQ and increase passenger transport attractiveness. Additionally, the paid parking zone in the city centre has been gradually expanded which aimed at disincentivising the use of private cars [Starshov, 2023].

On the whole, these changes encountered controversial reaction from the citizens who had to alter habitual routes. In particular, the number of bus lines in some residential areas was cut with increased occupancy rates and waiting times for remaining lines. In addition, withdrawal of long commercial bus lines led to a rise in the number of transfers which subsequently reduced UPT convenience and increased uncertainty for some users [Starshov, 2023]. Female citizens, whose routes are more complex due to higher number of household errands, faced the changes significantly less friendly than male citizens [Sokolova, Starshov, 2023].

The proposed approach allows assessing the impact of changes in the UPT system on various characteristics of service quality as considered by the users. Its application seems especially relevant given that nowadays multiple cities in Russia implement major regulatory and infrastructural changes which face the ambiguous reaction from the population.

DATA AND METHODS

The proposed approach is based on UPT service quality index (SQI) calculation that would account for user satisfaction with various UPTSQ attributes as well as their relative importance. This implies the use of focus groups to define UPTSQ attributes and a customer satisfaction survey for measuring (1) the level of the overall UPTSQ satisfaction and (2) the levels of satisfaction and importance of UPTSQ attributes.

Index development. The calculation of a composite score, SQI (service quality index) implies estimation of user satisfaction (s_i) with a set of UPTSQ attributes on a 7-point Likert scale where 1 stands for absolute dissatisfaction and 7 corresponds to absolute satisfaction. However, these attributes are not equal in terms of their importance for the users, which requires importance weights (w_i) to be introduced. Hence, the composite score is calculated as follows:

$$SQI = \sum_{i=1}^{k} w_i \frac{\sum_{j=1}^{N} s_{ij}}{N},$$

where SQI is the index value; k is the number of attributes; N is the number of respondents; w_i is the weight of the attribute i; s_{ij} is the satisfaction level of the attribute i of respondent j.

There are multiple approaches to calculate importance weights including ordinal ranking, pairwise comparison by experts, stated importance, and calculated importance. The first one is characterised by low variability, while the second method requires working with experts to obtain a consistent matrix of pairwise comparisons, which is not always possible. Stated importance is similar to measuring satisfaction, when a respondent is asked to measure importance based on a Likert scale. This approach is often used to consider its simplicity

[1] Peterburgskiy Dnevnik. (2024, February 1). In 2023, Saint Petersburg's transport travelled 572 million kilometres and transported 1.6 billion passengers. https://spbdnevnik.ru/news/2024-02-01/v-2023-godu-transport-sanktpeterburga-proehal-572-mln-kilometrov-i-perevyoz-16-mlrd-passazhirov. (in Russ.)

[2] Saint Petersburg Information and Analytical Center. (2023). Analytical Bulletin No. 3. https://iac.spb.ru/file/25.05.2022/Аналитический_вестник_№3_2023.pdf. (in Russ.)

[de Oña et al., 2016]. Yet, there are two immanent flaws of this method: (1) the tendency of the respondents to consistently overestimate attributes importance, and (2) low variability between the attributes. Weinstein [2000] proposed an alternative approach, derived importance, where attribute's importance is measured as the correlation coefficient between the overall UPT satisfaction and satisfaction with a particular attribute. Tacit character of this approach allows overcoming the attributes' importance overestimation bias.

By default, the sum of weights equals 1, which not only enhances their interpretability but also allows index value comparison in different contexts. For the proposed method it means comparability of index value among cities. This requires transformation of absolute weight values into relative weight values. Therefore, the importance weights are calculated the following way:

$$w_i = \frac{r_{o,i}}{\sum_{i=1}^{k} r_{o,i}},$$

where w_i is the relative importance weight of attribute i; k is the number of attributes; $r_{o,i}$ is the correlation coefficient between attribute i satisfaction and overall satisfaction levels.

However, the weakness of such a method consists in failure to calculate correlation when all respondents in theory assess satisfaction with a particular attribute equally given that covariance equals zero.

