Assessing the impact of bridge closure due to renovations on tram users' inconvenience in Amsterdam: A quantitative study.

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ABSTRACT,
This study assesses the impact of bridge closures caused by renovations on tram user's inconvenience in the city of Amsterdam. The present study addresses the gap in literature on specific factors that contribute to inconvenience at extended periods of disruption, such as maintenance projects. A survey is conducted on tram users of Amsterdam to identify which factors influence the perceived inconvenience of users, these factors are grouped into time-related, travel-related, and additional factors. A thorough analysis is conducted using factor analysis and regression analysis to quantify and measure the effect of these factors on inconvenience, and further create a list ranking their significance. The study was conducted using the responses of participants (N=25) who were asked a series of questions associated with travelling by tram, which were created to measure the perceived inconvenience of users on varying factors. The analysis has identified the significant effect of travel duration and waiting time on user inconvenience. The findings suggest that waiting time is the most significant determinant of user inconvenience and is linked with other contributing factors, this can be interpreted as users attaching a high value to their time when commuting. It is recommended that further research is done on now users set the value for their time to find further solutions on how to mitigate inconvenience from public transport disruptions.

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Tram Network, Public transport, Inconvenience, Disruptions, Renovations, Satisfaction, Commuting, Travel

1. INTRODUCTION

1.1 Background

Amsterdam is renowned for its public transport systems and its high interconnectedness between the different modes of transport allowing people to move around with ease and efficiency, featuring a tram network comprising approximately 200km of rails above ground. The network runs throughout the city with 650 possible switches and 500 stops, allowing commuters to travel medium-length distances that are too long for walking but not long enough to use other means, within the confines of Amsterdam's center, and reach destinations within the center that cannot be easily reached with any other transport mode (GVB, n.d.-b, para. 4).

1.2 Problem Statement

Closures of certain bridges due to renovations cause disruptions to linked tram lines, having a negative impact on its daily users. However, as Amsterdam's infrastructure of bridges and quay walls ages over time, there is an emerging need for maintenance to ensure safety and reliability for residents and visitors. Even though these renovations are necessary, they pose a significant challenge to the smooth operations of the tram network. These renovations result in the disruption of tram service which in turn create inconveniences for commuters, potentially leading to increased overcrowding in alternative public transport lines or an increase in CO2 emissions if the inconvenience created is too severe and the use of individual means of transport becomes the best alternative solution.

It is evident through a search in the available literature that there is a lack of specific research done into the identification of factors that can measure the level of inconvenience experienced by public transport users in disruptions of extended periods of time, such as renovations of railways, bridges, or stations. This study focuses on expanding the current knowledge available on the factors that measure the level of inconvenience experienced by tram users during bridge closures. This research is focused on identifying these factors with the measurement of one trip being from the starting point of a trip where passengers aboard the tram and ends at the point they reach their stop and alight, which counts as one trip.

1.3 Objectives of the Study

The main purpose of this study is to help to fill the gap that exists within the literature on factors that negatively affect the experience of users in public transport, with the intention of providing insight that can be utilized in large-scale projects, that is being implemented in Amsterdam regarding the renovation of bridges and quay walls (Urbiquay | NWO, 2023, sec. Logiquay). The means by which the contribution is achieved by measuring through a questionnaire the level of inconvenience experienced by tram users in Amsterdam, and creating a list of factors that contribute to inconvenience in ordernto provide useful information that can help the municipality better plan the logistics of reconstructing historic sites while maintaining the same level of efficiency in the public transport network. This study contributes to the limited literature on factors that contribute to tram user inconvenience by addressing the following research questions:

1) What are the key factors causing inconvenience to customers due to public transport disruptions?
2) What is the degree of perceived inconvenience of users in public transport when large scale projects disrupt tram lines?

2. LITERATURE REVIEW

2.1 Overview of Public Transport Systems in Amsterdam

In this section, the focus is on evaluating the available literature that can be relevant to the topic according to the different factors that contribute to inconvenience as well as identifying relevant insights that can be used to build upon and develop a better understanding of the topic at hand. Seeing that, most of the studies that measure inconvenience are based on train networks as they are the most common across many countries, and the main focus is on inconvenience created by inefficiencies within and across networks. This shows a lack of attention given to other niches of public transport such as tram networks which can serve as an opportunity for exploration into the internal workings of trams networks and gain an understanding on how they differ from other public transport networks. In most cases, measurements of inconvenience are specific to one mean of public transport such as train networks, and do not encompass the inconvenience passengers experience at times of complete railway disruptions over prolonged periods of time of 1-5years or longer(Philip et al., 2017). Coupled with the lack of tram network specific studies, it is evident that new research is required to fill in this specific gap. This study will attempt to contribute to a better understanding of the factors that contribute to rider dissatisfaction during disruptions of prolonged duration, in the context of tram networks.

