information

MDPI

Article

The Expectations of the Residents of Szczecin in the Field of Telematics Solutions after the Launch of the Szczecin Metropolitan Railway

Agnieszka Barczak

Faculty of Economics, West Pomeranian University of Technology in Szczecin, ul. Janickiego 31, 71-270 Szczecin, Poland; agnieszka-barczak@zut.edu.pl

Abstract: Transport is integral to every city, having a crucial impact on its functioning and development. As road infrastructure does not keep up to speed with the constantly growing numbers of vehicles on roads, new solutions are required. Fast urban railway systems are a solution that can reduce transport congestion, with environmental protection issues also taken into account. Contemporary public transport cannot function without modern communication and information technologies. The use of telematics in public transport allows passenger mobility to be sustainable and efficient. Therefore, it seems justified to conduct research on this issue. The aim of the study is to analyze the perception of the use of telematics solutions to service SKM in Szczecin (Poland) with the use of multivariate correspondence analysis. Results of the research indicate that people living in the area of gravity of the SKM have a positive opinion on the application of telematics solutions in the activities of the Szczecin Metropolitan Railway. The results obtained are local in nature, but show the direction that researchers can take in analyzing public transport in other agglomerations. In addition, the article presents a tool that greatly facilitates the analysis of survey data, even with a large number of results.

Keywords: agglomeration railway; city transport; multivariate correspondence analysis; telematics; ward's method

Citation: Barczak, A. The Expectations of the Residents of Szczecin in the Field of Telematics Solutions after the Launch of the Szczecin Metropolitan Railway. *Information* **2021**, *12*, 339. https://doi.org/10.3390/info12080339

Academic Editors: Antonio Comi and Joaquim Ferreira

Received: 6 July 2021
Accepted: 20 August 2021
Published: 23 August 2021

1. Introduction

Intensive urbanization, development of the automotive industry, and easier car availability result in increasing persons' mobility. City dwellers, apart from daily commuting to work and education, use cars also in their free time. They make use of services, entertainment, and recreation, but also of health care services and meet with friends. This results in an increase in the number of cars on the road and, as a result, an increase in environmental pollution as well as the problem of transport congestion.

Therefore, many cities have been promoting a sustainable urban transport system [1–4]. This means, for instance, that urban transport should be based on public transport [1,5], and that properly designed transport systems should meet the requirements for human mobility, as well as ensure transport safety. Transport accessibility is also a very important issue, considered to be one of the most important determinants of sustainable development of cities and agglomerations [6–8]. The agglomeration railroad is a solution that combines all these aspects. As Faron rightly notes, "the most effective, indeed only, means of transport is rail, which, in the form of the agglomeration railway network, can use the existing infrastructure to provide quick access to chosen destinations" [9] (p. 42).

However, it ought to be emphasized that the agglomeration railroad cannot function separately from the other means of urban transport (buses and streetcars). It is necessary to integrate the whole city transport system, which seems to be impossible to achieve unless telematic solutions are applied as the use of information technologies supports effective management [10]. "Transport telematics is currently emerging technological solution as part of sustainable transport system and connects many of vehicle structures with remotely connected communication devices and is ensuring smart mobility" [11] (p. 17).

The concept of telematics is identified with intelligent transport systems (ITS) and can be defined as the effective management of traffic and logistics through the application of transport management techniques in the supervision and management of street, road and highway traffic capacity [12–14].

Technical telematics solutions use electronic communication systems that carry information. These systems include wide area network (WAN) and local area network (LAN), radio beacons, satellite systems, data collection systems (sensors, video cameras, radars, etc.), as well as systems presenting information to administrators (e.g., GIS) and users (variable message signs, traffic lights, radio, WAP, WWW, SMS) [15]. The operation of telematics systems in rail transport is shown in Figure 1 [16].

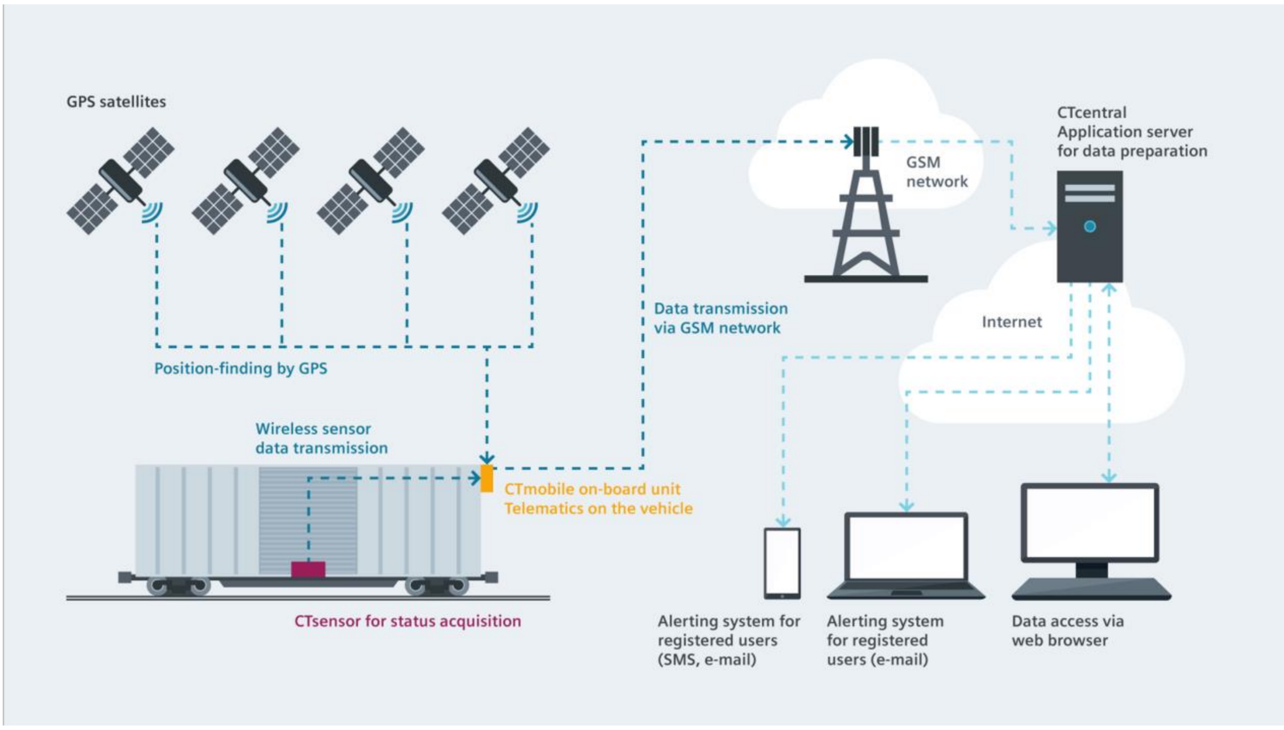

Figure 1. Telematics system in rail transport.