In addition to index value calculation, importance-satisfaction analysis was performed. Importance-satisfaction matrix is a supplementary tool for two-dimensional indexes [dos Santos, Lima, 2021]. This heuristic technique allows grouping attributes in four categories:

- high satisfaction – high importance;
- low satisfaction – high importance;
- low satisfaction – low importance;
- high satisfaction – low importance.

For such categorisation, average satisfaction and importance values among all attributes are calculated and used as reference values. Geometrically, they are represented as dividing lines between matrix quadrants.

Focus groups. To test the proposed method, three focus groups were conducted with 21 citizens of Saint Petersburg aged between 18 and 50 years. The proportion of female and male participants is close to equal. The absence of people older than 50 years is considered as a limitation of this study. The duration of focus groups was from 90 to 120 minutes.

The questions discussed included:

1) describing the feelings during the last UPT trip;

2) what makes up a good UPT trip;

3) what factors can deteriorate the UPT trip;

4) respondents' assessments of the UPTSQ in Saint Petersburg;

5) the problems respondents see in the current state of the UPT service in Saint Petersburg;

6) the difference, if any, between various UPT operators;

7) multiple follow-up questions.

In total, twenty pages of raw data with direct quotes were obtained. The content analysis of the focus groups transcripts allowed identifying 24 UPTSQ attributes, including average speed, waiting time, UPT shelters cleanliness, UPT interiors cleanliness, personnel courtesy, in-vehicle temperature, in-vehicle crowding, in-vehicle noise, rolling stock appearance, personal security, in-vehicle air quality, ride smoothness, ease of transfers, information availability, traffic safety, technical condition of the rolling stock, payment convenience, convenience of getting in and off, waiting conditions, ticket price, access time, route network, info provision at stops, and predictability.

Survey. To collect primary data on satisfaction, a CAWI[1]-survey was conducted in June 2024. The questionnaire was proliferated in the VK social network in communities of various districts and neighbourhoods of Saint Petersburg to account for geographic validity and include non-users [Beirão, Sarsfield Cabral, 2007]. In total, 415 responses were collected, of which 398 responses were submitted by respondents who currently live in the city under review.

Given that the effective sample size for the population of Saint Petersburg is 385, the collected sample is representative. 54.5% of the respondents are women while 45.5% are men, which is almost similar to the 2023 census: 2,525,455 (45.1%) of Saint Petersburg citizens are men and 3,074,589 (54.9%) are women[2]. The average age in the sample is 31.6 years for male respondents and 38.6 years for female respondents, while for the population as of 2022 it was 38.9 years for male citizens and 44.45 years for female citizens[3]. This indicated a slight age bias in terms of skewness to the younger respondents. The youngest respondent was 13 years old and the oldest was 72 years old. The sample demonstrates perfect internal reliability with Cronbach's alpha coefficient of 0.933 [Streiner, 2003].

RESULTS AND DISCUSSION

User satisfaction with UPTSQ attributes. The results of the survey demonstrate that the average overall UPTSQ satisfaction among respondents scores 4.31 out of 7.0 which is slightly higher that the average value (4.0). Table shows satisfaction and importance values for the attributes.

No attribute obtained a score close to the top (7.0) with the highest rated attribute being rolling stock appearance (4.88). Also, the respondents expressed a rela-

[1] Computer-assisted web interview.

[2] Rosstat. (2023). Population number by gender and age as of January 1, 2023. https://rosstat.gov.ru/compendium/document/13284. (in Russ.)

[3] Petrostat. (2022). The age and gender distribution of the population in St. Petersburg as of January 1, 2022. https://78.rosstat.gov.ru/storage/mediabank/14000622_Возраст-пол%20нас%20СП6%202022.pdf. (in Russ.)