2.2 Factors Contributing to Public Transport Inconvenience

Modeling objectives in terms of network optimization is quite straightforward whereas objectives accounting for passenger inconvenience are more difficult to model (Philip et al., 2017) as it involves human perception which is relatively more complex. Understanding the intricate nature of public transport inconvenience is essential for improving passenger experience. This review is divided into 3 primary categories of factors that contribute to public transport users' inconvenience. Time related factors, travel related factors and additional factors that influence the previous two factors. By examining the factors in such a structure, the aim is to break down the problem into to two smaller categories of inconvenience that affect users. The motivation for examining the factors that contribute to inconvenience in such a structure, is to understand how the different combinations of variables interact and shape the commuter's perceived experience.

2.2.1 *Time-Related Factors*

Most research done on public transport inconvenience focuses on time factors such as travel duration and waiting time users experience.(Díez-Gutiérrez & Tørset, 2019) focuses on making a division between the socioeconomic and trip characteristics and further separating the GC(generalized costs) and IC (inconvenience costs) to identify which factors were contributing the highest amount of inconvenience to the perception of passengers using the Norwegian ferry service network. The results show that depending on the trip purpose, the perceived inconvenience was different for the trip characteristics of waiting time and total travel time which were the most important for users travelling by ferry, meaning that by reducing the waiting time, there is a possibility for an increase in number of trips users take.(Mouwen, 2015) public transport user satisfaction, found that the factors contributing the highest user satisfaction in terms of time factors were the on-time performance of trains, travel speed, and the frequency of departures per hour. Similarly, a model created for train rescheduling in terms of inconvenience accounted for factors such as maximizing train punctuality, minimizing dwelling and connection time on transfers (Toletti Ulrich Weidmann et al., 2016).All these studies share a common consideration for the cost of time-related factors affecting public transport users experience.

2.2.2 *Travel-Related Factors*

In regard to travel related factors such as trip frequency, purpose and number of transfers needed to get from the starting point of the journey to the final destination, previous studies have commonly identified that travel frequency and trip purpose to be the most common contributing factors to user inconvenience. (Díez-Gutiérrez & Tørset, 2019) found that on ferry rides, depending on the trip purpose, the accessibility for different activities was perceived different in terms of inconvenience which led to the conclusion that IC must account for the purpose of each individual user's trip, this can be effectively used in the present study to gain more reliable insights. A different study that attempts to identify the willingness of users to endure inconvenience and still use mixed means of transport resulting from their environmental awareness also found that, besides gender and weather conditions, travel frequency was a defining factor of inconvenience for bike-transit users in Taiwan(Cheng & Liu, 2012). Results show that the users using bike-transit transport methods have a higher ability to overcome intermodal inconvenience, specifically, commuters who travel >15 times/ month, were more likely to overcome this inconvenience compared to leisure users who travel <4times/ month (Cheng & Liu, 2012). In addition to the previously mentioned factors, (Sato et al., 2013) mention that number of transfers also has to be considered in the timetable rescheduling as it is presumed that with an increase in the number of transfers the inconvenience experience also increases.

2.2.3 *Additional Factors*

General factors also have to be considered when determining the level of inconvenience users experience as depending on age (Díez-Gutiérrez & Tørset, 2019; Mouwen, 2015)gender (Cheng & Liu, 2012; Díez-Gutiérrez & Tørset, 2019; Mouwen, 2015)financial capabilities (Cheng & Liu, 2012; Díez-Gutiérrez & Tørset, 2019) as depending on these, the perception of IC changes. Although these do not have a direct correlation with the inconvenience experienced, when viewed in relation with time related factors and travel related factors, account for the different ways users perceive the inconveniences in public transport.

2.3 *Previous Studies and Gaps in Existing Research*

Even though there is a lot of literature that focuses on decreasing the user's inconvenience by optimizing the timetable scheduling of different means of transport from the perspective of providers, there is a lack of knowledge from the perspective of users. Most of these studies are focused minimizing the inconvenience of passengers on public transport through timetable optimization (Philip et al., 2017; Toletti Ulrich Weidmann et al., 2016), showing that they lack the input from the perspective of the users indicating that there is a lack of research done on the factors that are attributed to these negative experiences from the user's perspective. Additionally, the common focus is on improving upon operational inefficiencies that appear in the short-term, which highlights the lack of specific research done measuring the perceived inconvenience of users in cases of major, long-term disruptions.