The inhabitants of the Szczecin agglomeration had the opportunity to check how selected telematics systems in public transport in Szczecin worked before, hence there was no problem with the assessment of the proposed solutions. These include electronic information boards showing the number of the tram or bus lines, the course direction, and the waiting time for arrival (Figure 2 [17]). Where there are no electronic boards, passengers can use the virtual timetable by scanning the QR code (Figure 3 [18]).

In addition to the above-mentioned, the following telematics solutions are used in Szczecin:

- collecting public transport tolls—mobile applications,
- traffic control (coordination of traffic lights at selected intersections and routes),
- video monitoring,
- automatic registration of traffic violations at selected points,
- information management for drivers—variable message information boards (Figure 4 [19] i Figure 5 [20]),
- automatic toll collection for trucks.

Figure 2. Information board.

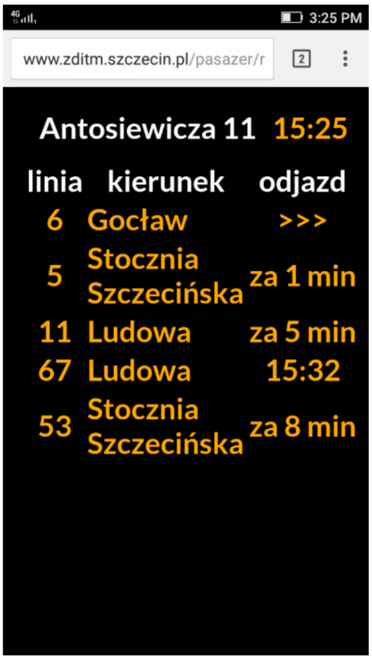

Figure 3. Virtual timetable.

The broadest interest of telematics, among others, i.e., medical telematics, environmental telematics, is transport. There are many publications about the use of telematics solutions in road transport [21,22]. Topolska and Bujak [23] wrote about the use of telematics in passenger transport in relation to agglomeration railroads. In their opinion, the co-ordination of urban railroads should cover areas such as technical solutions (organization of transfers which enable passengers to change the means of transport safely and efficiently), care for visual information systems to facilitate the transfer, and organizational solutions (co-ordination of routes, timetables in order to match their timing and maximize passenger comfort) [23].

Figure 4. A variable message board.

Figure 5. A variable message board.

Telematics in urban transport may be approached from two perspectives: that of the transport organizer or that of the transport users. This paper focuses on the latter.

Therefore, it was decided to analyze how the residents of the Szczecin Metropolitan Area (SMA) perceive the use of telematics solutions in connection with the launch of the Szczecin Metropolitan Railway (Szczecińska Kolej Metropolitalna, or SKM). SKM will consist of four lines constructed using existing railway infrastructure within the Szczecin

Metropolitan Area (SMA). The construction works on the linear and point assets of the SKM are ongoing and will be concluded in 2022. Therefore, it was hypothesized that SKM passengers' perceptions of the use of telematics solutions depend on their age, education level, frequency of public transport travel, and purpose of travel.

English-language information on SKM may be found in a few papers by Polish researchers, but those are mainly theoretical analyses [24,25]. Researchers analyze the operation of agglomeration railroads also in other locations [9,26–28]. Therefore, this work will complement the existing research. The public transport operation in the SMA and the exact conceptual assumptions and SKM catchment areas are presented in the study by Barczak [29]. This study is an extension of that publication and deals with a fragment of research related to the use of telematics solutions.

2. Materials and Methods

In order to verify assumption, a standardized interview was carried out on a sample group of residents living within the SKM catchment area. Since the survey was also intended to reach the elderly, who often do not use the Internet, personal interviews were planned. The interviews were conducted without the participation of third parties, directly, anonymously, from 12 April to 25 May 2021. To make the group more diverse, the study was conducted at different times and in different locations. Interviews were conducted on a group of 400 respondents. It is therefore appropriate to note that the representative sample of agglomeration residents comprises 384 persons.

The first stage of the study is a brief analysis of the characteristics of the respondents. This will be helpful later in the article—during the analysis of the obtained results.

As mentioned earlier, 400 persons participated in the survey. The most numerous group of respondents is between 41 and 50 years old—130 persons, while the least numerous is the group up to 15 years of age—19 persons (Figure 6).

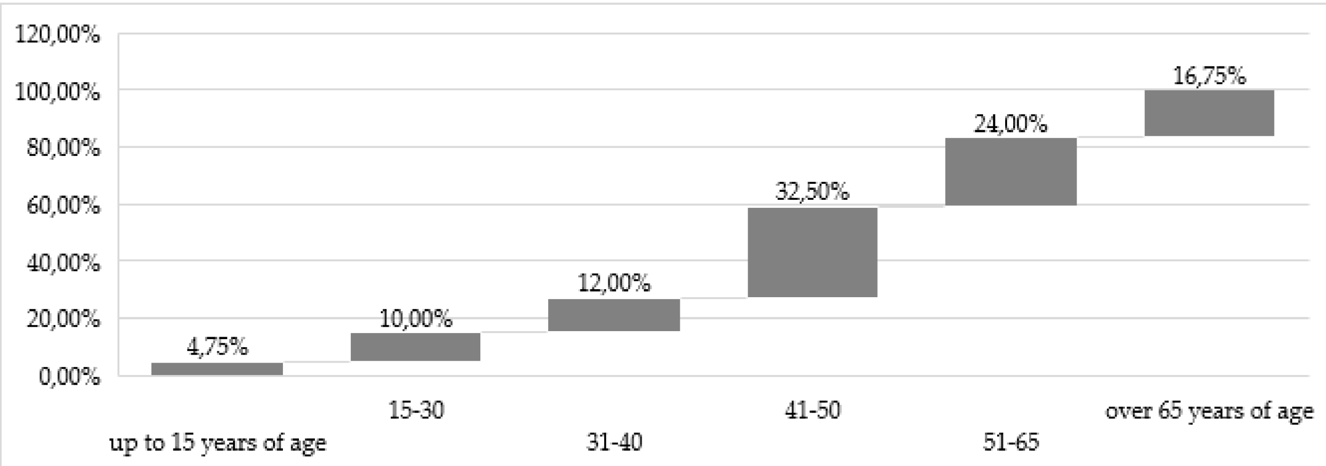

Figure 6. Age structure.