Satisfaction and importance of the attributes of the urban passenger transport service quality
Показатели удовлетворенности и значимости атрибутов качества обслуживания городским пассажирским транспортом

Attributes	Satisfaction	Absolute importance	Relative importance	Attribute's composite score contribution
Average speed	4.09	0.61	0.0508	0.2076
Waiting time	3.63	0.66	0.0552	0.2002
UPT shelters cleanliness	4.05	0.43	0.0361	0.1464
UPT interiors cleanliness	4.76	0.48	0.0400	0.1903
Personnel courtesy	4.77	0.46	0.0386	0.1844
In-vehicle temperature	3.45	0.46	0.0383	0.1324
In-vehicle crowding	3.36	0.47	0.0397	0.1331
In-vehicle noise	4.03	0.43	0.0359	0.1445
Rolling stock appearance	4.88	0.45	0.0373	0.1819
Personal security	3.48	0.41	0.0343	0.1196
In-vehicle air quality	3.76	0.48	0.0401	0.1510
Ride smoothness	3.39	0.50	0.0420	0.1423
Ease of transfers	3.85	0.54	0.0450	0.1735
Information availability	4.52	0.56	0.0470	0.2121
Traffic safety	3.57	0.57	0.0476	0.1699
Technical condition of the rolling stock	4.04	0.57	0.0473	0.1912
Payment convenience	4.57	0.34	0.0281	0.1286
Convenience of getting in and off	4.67	0.51	0.0425	0.1986
Waiting conditions	3.47	0.55	0.0463	0.1609
Ticket price	3.30	0.36	0.0297	0.0980
Access time	4.56	0.51	0.0430	0.1959
Route network	4.12	0.57	0.0475	0.1953
Info provision at stops	4.12	0.50	0.0419	0.1726
Predictability	3.63	0.55	0.0458	0.1664

tively high level of satisfaction with such attributes as personnel courtesy (4.77), UPT interiors cleanliness (4.76), boarding conditions (4.67), payment convenience (4.57), access time (4.56), and information availability (4.52). On the contrary, the attributes such as ticket price (3.30), in-vehicle crowding (3.36), ride smoothness (3.39), in-vehicle temperature (3.45), and waiting conditions (3.47) occurred to cause relatively low level of satisfaction. In terms of importance, waiting time (0.66) and average speed (0.61) are on the top of the list, while payment convenience (0.34) and ticket price (0.36) are on the bottom.

Analysis of the respondents' satisfaction shows that they are more content with the attributes of rolling stock appearance and payment, which can be linked to the rolling stock renewal campaign in which new low-floor vehicles were purchased. Moreover, all the new vehicles are equipped with payment facilities that allow paying with credit cards. One of the 2022 changes was withdrawal of cash payment for land transport. Positive satisfaction score for payment conditions shows that this measure encountered little resistance from the users.

However, the technical characteristics of the new rolling stock seem to be assessed worse by the users who are less satisfied with in-vehicle temperature and ride smoothness. As of the former, it is most critical in summer when the outside temperature is high. Even though the new rolling stock is equipped with air conditioners, there are problems with their operation. One of the mentioned reasons is passengers opening windows, which decreases the conditioning effectiveness[1]. However, people tend to open windows when they are hot, so this is barely a real problem. The other two mentioned reasons are broken air conditioners and lack of incentives for the UPT operators to make the drivers switch on air conditioners considering the increase fuel consumption by 8–10%[2]. The potential solutions might include technical control for air conditioners in the summer as well as penalty for operators if air

[1] Sankt-Peterburgskie Vedomosti newspaper. (2024, June 10). Memo instead of air conditioning. SPb Vedomosti answers readers' questions. https://spbvedomosti.ru/news/gorod/pamyatka-vmesto-konditsionera-spb-vedomosti-otvechayut-na-voprosy-chitateley/. (in Russ.)

[2] Komsomolskaya Pravda. (2024, July 4). The authorities of Saint Petersburg explained why air conditioners do not work in some buses in the heat: In June, there were recorded 559 cases of non-working air conditioning in the buses of Saint Petersburg. https://news.mail.ru/society/61801665/. (in Russ.)

conditioning is off. Application of the proposed approach for measuring the UPTSQ by operator might serve as a control indicator for this and other attributes.

Another problem with the new rolling stock is severe braking and acceleration that was mentioned as early as few months after introducing changes in 2022 and attributed to particular bus models[1]. The results suggest that this problem has not been solved until now. It requires in-depth research to estimate the scope of the problem and develop solutions. Yet, such commonly accepted measures as organisation of UPT movement priority, special smooth ride trainings for bus drivers as well as better technical maintenance can be considered.