2.4 *Conceptual Framework*

The conceptual framework is created to identify the key factors and the relationship they have with the dependent variables of perceived inconvenience as well as the likely effect of moderator variables. Perceived inconvenience, which is the dependent variable, which is used to measure the dissatisfaction of users. Independent variables are grouped into time-related factors, travel-related factors, and additional factors. Time-related factors account for travel duration, waiting time and service frequency. Travel-related factors include trip frequency, availability of alternative routes and number of transfers required to reach the destination. Additional factors consist of age, gender, and occupation which might influence users' perception of inconvenience in either direction. Moderating variables such as past experiences with disruptions, expectations for the service, availability of alternative routes/modes of transport and the user's ability to adapt influence the perceived inconvenience of a user. These factors can either increase or decrease the degree of inconvenience depending on the individual's characteristics. Taking into accounting for these variables, the hypotheses that can be drawn are as follows. 1) Increases in travel and waiting time, combined with reductions in service frequency, increase the perceived inconvenience of users. 2) Frequent users, that have a specific purpose for travelling, like going to work or school, might experience a higher level of inconvenience from an increase in the number of transfers they have to make. Additionally, since these users have a specific purpose for their trip, this would likely mean that they also have a higher resilience in enduring these inconveniences (Cheng & Liu, 2012). Users who use mixed means of transport (e.g., bike-tram) are expected to endure higher levels of inconvenience than people who do not use mixed methods. Overall, the conceptual framework is based on the hypothesis that additional factors along with personal attributes of everyone modify the impact of time-related and travel-related factors on perceived inconvenience.

3. METHODOLOGY

3.1 Research Design

A qualitative method was employed as the strategy to understand the severity of the inconvenience created by bridge renovations in the tram network of Amsterdam. The instrument used for the data collection was a survey in which the data was collected from regular tram users in Amsterdam before a period of network disruptions created by bridge renovations. Additionally, interviews with important stakeholders will be conducted to assess their perceived level of inconvenience as well as confirm the validity of the list of factors that will be used to formulate the survey questions in order to measure the level of inconvenience. The research methods employed in this inquiry will be an online survey which attempt to quantitatively assess the level of inconvenience tram users experience at these times. Further, the analysis will contribute to the understanding of how much inconvenience users are willing to endure and still use the tram, while also identifying the tipping point at which the inconvenience is severe enough to deter users from using the network and resort to using alternative means of transport.

3.2 Sampling and Collection

This study is primarily focus on permanent residents of Amsterdam specifically, those who use the tram network regularly, to gain a better understanding of how such an inconvenience is perceived. Although there is a need to gain a complete view of the perceived inconvenience from all users, the study will not be focused on non-regular users such as non-permanent residents or people who rarely use trams as they might have limited interaction with the tram network and their reference point for the base quality of the service is different. This might cause them to have a more negative view of the entire network based on very few interactions they have with the system. Prospect theory suggests that individuals evaluate their potential losses/gains relative to a reference point(Kahneman & Tversky, 1979),this can justify this exclusion of non-permanent residents who do not use the tram network daily. The which in this case is past experiences with the tram network. Non-permanent residence might have a different reference point for the quality of the tram network which can lead to a skewness in the perception of inconvenience which in turn might lead to a skewness in the results. Thus, for this study the input of daily users could be more valuable in understanding the amount of inconvenience experienced at times of bridge renovations.

3.3 Survey

The data was collected through an online survey which was created to quantitatively assess the level of inconvenience tram users experience at these times. The questions used in the survey were developed based on existing literature and findings. The survey consists of questions that are linked with one or more of the independent variables and can explain a portion of the inconvenience users experience. It was distributed to participants through personal networks and different social media platforms. To assure ethical compliance a request was filed to the ethics committee to obtain approval for further data collection. The participants were clearly informed that the survey is entirely voluntary and that they have the right to stop participating at any point in time. Participants were also informed that the data collected will solely be used for research purposes and will be kept confidential and stored anonymously with no personally identifiable information attached to it for the duration of the research, after which the data would be deleted. All the responses collected were checked for the response status of each participant, in the case where participants do not give consent for their data to be used, the entry rows were excluded from the analysis.

3.3.2 Data Analysis

The data collected from the surveys was compiled into a dataset and analyzed using RStudio to quantify the results and create a visual and statistical representation ranking the factors from the most significant to least significant factor that contribute to inconvenience for each demographic group. The data collected from these surveys was compiled into a data frame and imported into RStudio for the results to be further analyzed. The process employed begins with the cleaning and preparation of the dataset whereby the data is cleaned of missing values and all variables that are to be used for a descriptive analysis were coded into numeric values. Then the descriptive statistics calculations are done to understand the structure of the dataset and gain a better view of how the data is distributed within the dataset. In the following step, the survey questions were separated into quantitative and demographic questions which then were grouped according to the three variable factors that contribute to perceived inconvenience (time-related, travel-related, additional factors). Factor analysis was performed to identify the factors contributing the perceived inconvenience and the underlying relationships between the participant's responses, as well as to reduce the number of data entries to a smaller number of factors. A regression analysis was then used to examine the relationship between the independent variables (time-related, travel-related) and the dependent variable (perceived inconvenience). Then to account for the effects of moderating variables, multiple regression models are ran searching for potential influences by additional factors such as age and gender have on the relationship between perceived inconvenience and the three factors. ANOVA tests were conducted to uncover how different demographic groups perceive inconvenience and whether there are significant differences between and across the groups or not. Finally, the results are visualized using charts and plots to illustrate the findings and highlight the most significant factors contributing to inconvenience. Lastly the results from the analysis will be used to create a comprehensive list ranking the factors that contribute to inconvenience from most to least significant.