Most of the respondents have higher education—155 persons, and secondary education—152 persons. The least numerous is the group of persons with primary education—32 respondents. They are mainly under 15 years old (Figure 7).

The respondents most often use public transport 5 times a week or more—322 persons. The categories "rarely" and "not at all" were ticked by 16 persons, and the category "once a week" was ticked by 14 persons (Figure 8).

More than half of the respondents use public transport to get to their workplace—217 persons. The least frequent use of public transport is for sport activities—28 persons (Figure 9).

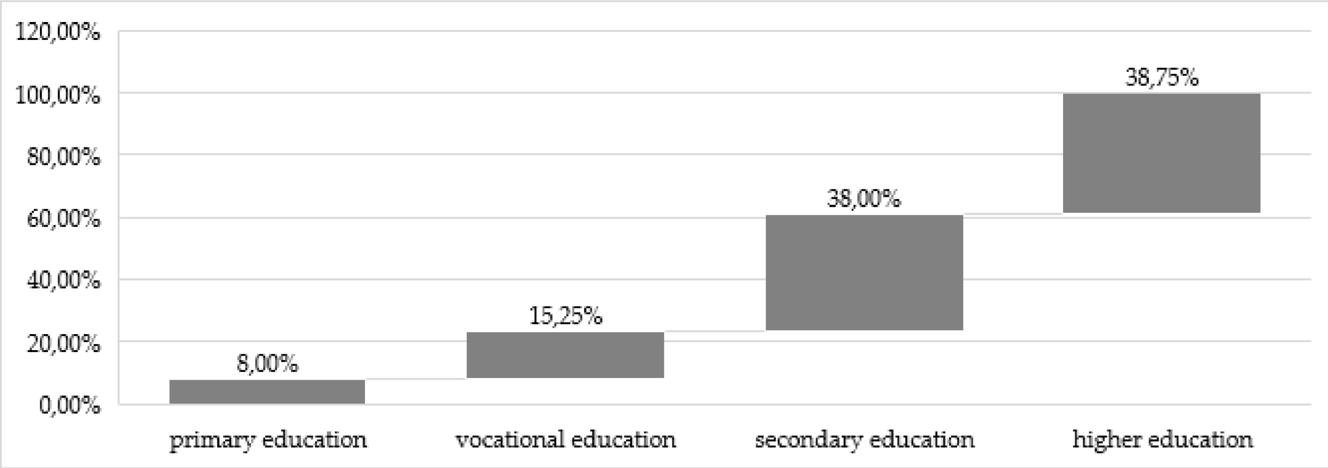

Figure 7. Education.

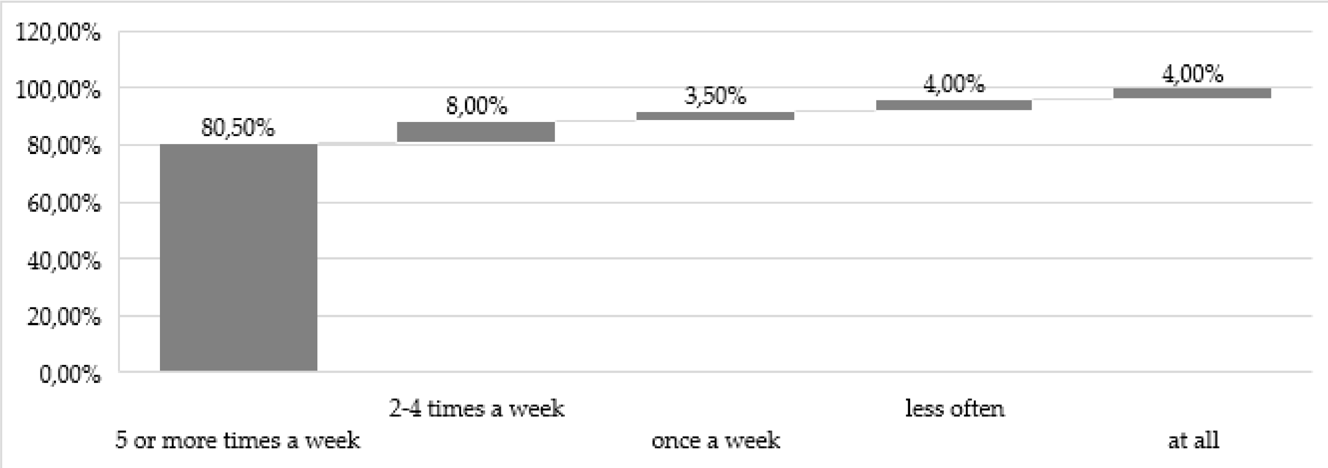

Figure 8. Frequency of using public transport.

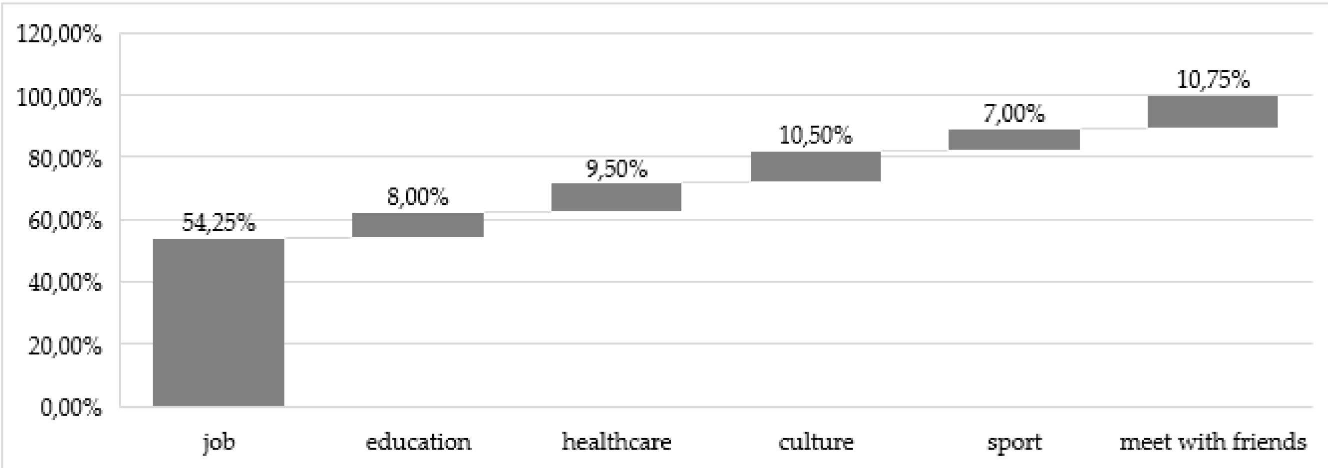

Figure 9. The most common destination.