Traffic safety in general occurred to be one of major considerations of the respondents. Such a result does not correspond to the introduction of gross contract system that does not give incentives to the operators and drivers to compete for users. One possible explanation might be two largely covered by the media fatal traffic incidents with UPT vehicles in spring 2024 when a new tram with faulty brakes crushed into pedestrians[2] and when a new bus fell in the river due to the driver's health issues[3].

The majority of users are satisfied with general information availability, which can be attributed to mapping platforms that show actual UPT lines and are instrumental in building routes directly to the destination considering access / egress and waiting time as well as transfers. In addition, in recent years *Organizator perevozok* subsidiary has substantially improved information provision at its web page as well as in social network community and launched a Telegram bot that notifies passengers about temporary changes and disruptions in the route network. However, the users expressed less satisfaction with information at the stops despite new information posters installed. The result might be due to only partial presence of the new posters and the absence of the relevant details considering route changes / disruptions. The previous research[4] has found the positive perception of electronic displays providing the latest information as well as their beneficial effect on waiting time perception by the users. The potential solutions might include installation of electronic displays as well as introduction of traditional paper announcements about planned route changes at the stops considering that not all UPT users rely on web services.

Relatively positive assessment of personnel courtesy might be associated with good training of new controllers who occasionally visit UPT in contrast to old controllers who were adjacent to a particular vehicle. Access time was also assessed positively, which indicates a fairly good allocation of the stops as well as successful new stops introduction after commercial bus lines removal given that the latter allowed stopping at any place of the line where boarding is legal according to the traffic rules.

Average speed obtained an average score, which indicates that it is generally seen as satisfactory and that introduction of new contracting model did not affect user perception of the trip time too much. Otherwise, this attribute would obtain a lower score. On the contrary, a lower satisfaction level with transfers signifies that the citizens negatively perceive increased transfer burden due to long commercial bus lines removal. Trips with transfers are always perceived worse than direct trips. However, they are impossible to envisage considering the complexity of routes in a large city. Common measures include introduction of trunk-feeder network[5] and transfer nodes between trunk lines [Batty, Palacin, González-Gil, 2015]. The point is to reduce walking distance and waiting time. In terms of Saint Petersburg, the metro system as well as some tram, bus, and trolleybus lines can be viewed as trunk routes. In some lands, UPT stops are allocated considerably far from metro stations or from the stops of crossing lines. The city might opt for infrastructural changes to allocate them closer. However, such measure is rather time- and resource-consuming.

The commercial bus lines removal might have also negatively affected satisfaction with waiting time given that in some residential areas the number of the UPT lines has been substantially reduced. Furthermore, under the gross contract model the operators have no economic stimuli to provide more frequent services in rush hours, which might have led to poor perception of crowding conditions in spite of the larger size of the new buses. In some cases, both problems originate in schedule disruptions due to traffic congestions. In addition to a generally better adjustment of the timetable and the fleet size to the demand, provision of traffic priority through dedicated lines and smart lights might be recommended. This will also have a better effect on arrival time predictability which is now perceived relatively poor.

Many respondents express their dissatisfaction with personal security which can be subject to the shift from adjacent controllers to occasionally visiting controllers. This left the users with no authoritative person in the vehicle (except for the driver who is isolated in the cabin and

[1] Sankt Peterburgskie Vedomosti. (2022, August 1). It shakes and pushes. Why do the new buses cause complaints from Saint Petersburg citizens? https://spbvedomosti.ru/news/gorod/tryaset-i-tolkaet-pochemu-novye-avtobusy-vyzyvayut-narekaniya-u-peterburzhtsev/. (in Russ.)

[2] RIA Novosti. (2024, April 12). Pedestrians in Saint Petersburg were hit by an AI-equipped tram. https://ria.ru/20240412/tramvay-1939687052.html. (in Russ.)

[3] Delovoy Peterburg. (2024, May 15). System faults remained: The tragedy on the Moika river exposed the old problems of carriers. https://www.dp.ru/a/2024/05/15/ostalis-mednie-trubi-tragedija. (in Russ.)

[4] National Academies of Sciences, Engineering, and Medicine. (2013). Transit Capacity and Quality of Service Manual, Third Edition. Washington, DC: The National Academies Press, 685 p. https://doi.org/10.17226/24766.