4. RESULTS

4.1 Demographics

Through the survey a total of 29 participant responses were collected, 4 of which did not complete the survey and thus were excluded from the analysis yielding 25 responses. The sample consisted of 44% men (n=11) and 56% women (n=14). The age distribution ranged from 18 to 36 years, with a mean age of 22.8 years (SD=3.55). the responses were comprised of full-time employees (N=15), part-time employees (N=5), students (N=4) and one participant (N=1) working as a freelancer. Of the total number of participants, 40% said that they have a transportation subscription which they use regularly for travels.

4.2 Factor Analysis

Factor analysis was employed to decrease the complexity of the dataset by reduce the dimension and decreasing the number of variables of correlated variables. To perform the factor analysis the responses were grouped based on the variable they are measuring. The variables that affected the degree of inconvenience based on previous studies included travel duration, waiting time, trip frequency, number of transfers. The factor analysis used the minimum residual (minres) solution to adjust the diagonal elements of the correlation matrix and minimize the squared residuals when the factor model is the eigen value decomposition of the reduced matrix. Varimax rotation was utilized to maximize the value of outliers and minimize the value of average factor loadings. Scree plots (figure 1, figure 2) and eigen values (Table 1) identified the "Elbow point" to determine the number of factors to be used (N=2) in FA.

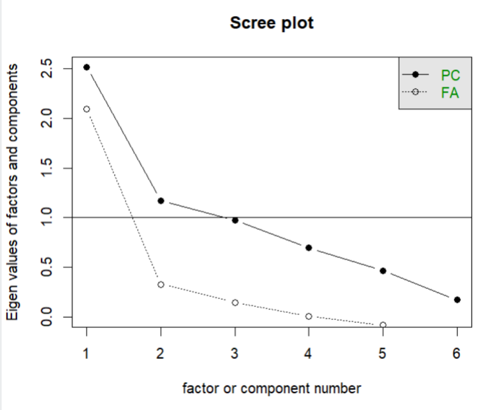

Figure 1. Scree plot time-related factors.

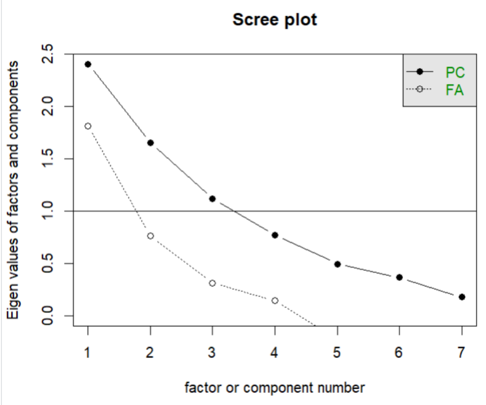

Figure. 2. Scree plot travel-related factors.

Table 1. Eigen values of factors.

Eigen Value	Time Related Factors	Travel Related Factors
1	**2.2335152**	**1.9559479**
2	0.8842860	1.3023634
3	0.1849618	0.4013979
4	0.0327776	0.2049464
5	**-0.0543210**	**-0.1102221**
6	-0.1819692	-0.1923704

Table 2 provides the factor analysis of perceived inconvenience showing the significance of each variable, and the explanatory power of each factor. Time-related factors, with the highest eigen value of 2.09, explain 35% of the total variance, highlighting the significant effect on the perception of inconvenience. Whilst, travel-related factors, with an eigen value of 1.817, account for 26% of the variance, indicating a significant but smaller influence than time-related factors. In addition, a further exploration of the results was done using the factor loadings of each variable, to assess the significance of factors as well as the underlying variables, that were compiled to create the factor groups. The results were then interpreted using the factor loadings of each variable to determine what percentage of variance can be explained by each variable. according to (Factor Analysis in Market Research - Qualtrics, 2023), values ranging from (-1 to 1) are generally accepted and with high factor loadings indicating a significant effect by the independent variable. The first category included time related variables related to travel duration (0.59), waiting time (1.63), service frequency (0.01) whereas travel duration was found to have a moderately significance and waiting time indicated the highest significance in the study. In the travel related factors of trip frequency (1.13), number of transfers (-1.19) and availability of alternative routes (-1.07) showed a significant effect on the perceived inconvenience with two of the variables having an inverse relationship with the dependent variable.