In order to verify the research hypothesis, multivariate correspondence analysis, which uses qualitative data and examines the structure of associations between categories of variables, was applied. This method is widely described in the literature [30–36], therefore the publication is limited to presenting its basic assumptions.

The correspondence analysis procedure begins with the transformation of the contingency table into a correspondence matrix (matrix of relative numbers). Then, row and column profiles, row and column weights, and distances between rows and columns are calculated using the χ^2 metric. Next, it is necessary to find an n-dimensional (usually two- or three-dimensional) space that best represents the points under consideration. The resulting configuration is rotated to maximize the variance explained by each dimension of this space.

The row profile matrix is determined by dividing each relative abundance in a row of the correspondence matrix by the sum of all frequencies in the corresponding row. The column profile matrix is created in the same way. In a further step, the distances between rows and columns are calculated using the χ^2 metric. For rows, from the following formula (the formulas are from the study [36]):

$$\chi^2 = d^2(h,\ h') = \sum_j \frac{\left(p_{hj}\ /\ p_{h\circ} - p_{h'j}\ /\ p_{h'\circ}\right)^2}{p_{\circ j}} \tag{1}$$

where:
$d^2(h,\ h')$—the distance χ^2 between the h-th and h'-th row;
$p_{hj}\ /\ p_{h\circ}$—row profile elements;
$p_{\circ j}$—average row profile elements;
$h, h' = 1, \ldots, H$;
while for columns from the following formula:

$$\chi^2 = d^2(j,\ j') = \sum_j \frac{\left(p_{hj}\ /\ p_{\circ j} - p_{hj'}\ /\ p_{\circ j'}\right)^2}{p_{h\circ}} \tag{2}$$

where:
$d^2(j,\ j')$—the distance χ^2 between the j-th and j'-th column;
$p_{hj}\ /\ p_{\circ j}$—column profile elements;
$p_{h\circ}$—average column profile elements;
$j, j' = 1, \ldots, J$;

The inertia, which acts as a measure of variance in correspondence analysis, is determined in turn. Total inertia is a measure of the degree of dispersion of profiles around their respective centroids. It is defined as the weighted average of the χ^2 distances between row and column profiles and the corresponding average profiles. For rows, it is determined from the following formula:

$$\wedge_h^2 = \sum_h r_h d_h^2 \tag{3}$$

where:
d_h^2—the distance χ^2 between row and centroid;
r_h—row weight (the sum of the frequencies in the row of the correspondence matrix);
and for columns from the following formula:

$$\wedge_j^2 = \sum_j c_j d_j^2 \tag{4}$$

where:
d_j^2—the distance χ^2 between column and centroid;
c_j—column weight;

In order to analyze the relationships between a larger number of variables, it is necessary to use multivariate correspondence analysis. In this method, the classical two-dimensional contingency table is replaced by a Burt matrix.

A Burt matrix is based on a complex marker matrix (combination of multiple sub-matrices corresponding to consecutive variables). The complex marker matrix $\boldsymbol{Z}$ has the following form:

$$\boldsymbol{Z} = [\boldsymbol{Z_1}\ \ \boldsymbol{Z_2}\ \ldots\ \boldsymbol{Z_Q}] \tag{5}$$

where:
$\boldsymbol{Z_1}\ \boldsymbol{Z_2}\ \ldots\ \boldsymbol{Z_Q}$—the matrices of markers of consecutive variables;
Q—quantity of variables;
A Burt matrix $\boldsymbol{B}$ is determined from the following formula:

$$\boldsymbol{B} = \boldsymbol{Z^T Z} \tag{6}$$

The resulting matrix is a symmetric block matrix. On its main diagonal are diagonal matrices that show the number of occurrences of each variable's category. Off the main diagonal are the contingency tables for each pair of variables.

As the graph obtained with the use of multivariate correspondence analysis is not always fully legible, the method used was supplemented with a cluster analysis—the agglomeration method of Ward. Ward's method has been thoroughly described in many publications (e.g., [37–40]).

The Ward method can be presented in a few steps (based on [40], patterns come from the same source):

1. Normalization—it is applied usually because of the possible scale differences among the questions (j):

$$m_{k,\ j} = \frac{x_{k,\ j} - x_{mn,\ j}}{s} \tag{7}$$

where:
$x_{k\ j}$—answer value (x) of the questions (j) concerning the users (k),
x_{mj}—mean of the answers (mn) regarding a question (j),
s_j—standard deviance (s) regarding a question (j),
m_{kj}—normalized answer value (m).

2. Designation the distance (d) between 2 users or clusters (k and l) was calculated with the quadratic Euclidean distance using the normalized values for the total number of questions (q):

$$d(k,l) = \sum_{j=1}^{q} \left(m_{kj} - m_{lj}\right)^2 \tag{8}$$

3. "Users or clusters of minimal distance to each other will be unified into a new cluster (k+l). If the new cluster exists, its distances have to be redefined towards all other users or clusters (a). Different clustering methods use different algorithms for calculation of new distances. Ward's method calculates the optimal minimum distance taking into account the number of users in the clusters" ([40], p. 27).

$$d(a,\ k+l) = \frac{(N_a + N_k) * d(a,\ k) + (N_a + N_l) * d(a,\ l) - N_a * d(k,\ l)}{N_a + N_k + N_l} \tag{9}$$

where:
N_a—number of users (a) in the cluster,
N_k—number of users (k) in the cluster,
N_l—number of users (l) in the cluster.

For greater clarity, the step-by-step methodology is shown in Figure 10.