[5] Trunk lines are long lines that are used for transferring to the central business district while feeder lines are used mainly to transfer to trunk lines or travel within the living district.

sometimes might not see or have little interest towards what is happening in the passenger compartment) who watched for the appropriate behaviour of the users. Considering higher cost-efficiency of the new type of controllers, panic buttons might act as an innovative solution that allows informing the driver about offenses in the vehicle [Batty, Palacin, González-Gil, 2015].

Trip cost obtained the lowest satisfaction score, which is in-vein with dos Santos and Lima [2021], who found that fare cost and integration were perceived poorly relative to other UPT characteristics. Such a result might be explained by the fact that fare is the direct monetary expenses of the users which are always perceived negatively. In addition, UPT ticket prices have more than doubled within the previous decade by a yearly increase. Finally, there is still a lack of complete fare integration between the metro, the rail, and other transportation modes.

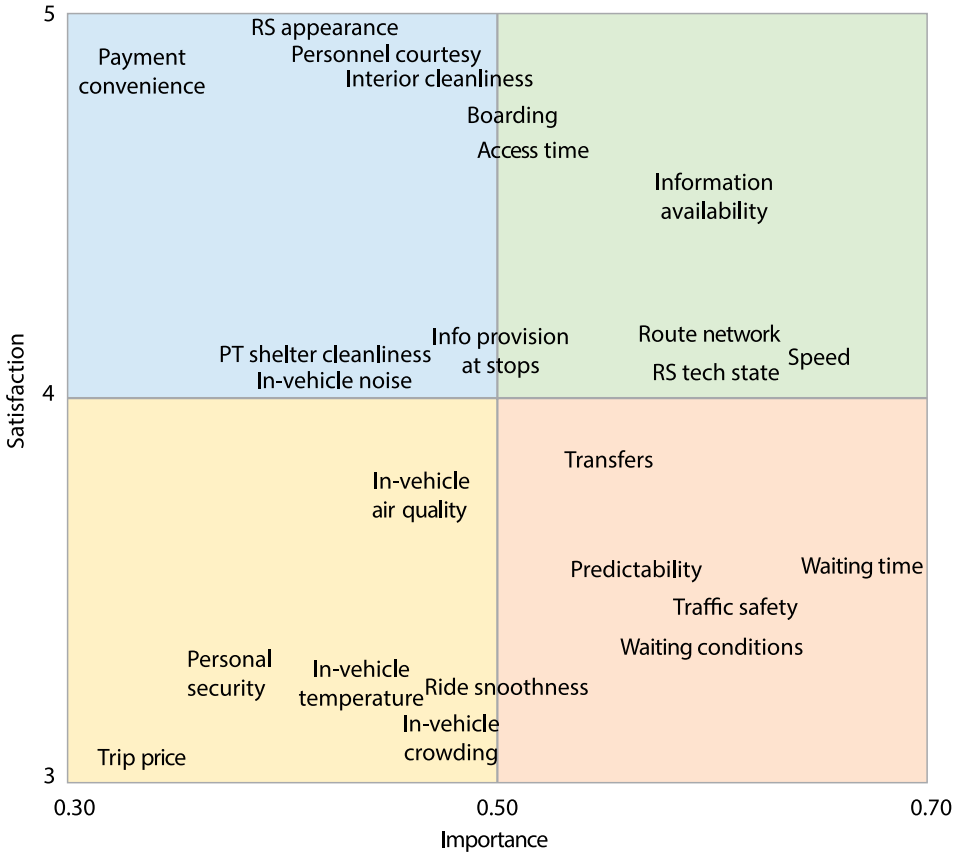
Index value. The SQI value based on the formulae presented above is 3.996 out of 7.0 points maximum. This number does not say much *per se* except for the fact that the UPTSQ in Saint Petersburg is very close to the arithmetic mean (4.0). However, the proposed approach will be considerably more insightful in longitudinal and comparative studies where the UPTSQ is compared across time in one or multiple cities. This not only provides the basis for best practices analysis but also allows assessing the effect of changes in the UPT system on the overall UPTSQ and the satisfaction with its attributes.