Table 2. Factor analysis of perceived inconvenience

Factors	Factor Loading	Eigen Value	Explained Variance
Time-Related Factors		**2.09**	**35%**
Travel Duration	0.59		
Waiting Time	1.63		
Service Frequency	0.01		
Travel-Related Factors		**1.817**	**26%**
Trip Frequency	1.13		
Number of Transfers	-1.19		
Alternative Routes	-1.07		

For some of the variables the factor loading value was high such as waiting time, indicating a strong correlation between variable groups that were compiled into factors. Although the model seems to be fitting well with the underlying structure of the data, an explained variance as such could also be an indication that there are more underlying factors that affect a user experience and perception of inconvenience which were not accounted for in the present study. Furthermore, the model's fit was tested using several tools such as the root mean squared error (RMSEA), root mean square residual (RMSR), which are used to assess the goodness of the model fit, and the Tucker Lewis index (TLI), which measures the reliability of the factors used and. Root mean square error of approximation (RMSEA) scores were Time-related factors (0.17), travel-related factors (0), which fell below the acceptable threshold of 0.06 indicating that it is a close fit between the model and the data. The low RMSEA score indicates that there might be small inconsistencies between the parameters suggesting that the fit is a good approximation. Root mean square of Residuals (RMSR) measures the average of squared differences between observed and predicted values. with an RMSR value of time related factors (0.1) indicating few residuals and suggesting a good fit with the model as it is close to 0, travel related factors (0.17) also indicating a good fit as it is within the acceptable range of 0.2-0.5, showing that a model can predict the data relatively accurately, with values below the range and closer to 0 indicating that the model is performing well. For TLI the acceptable range of values is > 0.9, results are inconsistent, with time-related factors (1.208) and travel-related factors (0.283), indicating that the model might present some issues with reliability.

4.3 Multiple Regression Analysis

Multiple regression analyses were conducted to examine the relationship between the inconvenience and the independent variables of travel duration, waiting time, trip frequency and number of transfers, frequency of service and availability of alternative routes. The analysis was performed to determine the effect time-related and travel-related factors have on the inconvenience participants experience. Results of the regression analyses are presented in table 2.

The coefficients for travel duration were found to have a statistically significant effect ($\beta = 0.29$, $R^2 = 0.2$, F (1,23) = 5.82, p-value = 0.024), indicating that longer travel times have a significant impact on inconvenience. Waiting time also had a statistically significant effect on inconvenience with ($\beta = 0.359$, $R^2 = 0.288$, F (1,23) = 9.318, p-value = 0.006), suggesting that inconvenience increases with longer waiting times. Trip frequency also had a significant and inverse effect with ($\beta = -0.189$, $R^2 = 0.208$, F (1,23) = 6.046, p-value = 0.022), showing that with a higher frequency of travels, participants experience a lower degree of inconvenience, which could be attributed to the fact that they are more accustomed with the network due to the frequency of their use, making their perception of inconvenience lower. The number of transfers that participants had to make was found to be negatively related to inconvenience with no statistical significance since p-value is higher than the alpha level of 0.05 ($\beta = -0.257$, $R^2 = 0.094$, F (1,23) = 2.4, p-value = 0.135), showing that more transfers decrease the perceived inconvenience, which does not correspond with actual observations. Service frequency did not have a significant effect on inconvenience with ($\beta = 0.015$, $R^2 = 0.001$, F (1,23) = 0.023, p-value = 0.881). Last variable that was checked was associated with the availability of alternative routes, which showed marginal effect on inconvenience with ($\beta = 0.369$, $R^2 = 0.116$, F (1,23) = 3.013, p-value = 0.096) which were not statistically significant. Lastly an overall regression model was run on the dependent variable of inconvenience against all relevant independent variables and the results were not statistically significant.

Table 3. Regression Analysis results

Factor	Beta	R-Squared	F-Statistic	DF	P-Value
Time-related					
Travel Duration	0.291	0.202	5.82	1,23	0.024
Waiting Time	0.359	0.288	9.318	1,23	0.006
Service Frequency	0.015	0.001	0.023	1,23	0.881
Travel-related					
Trip Frequency	-0.189	0.208	6.046	1,23	0.022
Transfers	-0.257	0.094	2.4	1,23	0.135
Alternative Routes	0.369	0.116	3.013	1,23	0.096

To evaluate the fit of the model, $R^2 = 0.49$ which indicates the proportion of variance in the dependent variable that is explained by the independent variables whilst and Adjusted $R^2 = 0.35$ adjusts for the number of predictors in the model. Findings suggest that 49% of the variance in inconvenience can be explained by the independent variables described above. Diagnostic tests showed no multicollinearity (VIF < 2).