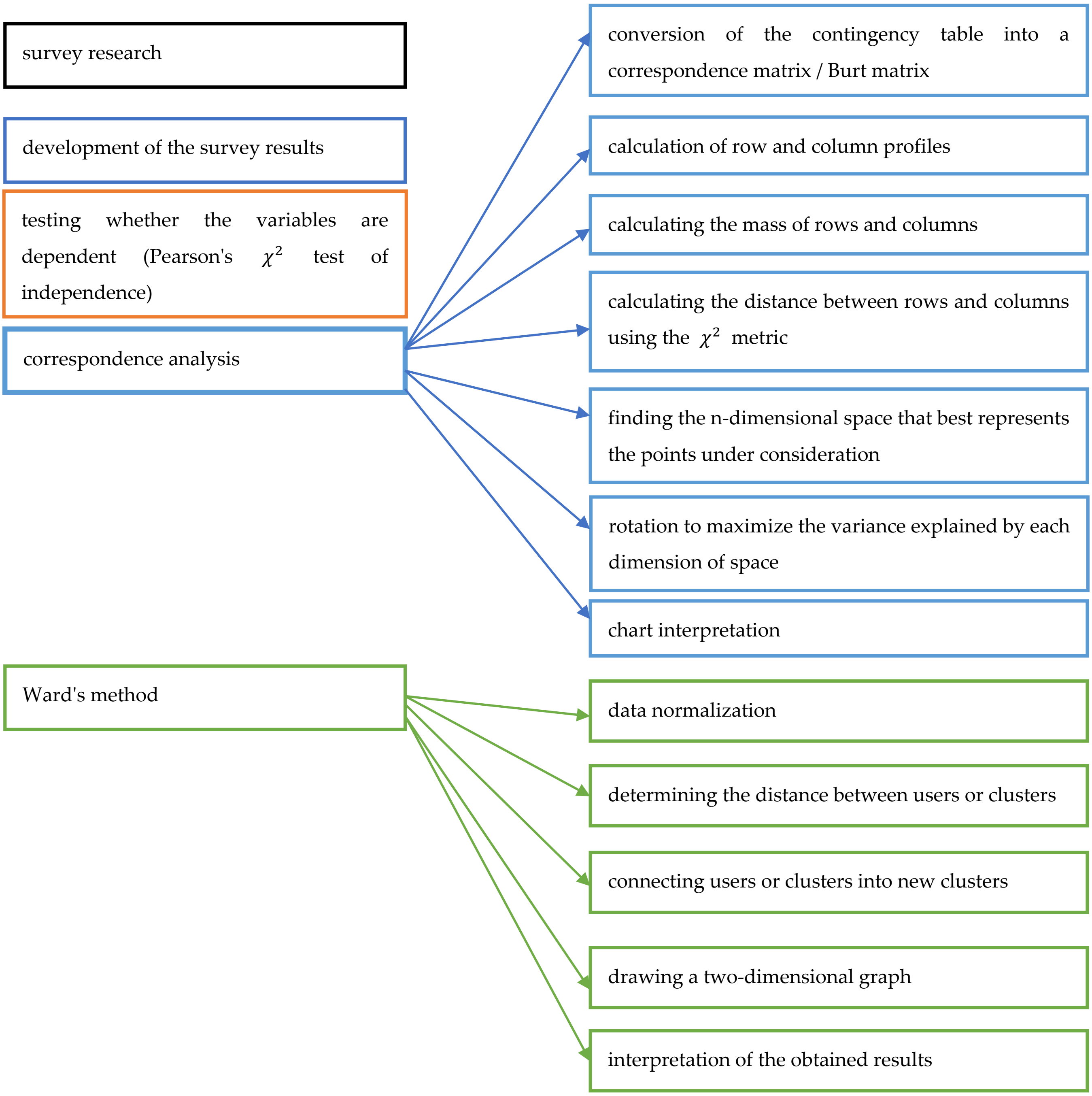

Figure 10. Diagram of the methodology.

3. Results

For the purpose of this study, four variables characterizing the perception of the use of telematics solutions by future SKM passengers were considered. These variables were analyzed in relation to the age (A) and education level (E) of the respondents. Frequencies of urban transport use (F) and most frequently chosen destinations (D) were also considered.

As mentioned before, this is part of a large survey. For this publication, questions concerning the use of telematics solutions were selected, which, together with possible answers, are presented in Table 1.

Table 1. Questions in the survey questionnaire.

Symbol	Questions	Answers
P1	Please indicate if you will use the following systems that enable positioning of objects using GPS satellite navigation	
P1-01	monitors displaying the real time until the train arrives at the SKM station	1. Yes 2. No 3. I don't know
P1-02	free app to track the actual train timetable	1. Yes 2. No 3. I don't know
P1-03	free application for real-time planning of connecting other means of public transport with SKM (the application takes into account indications of devices for monitoring road traffic and weather conditions)	1. Yes 2. No 3. I don't know
P1-04	free application to track the level of congestion on SKM trains	1. Yes 2. No 3. I don't know

Before proceeding to the correspondence analysis, it was examined whether the variables were dependent. Since the responses obtained are measured on a nominal scale, Pearson's χ^2 test for independence was used to assess the dependence of the variables. Table 2 presents the values of the χ^2 statistic, i.e., the probability of rejecting the null hypothesis of independence of the variables analyzed. All variables presented met the required conditions of dependence and were used for further analysis.

Table 2. Value of the χ^2 statistic.

Pairs of Questions (A)		Pairs of Questions (E)		Pairs of Questions (F)		Pairs of Questions (D)	
P1-01	198.0636 [0.0000]	P1-01	134.0429 [0.0000]	P1-01	112.3712 [0.0000]	P1-01	108.8248 [0.0000]
P1-02	295.5743 [0.0000]	P1-02	79.2131 [0.0000]	P1-02	101.2435 [0.0000]	P1-02	44.1485 [0.0000]
P1-03	368.8575 [0.0000]	P1-03	64.9235 [0.0000]	P1-03	107.1821 [0.0000]	P1-03	42.4286 [0.0000]
P1-04	341,6718 [0.0000]	P1-04	40,7686 [0.0000]	P1-04	102,4273 [0.0000]	P1-04	47,2814 [0.0000]

P1-01—screens displaying the real time until train arrival at SKM stations; P1-02—a free application for tracking live train schedules; P1-03—a free application for live time planning of transport means connections with SKM (taking into account devices for traffic and weather conditions monitoring); P1-04—a free application for tracking vehicle congestion levels.

Figure 11 shows a three-dimensional perception map based on a 27 × 27 Burt matrix. It should be noted that only those variables that show connections between categories of variables are presented graphically. Based on the map, the relationships between the categories of variables were typified.

Complementary to the analysis is Figure 12, which presents a diagram of hierarchical classification of categories of variables, which was made by Ward's method. The horizontal red line indicates the stage at which the merging of the classes was interrupted. The intersection was determined based on the analysis of the distance of binding relative to the bonding stages (Euclidean distance). The diagram in combination with the correspondence analysis allows for more detailed analysis of the obtained results.