Importance-satisfaction analysis. Figure presents the importance-satisfaction matrix. The average attributes satisfaction level occurred to be very close to 4.0 while the average attributes importance level was close to 0.50. Hence, these values have been taken for quadrants delineation.

Six attributes that occurred to lie in the upper-right quadrant (high importance – high satisfaction) include information availability, average speed, route network, rolling stock technical state, boarding conditions, and access time. These are UPT characteristics that require analysis of measures that have proven to increase their quality in recent years and their extrapolation to the entire system. For example, organisation of high boarding platforms at some tram and bus / e-bus / trolleybus stops improved boarding conditions.

The upper-left quadrant (low importance – high satisfaction) lists seven attributes, such as rolling stock appearance, personnel courtesy, interior cleanliness, payment convenience, info provision at stops, waiting shelters cleanliness, and in-vehicle noise. These are attributes for which solutions of the previous years have proven to be successful as well. However, considering their lower relative importance, attention and resources of policy makers can be drawn to the lower-right quadrant.

Five attributes in the lower-left quadrant (low importance – low satisfaction) include in-vehicle air quality, personal security, in-vehicle temperature, in-vehicle crowd-



UPTSQ attributes importance-satisfaction matrix

Матрица «важность – удовлетворенность атрибутами качества транспортного обслуживания»

ing, and trip price. These are attributes with which the users are generally dissatisfied but which are not much important and do not highly affect service quality. Allocation of extra resources to improve them is justified when pending problems with the attributes in the lower-right quadrant are resolved.

The lower-right quadrant (low importance – low satisfaction) presents the highest interests considering that it encompasses six attributes deteriorating the most UPTSQ. These are transfers, arrival predictability, waiting time, traffic safety, waiting conditions, and ride smoothness. Importance-satisfaction analysis shows that these attributes should be among the priorities for further UPT system development. This requires extra resources that can be taken from policies directed at trip characteristics corresponding to attributes on the upper-left quadrant. For example, if a decision-maker faces a choice between investing more resources in new payment facilities or safe driving trainings for drivers, the choice should be in favour of the latter. As stated above, the proposed approach allows studying effectiveness of the changes in the UPT. In particular, the regulator can establish target indicators for attributes in the lower-right quadrant.

CONCLUSION

This study looks at the development and testing of a managerial tool for decision-making in the UPT area. The authors have proposed an approach to measure the UPTSQ based on subjective preferences of the users. This is an alternative approach to objective performance indicators that do not provide ground for measures prioritisation.

The UPT is a complex service that implies involvement of multiple bodies which naturally creates information asymmetry and gaps in service provision. Despite the fact that performance-oriented logic is preeminent as the main goal of the UPT is to provide transfer from origin to destination, it can be considered as a public space, where people spend considerable amount of their daily time. In this regard, other factors (comfort, safety) gain importance.

This is especially relevant due to the increased number of alternatives to UPT trips – taxi services, private cars, and active mobility. Facing the problem of traffic congestion and other externalities of increased motorisation, authorities in many cities strive to reduce the use of private cars by introducing paid parking, car-free-zones and narrowing roadways. UPTSQ improvement, among other things, decreases switching costs for car users.

The proposed approach includes UPTSQ attributes validation via focus groups and measurement of their importance and satisfaction. Based on that, a service quality index is developed that can be used for longitudinal and comparative analysis to identify good practices and assess the effect of changes on the overall service quality and user satisfaction with the particular attributes. In addition, importance-satisfaction analysis can be used for policy prioritisation.

The presented approach tested in the context of Saint Petersburg helped identify the UPTSQ attributes with relatively high and low levels of satisfaction and importance. The results were discussed with respect to changes of the recent years. It was found that the users in Saint Petersburg are most satisfied with rolling stock appearance, personnel courtesy and the interiors cleanliness, while ticket price, in-vehicle crowding, and ride smoothness are the major sources of discontent. For each problematic attribute potential solutions were provided. They were then prioritised based on the importance-satisfaction matrix.

To sum up, UPTSQ measurement might be a helpful supportive managerial tool for UPT system development. Future studies could apply this approach in other contexts and share their findings. ■

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