Multiple one-way ANOVA tests were conducted to examine the relationship between perceived inconvenience and the independent variables mentioned previously. The analysis aimed to determine if there were statistically significant differences between the responses for different questions the participants responded to. Results of the ANOVA analyses are presented in **table.**

Travel duration had a statistically significant effect on perceived inconvenience with (F (1, 23) = 5.044, p = 0.035). This indicates that longer travel durations significantly increase the inconvenience experienced by users. Similarly, waiting time also had a statistically significant effect on inconvenience with

(F (1, 23) = 9.618, p = 0.005), suggesting that inconvenience also increases with longer waiting times. Service frequency, however, did not have a significant effect (F (1, 23) = 0.026, p = 0.874). this indicates that changes in frequency of service may not be a reliable predictor of inconvenience. Trip frequency significantly affected inconvenience with (F (1, 23) = 5.51, p = 0.028) suggesting that more frequent trips reduce inconvenience, possibly attributed to the same reason as before. The number of transfers participants had to make was also found to be statistically significant (F (1, 23) = 4.777, p = 0.039) indicating that more transfers result to higher inconvenience. Lastly, the availability of alternative routes showed a marginal effect on inconvenience (F (1, 23) = 3.495, p = 0.074). Whilst this result is not statistically significant, the high F-value indicates a possible trend where with more alternative routes there could be a reduction in the inconvenience users experience. Overall, the ANOVA outcomes had similar indications as the previous analysis reinforcing the findings of this study.

Table 4. ANOVA test results

Factors	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Travel Duration	1	5.295	5.295	5.044	0.035
Waiting Time	1	8.681	8.681	9.618	0.005
Service Frequency	1	0.033	0.033	0.026	0.874
Trip Frequency	1	5.689	5.689	5.510	0.028
Number of Transfers	1	5.063	5.063	4.777	0.039
Alternative Routes	1	3.884	3.884	3.495	0.074
Residuals	**23**	**24.145**	**1.050**	**NA**	**NA**

5. DISCUSSION

5.1 Analysis of Findings

The purpose of this study was to look into the relationship between the inconvenience users experience and what are its cause, while also offering a list raking their significance. The results of this study provide insights into the factors contributing to tram user inconvenience. The analysis revealed several key points that align with and expand upon the existing literature. The variables were grouped based on the factor they are influencing and analyzed in pairs of 2-3 variables against the dependent variable of inconvenience. Multiple regression analysis was conducted to identify the influence each variable had on commuter inconvenience. The results from this study offer valuable insights into the factors contributing to the perceived inconvenience in public transport systems, particularly the tram network.

Through the factor analysis it was revealed that time-related factors explained 35% of the variance which is aligned with the findings from previous research supporting that travel duration and waiting time are critical determinants of user's inconvenience. The regression analysis then further reinforced this finding by revealing that waiting time significantly impacts the perceived inconvenience of users. The results of the study are consistent with existing research suggesting that there is an impact of extended waiting times on users' experience with public transport networks. Waiting time was found to have a strong and positive correlation with inconvenience suggesting that as waiting time increases so does the inconvenience experienced. This aligns with Díez-Gutiérrez & Tørset (2019) findings that waiting time largely contributing to the perception of inconvenience. Similarly, travel duration, showed a statistical significance, further confirming previous findings. This indicates that longer travel times are viewed as an inconvenience. Service frequency, contrarily to previous studies, was found to not be statistically significant. This can be attributed to an error in the data collection or analysis stage. It was expected that with increases in service frequency inconvenience would decrease as with a more frequent service user's waiting times are reduced.