The following classes were obtained, on the basis of which regularities of the studied phenomenon were identified (classes I–VII):

Class I—respondents aged 51–65 years (A5) and over 65 years (A6) traveling for health care services (D3) will not use a free application for tracking live train schedule (P1-02:2). They will also not use a free application for tracking vehicle congestion levels (P1-04:2).

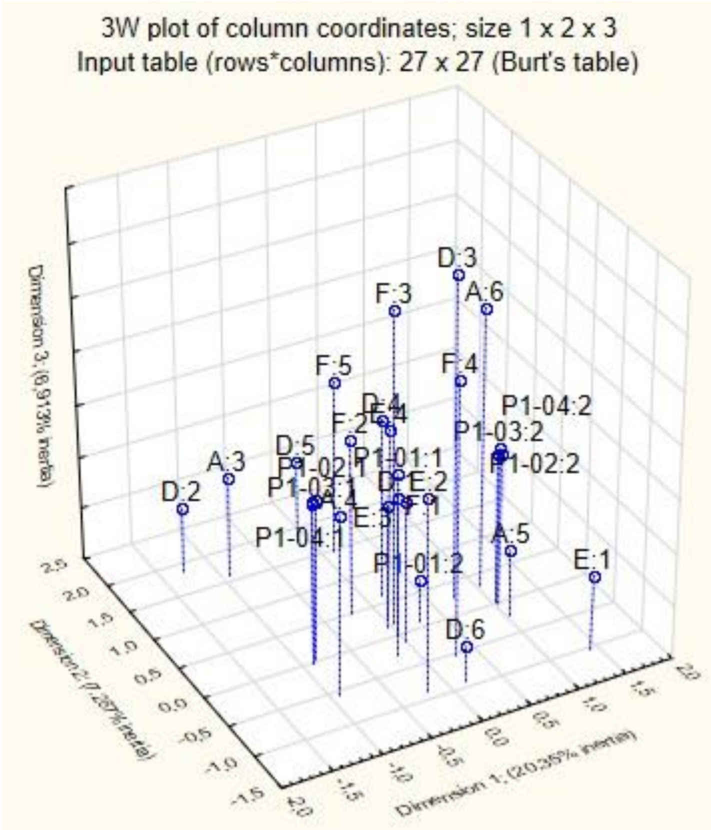

Figure 11. Three-dimensional map of perception.

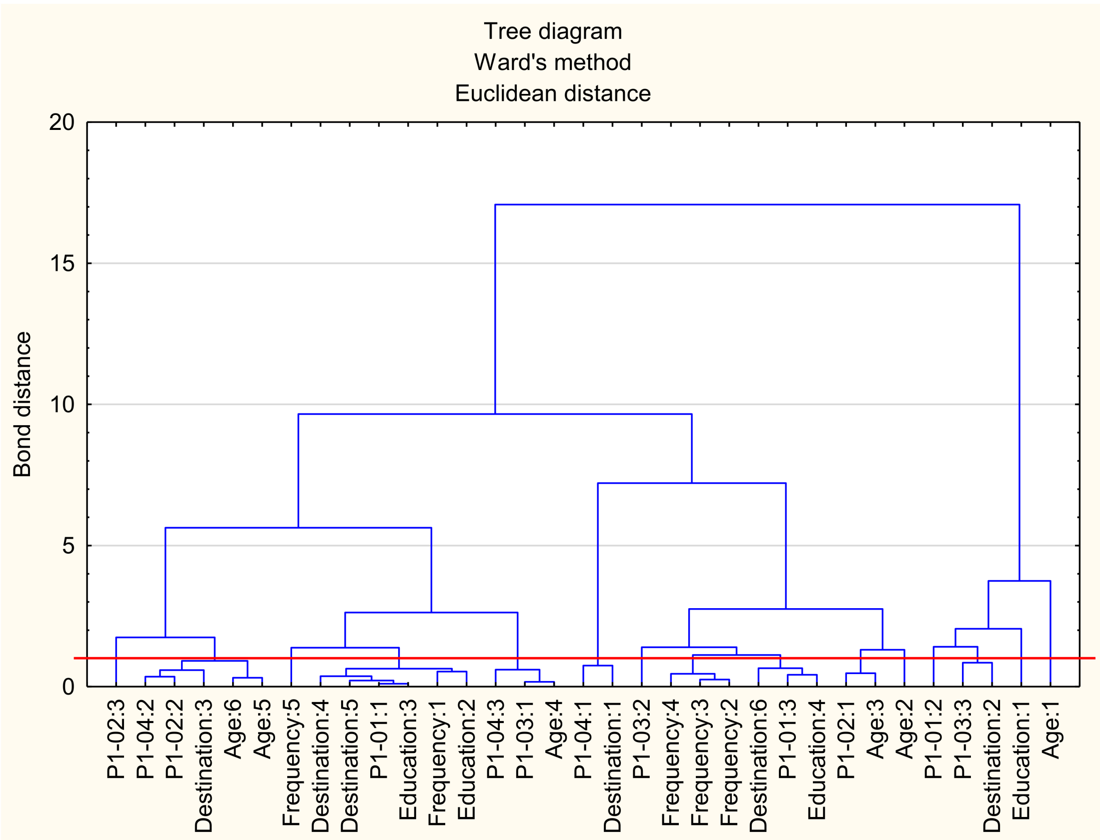

Figure 12. Diagram of hierarchical classification of variable categories—Ward's method.

Class II—respondents with vocational (E2) and secondary education (E3), using public transport five times a week or more (F1) and not using it at all (F5), travelling by public transport to visit cultural institutions (D4) and sports facilities (D5) declare willingness to use information about real time to train arrival displayed on monitors at SKM stations (P1-01:1).

Class III—respondents aged 41–50 years (A4) declare willingness to use a free application for live time planning of transport means connections with SKM (P1-03:1). However, they find it difficult to judge whether a free app to track vehicle congestion levels would be useful to use (P1-04:3).

Class IV—respondents who travel by public transport to get to their place of work (D1) say that they would like to use a free app to monitor vehicle congestion levels (P1-04:1).

Class V—persons with tertiary education (E4) using public transport 2–4 times a week (F2), once a week (F3), and less often (F4), travelling by public transport to meet friends (D6) will not use a free application for live time planning of transport means connections with SKM (P1-03:2). Respondents are unable to judge whether monitors at SKM stations displaying the actual time to train arrival would be useful to them (P1-01:3).

Class VI—respondents aged 15–30 (A2) and 31–40 (A3) say they would like to use a free application for tracking live train schedules (P1-02:1).

Class VII—respondents traveling by public transport to reach an educational facility (D2) will not use screens that display the actual time until train arrival at SKM stations (P1-01:2). Persons in this group do not know whether a free application for live time planning of transport means connections with SKM would be useful (P1-03:3).

4. Discussion

Since the SKM is under construction and will be operational in 2022, there is a lack of previous research on this topic. Surveys on residents' expectations after the launch of SKM can be found in the paper by Barczak [29].

The analysis conducted allows for concluding that the hypothesis posed in the introduction has been confirmed. Perception of the use of telematics solutions by future SKM passengers depends on age. This is evidenced, inter alia, by the fact that persons aged 51–65 years and over 65 years will not use applications to track the actual train schedule and to track the level of vehicle congestion (Class I). Deeper analysis shows that 86.57% of those over 65 and 92.71% of those aged 61–65 will not use the app to track the actual train schedule. Of those over the age of 65 (97.92% of those aged 51–65), 95.52% will not use the app for scheduling connecting transport modes, and 97.01% of those surveyed (96.88% of those aged 51–65) will not use the app for tracking vehicle congestion levels. This is presumably due to the fact that these persons do not use smartphones and feel apprehensive about using modern solutions. In other age groups, the percentage of persons declaring willingness to use the proposed telematics solutions is much higher. In the group of persons aged 41–50 years, it exceeds 97% of respondents; in the group of persons aged 31–40 years, it is over 93%; while in the group of persons aged 15–30 years, the interest in telematics solutions is slightly over 50%. In the group up to 15 years of age, respondents declare only use of the application for tracking the actual train schedule—73.68% of respondents (due to the small size of the group—19 persons—the correspondence analysis did not show any visible relationship between the categories). It may be assumed that young persons do not pay much attention to this type of solutions.

The perception of telematics solutions is also dependent on the level of education, frequency of using public transport, and purpose of travel. However, these relationships are not as visible as in the case of age. To a large extent, it depends on the level of diversity of travelers (persons who do not use public transport were also surveyed), but also on the fact that SKM is not yet launched, and it is difficult for respondents to evaluate something that does not work (telematic solutions).

As previously mentioned, the inhabitants of the Szczecin agglomeration know some telematics solutions that were used in public transport for several years. This made it much easier to evaluate the proposed solutions.

The solutions obtained a clear signal for SKM contractors, i.e., that such solutions are necessary and that travelers will use them. The results of the survey can also be used to determine the target groups to which advertising activities should be directed. The obtained research results are of local importance, but may inspire similar research in other agglomerations around the world. As mentioned before, the literature lacks questionnaire studies taking into account the evaluation of telematics solutions in public transport, and a presented research results clearly indicate the limitations of using telematics solutions by public transport passengers. These restrictions relate to age and education levels, as well as the frequency and reason for using public transport. It can be assumed that, also in other cities, these relationships will be similar, as long as there are no significant cultural differences. The research results can be applied not only to the agglomeration railway, but also to other means of public transport.

The tests were carried out before the systems were put into use, which guarantees that the implemented solutions will be satisfactory for passengers.

At the same time, in addition to indicating the direction of possible research on public transport, the article indicates methods helpful in analyzing qualitative surveys. It should be noted, however, that, due to the complexity of calculations, it is worth using appropriate statistical software.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Conflicts of Interest: The author declare no conflict of interest.

References

1. Ogryzek, M.; Adamska-Kmieć, D.; Klimach, A. Sustainable Transport: An Efficient Transportation Network-Case Study. *Sustainability* **2020**, *12*, 8274. [CrossRef]
2. Mohan, D.; Tiwari, G. Sustainable Transport Systems. Linkages Between Environmental Issues, Public Transport, Non-Motorised Transport and Safety. *Econ. Polit. Wkly.* **1999**, *XXXIV*, 1589–1596.
3. Zakharov, D.; Magaril, E.; Rada, E.C. Sustainability of the Urban Transport System under Changes in Weather and Road Conditions Affecting Vehicle Operation. *Sustainability* **2018**, *10*, 2052. [CrossRef]
4. Black, J.; Páez, A.; Suthanaya, P. Sustainable Urban transportation: Performance indicators and some analytical approaches. *J. Urban Plan. Dev.* **2002**, *128*, 184–209. [CrossRef]
5. Badland, H.; Hickey, S.; Bull, F.; Giles-Corti, B. Public transport access and availability in the RESIDE study: Is it taking us where we want to go? *J. Transp. Health* **2014**, *1*, 45–49. [CrossRef]
6. Linneker, B.J.; Spence, N.A. An Accessibility Analysis of the Impact of the M25 London Orbital Motorway on Britain. *Reg. Stud.* **1992**, *26*, 31–47. [CrossRef]
7. Taylor, M.A.P.; Sekhar, S.V.C.; D'Este, G.M. Application of accessibility based methods for vulnerability analysis of strategic road networks. *Netw. Spat. Econ.* **2006**, *6*, 267–291. [CrossRef]
8. López, E.; Gutiérrez, J.; Gómez, G. Measuring regional cohesion effects of large-scale transport infrastructure investments: An accessibility approach. *Eur. Plan. Stud.* **2008**, *16*, 277–301. [CrossRef]
9. Faron, A. Rapid agglomeration light rail system as a response to spatial planning in the Cracow metropolitan area: Typology of train stops. *Zeszyty Naukowe. Transport/Politechnika Śląska* **2016**, *92*, 41–51. [CrossRef]
10. Lejda, K.; Siedlecka, S. Inteligentne Systemy sterowania ruchem w miastach. *Autobusy Tech. Eksploat. Syst. Transp.* **2016**, *12*, 680–683.
11. Gidebo, F.A.; Szpytko, J. Transport System Telematics for Smart Cities Concept—A Case of Addis Smart Mobility Project. In *Research and the Future of Telematics. TST 2020. Communications in Computer and Information Science*; Mikulski, J., Ed.; Springer: Cham, Switzerland, 2020; Volume 1289, p. 17. [CrossRef]
12. Williams, B. *Intelligent Transport Systems Standards*; Artech House: Norwood, MA, USA, 2008; p. 35.
13. Perallos, A.; Hernandez-Jayo, U.; Onieva, E.; Garcia-Zuazola, I. *Intelligent Transport Systems*; Wiley & Sons: Chichester, UK, 2016.