Travel-related factors were found to have an explained variance of 26%. This can be attributed to the small sample size which could have skewed the results or not have created a complete representation of the population. Regardless of the explanatory power, the factor was statistically significant as through the regression model it was found that trip frequency is negatively correlated with inconvenience, meaning that with more regular tram use, the inconvenience experienced decreases, this can be attributed to users getting accustomed to the small inconveniences, building resilience, and viewing them as a normal part of public transport. These findings are consistent with (Cheng & Liu, 2012; Sato et al., 2013).While increases in trip frequency lower inconvenience scores, the number of transfers should have an inverse effect on the depended variable, whereby with every additional transfer, the inconvenience users experience increases but the actual outcomes of the analysis differ (β = -0,257). Since additional transfers require a change of transportation mean, the inconvenience created by an increase in the number of transfers can be either due to additional waiting time where transfer times are long or when there is not enough time for users to change means and they are in a rush to make the connection on time. In both cases, previous findings suggest that users prefer direct routes and view transfers as a significant inconvenience, contradicting the findings of this study. Lastly, the availability of alternative routes was found to have a positive effect on inconvenience, meaning that with more routes available, inconvenience would increase. These results on the availability of alternative routes should have had a negative effect on inconvenience as it is only logical that the availability of alternative routes should increase flexibility and decrease inconveniences when one mean of transport is disrupted. Surprisingly, there was no statistically significant effect which may be an indication that alternative routes might not exist or are inefficient. Additionally, these alternatives may not cover the same areas or have stops at convenient locations where users would use them, making them less practical for users who are accustomed to certain routes. Contrarily, this could also be attributed to underlying psychological factors that can be explained by theories such as familiarity heuristic and status quo bias. The status quo bias states that people prefer to choose things that remain the same even if alternatives exist meaning that until users see and experience a disruption, they are unlikely to view an alternative as a likely option (Samuelson & Zeckhauser, 1988). Familiarity heuristic reinforces this as it states that people tend to go for the more familiar option when making decisions (Schwikert & Curran, 2014). This means that even though there might be existing alternatives prior to disruptions, since a user has found the one that works best for them and became familiar with it, they would rather stick with that choice instead of using an alternative, this tells us that even though it is unlikely to happen, the best option would be to not have the disruption.

While factor and regression analysis results focused mostly on time and travel related factors, additional factors such as age, gender and occupation were speculated to influence inconvenience, the results in this study were not statistically significant for age independently, but the results of age having an indirect effect as a moderating variable were slightly significant. Indicating that as age increases, the effects of other variables on inconveniences also increases. This could suggest that while these factors may influence perceived inconvenience, the effect created by additional factors may be more case by case dependent. For example, age had a statistically significant effect on inconvenience when it is in interaction with waiting time and number of transfers which would insinuate that younger people might tolerate longer waiting times and more transfers than older people. Occupation could also have an influence with students having the most flexibility in their schedule keeping inconvenience lower. Comparing students to part- and full-time employees, there could be a difference where employed people rely more heavily on the transportation network since they must be at work on time and any small delay in transportation could affect their punctuality and performance at work. More thorough analysis can be done to explore more in how these demographic factors affect inconvenience.

5.2 Limitations

The sample used in this study was relatively small, which is the first limitation of this study potentially causing some severe problems such as producing wrong results or results that do not represent the population, another additional limitation could be inaccurate responses due to indifference for results from participants (Faber & Fonseca, 2014). Having a larger sample would enhance the validity and reliability of results as well as exploring more intricate combinations of variables. additionally, most participants were around the age of 23 and were contacted through personal connections. This further restricted the ability of this study to accurately represent the entire population of Amsterdam as it lacked responses from other age groups. Another limitation of this study is that while the factors contributing to inconvenience were found, only 61% of the variance was explained by the model. This likely means that there are additional factors that were not accounted for in the survey.

5.3 Implications

The findings in this study are indicative of how users value their time when commuting, while showing how the loss of additional time when commuting contributes to the increase of perceived inconvenience. This can have multiple practical implications in terms of how and when renovation projects are scheduled and what measures are taken to not extenuate the problem. As time-related factors were found to have the highest effect on the perceived inconvenience of users, coupled with waiting time being a flexible variable that affects user's perception which can be accounted for in all other factors that were measured previously. Although this study was not able to produce any indications that travel-related factors affect the perceived inconvenience of users, it can be assumed that with decreases in the number of transfers users have to make as well as the provision of alternative routes, can help in decreasing the inconvenience of users. Seeing how users value their time when commuting as well as the avoidance of trips with multiple transfers (< 1), the authorities should focus on keeping the time related factors as low as possible to ensure that the inconvenience users experience at times of disruption is minimal. The implementation of a plan as such in practice would require a careful logistical planning of the multiple renovation projects necessary in the city of Amsterdam. Within this plan, an outline of all renovation projects should be made the scheduling of which should be done in a way that nearing tram lines, that can be deemed as alternatives for each other, should not be disrupted at the same time, while lines that run on the same track line should be disrupted at the same time. Further research can be done here where more accurate travelling data can be sourced from users to uncover more detailed information about travelling patterns of users are recorder and further used to create maps showing where the highest usage of each line is. The possession of data as such would create a possibility for partial tram line disruptions, whereby if there is a section of the tramline that does not pass through a renovation site, but a high number of people use it regularly, then the trams using the line would run from the starting point until renovation site. This can also be scaled up where if a line is used through the entire length of the route, then multiple trams can be installed on the same lines with smaller routes running until the renovation sites. To ensure the harmonious operation of the multiple public transportation means a revision of all public transport schedules should be conducted to account for the short delays created by disruptions in order to decrease the chance or eliminate the possibility of missed transfers. Additionally, an open line of communication between the provider and users would be useful to have so that users can be properly informed about the times and locations of disruptions, as well as be aware of available alternatives so that they can better plan their own daily schedules. Additional points of attention would be, to ensure that travel duration does not increase in an alternative route relative to the original one as it was found to have a positive and relatively significant effect on the inconvenience users experience. Overall, prioritizing the punctuality and efficiency of the service is essential, while monitoring costs carefully can prevent excess resource consumption. Creating a balance between service levels and resource consumption can promote operational stability, mitigating user inconvenience without significantly increasing operational expenses.