14. Karoń, G.; Mikulski, J.; Janecki, R. Design and Implementation of ITS Systems in Urban Agglomerations—Selected System Problems. *Arch. Transp. Syst. Telemat.* **2019**, *12*, 17–21.
15. Siergiejczyk, M. Communication Architecture in the Chosen Telematics Transport Systems. *Comput. Sci.* **2012**, 103–132. [CrossRef]
16. Telematic Systems. Available online: https://www.mobility.siemens.com/global/en/portfolio/rail/automation/telematic-systems.html (accessed on 19 August 2021).
17. Tablice informacyjne na przystankach w systemie obrony cywilnej? Available online: https://radioszczecin.pl/1,121787,tablice-informacyjne-na-przystankach-w-systemie- (accessed on 19 August 2021).
18. Wirtualne tablice na przystankach. Available online: https://www.zditm.szczecin.pl/pl/pasazer/aktualnosci,1513867142,wirtualne-tablice-na-przystankach (accessed on 19 August 2021).
19. Nieczytelne tablice Systemu Zarządzania Ruchem. *Jest okazja je poprawić!* Available online: https://szczecin.wyborcza.pl/szczecin/7,34939,17736389,nieczytelne-tablice-systemu-zarzadzania-ruchem-jest-okazja.html (accessed on 19 August 2021).
20. Tablice zmiennej treści ułatwią życie kierowcom? Available online: https://gorzowianin.com/wiadomosc/9359-tablice-zmiennej-tresci-ulatwia-zycie-kierowcom.html (accessed on 19 August 2021).
21. Osińska, M.; Zalewski, W. Determinants of Using Telematics Systems in Road Transport Companies. *Eur. Res. Stud. J.* **2020**, *XXIII*, 474–487. [CrossRef]
22. Zalewski, W. Telematics Systems in Road Transport. *J. Posit. Manag.* **2019**, *10*, 3–20. [CrossRef]
23. Topolska, K.; Bujak, A. The role of telematics in functioning of mixed passenger transport services in an urban agglomeration. *Arch. Transp. Syst. Telemat.* **2016**, *9*, 37–42.
24. Drewnowski, A. Passenger transport as a part of the Szczecin Metropolitan Railway project—Problems with reactivation the connection Szczecin–Police. *EJSM* **2018**, *27*, 146–148. [CrossRef]
25. Pietrzak, K.; Pietrzak, O. Can the Metropolitan Rail System Hamper the Development of Individual Transport? (Case Study on the Example of the Szczecin Metropolitan Railway, Szczecin, Poland). In *Transport Development Challenges in the 21st Century. TranSopot 2019. Springer Proceedings in Business and Economics*; Suchanek, M., Ed.; Springer: Cham, Switzerland, 2021. [CrossRef]
26. Macioszek, E.; Lach, D. The Concept of Construction of Agglomeration Railway System in the Upper Silesian Conurbation. *J. Manag. Financ. Sci.* **2018**, *XI*, 67–77.
27. Lin, S.; Dhakal, P.R.; Wu, Z. The Impact of High-Speed Railway on China's Regional Economic Growth Based on the Perspective of Regional Heterogeneity of Quality of Place. *Sustainability* **2021**, *13*, 4820. [CrossRef]
28. Li, J.; Qian, Y.; Zeng, J.; Yin, F.; Zhu, L.; Guang, X. Research on the Influence of a High-Speed Railway on the Spatial Structure of theWestern Urban Agglomeration Based on Fractal Theory—Taking the Chengdu–Chongqing Urban Agglomeration as an Example. *Sustainability* **2020**, *12*, 7550. [CrossRef]
29. Barczak, A. The Szczecin Metropolitan Railway and its expectations on urban transport in the Szczecin agglomeration. *Sci. J. Marit. Univ. Szczec.* **2021**, *66*. Available online: https://repository.am.szczecin.pl/handle/123456789/2665 (accessed on 19 August 2021).
30. Abdi, H. Multivariate analysis. In *Encyclopedia for Research Methods for the Social Sciences*; Lewis-Beck, M., Bryman, A., Futing, T., Eds.; Sage: Thousand Oaks, CA, USA, 2003; pp. 699–702.
31. Abdi, H.; Valentin, D. Multiple correspondence analysis. In *Encyclopedia of Measurement and Statistics*; Salkind, N.J., Ed.; SAGE Publications: Thousand Oaks, CA, USA, 2007; pp. 651–657.
32. Abdi, H.; Williams, L.J.; Valentin, D. Multiple factor analysis: Principal component analysis for multi-table and multi-block data sets. *Wiley Interdiscip. Rev. Comput. Stat.* **2013**, *5*, 149–179. [CrossRef]
33. Greenacre, M.J. *Correspondence Analysis in Practice*, 2nd ed.; Chapman & Hall/CRC: Boca Raton, FL, USA, 2007.
34. Hwang, H.; Tomiuk, M.A.; Takane, Y. Correspondence analysis, multiple correspondence analysis and recent developments. In *Handbook of Quantitative Methods in Psychology*; Millsap, R., Maydeu-Olivares, A., Eds.; Sage Publications: London, UK, 2010.
35. Kroonenberg, P.M.; Greenacre, M. Correspondence Analysis. *Wiley Interdiscip. Rev. Comput. Stat.* **2004**. [CrossRef]
36. Rozmus, D. Analiza korespondencji. In *Metody Statystycznej Analizy Wielowymiarowej w Badaniach Marketingowych*; Gatnar, E., Walesiak, M., Eds.; Wydawnictwo Akademii Ekonomicznej im. Oskara Langego we Wrocławiu: Wrocław, Poland, 2004; pp. 285–302.
37. Murtagh, F.; Legendre, P. Ward's Hierarchical Clustering Method: Clustering Criterion and Agglomerative Algorithm. *J. Classif.* **2014**, *31*, 274–295. [CrossRef]
38. Großwendt, A.; Röglin, H.; Schmidt, M. Analysis of Ward's Method. In Proceedings of the 2019 Annual ACM-SIAM Symposium on Discrete Algorithms (SODA), San Diego, CA, USA, 6–9 January 2019. [CrossRef]
39. Bonald, T.; Hierarchical Clustering. January 2019. Available online: https://perso.telecom-paristech.fr/bonald/documents/hierarchy.pdf (accessed on 19 August 2021).
40. Eszergár-Kiss, D.; Caesar, B. Definition of user groups applying Ward's method. *Transp. Res. Procedia* **2017**, *22*, 25–34. [CrossRef]