6. CONCLUSION

This chapter concludes the study by summarizing the key research finding in relation to the research question, as well as the contribution they have. It will also review the limitations and propose recommendations for future research. This study aimed to identify the factors that measure inconvenience caused to tram users due to public transport disruptions caused by bridge closures in Amsterdam. The primary research questions were to identify the key factors of inconvenience and assess the degree of perceived inconvenience during disruptions. Results of the study indicated that time-related factors, such as waiting time and travel duration are significant predictors of inconvenience, with the power to explain 29% of the variance. Additionally, more frequent users reported experiencing less inconvenience, while the rest of the results were inconsistent with previous research and expected outcomes. Several contributions were made for theoretical and practical use. In theory, this study contributed to filling a gap on user-perceived inconvenience expanding the understanding of how time-related and travel-related factors impact perceived inconvenience. In terms of practical contributions, the findings offer insights for the public transport authorities to improve their service. Relevant points of attention would be improving on service frequency by decreasing waiting times and number of transfers to mitigate the effects of disruptions. The main limitation of this study is attributed to the relatively small sample size, which limited the reliability and accuracy of results. Future research should employ a longitudinal approach to assess the impact of these disruptions over their duration so that psychological effects are mitigated, and more accurate quantitative data is produced. Future research should also ensure that there is a sufficiently large sample size available with a diverse demographic distribution for more representative results.

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8. APPENDIX

8.1 Survey

Inconvenience

Start of Block: Description

Q1 Dear Participant, thank you for taking the time to participate in this survey. My name is Maximos Christodoulou, I am conducting this research as part of my bachelor thesis at the University of Twente. The focus of this study is to assess the impact of bridge closures due to renovations on the inconvenience experienced by tram users in Amsterdam. The purpose of this study is to quantify and measure the level of inconvenience experienced by tram users at times of prolonged disruptions, while also identifying the key factors that contribute

to this inconvenience as well as narrowing down the tipping point at which the inconvenience is greater than the utility of the public transport system. Your participation is crucial in helping us understand the extent of this inconvenience and contribute to better logistical planning of large scale renovation projects in Amsterdam.
By participating in this survey, you are contributing to important research that aims to improve the efficiency and reliability of Amsterdam's tram network during times of necessary infrastructure maintenance. Your feedback will provide valuable insights to the municipality, aiding in better logistical planning and minimizing disruption for all tram users.

Your participation in this survey is entirely voluntary! You may choose to stop participating at any time. If you decide to withdraw from the survey, any data you have provided will be deleted upon request.
All responses will be kept confidential and used for research purposes only. The data will be stored anonymously, and no personally identifiable information will be published.

Thank you once again for your participation, sincerely, Maximos Christodolou.

Contact information: M.christodoulou@student.utwente.nl

Q2 After reading the information above do you consent to participate in this study?

○ No, I do not consent (3)

○ Yes, I consent (4)

Skip To: End of Survey If After reading the information above do you consent to participate in this study? = No, I do not consent

End of Block: Description

Start of Block: Demographics

*

Q3 What is your age

____

Q4 Gender

○ Male (1)

○ Female (2)

○ Other (4)

Q5 Occupation

○ Student (2)

○ Full-time employee (3)

○ Part-time employee (4)

○ Freelancer (5)

○ Other (6) ____

Q6 Choose what applies to you:

○ Dutch (1)

○ Expat (Please specify nationality) (2) ____

End of Block: Demographics

Start of Block: Money related

Q7 Do you have a transportation subscription? (e.g., monthly pass)

○ Yes (1)

○ No (2)

Q8 How much money do you typically spend on trams weekly?

- Less than €20 (1)
- €20-€50 (2)
- €50-€100 (3)
- €100+ (4)

Page Break

Q9 How many times do you use the tram weekly (on average)?

- ○ Less than once a week (8)
- ○ Once a week (9)
- ○ 2-3 times a week (2)
- ○ 4-6 times a week (3)
- ○ Daily (4)

Q10 How many times do you use the tram in one day? (one way trip)

____

____

Q11 How much time do you spend on average traveling by tram from your origin to your destination? (one way trip).

- ○ Less than 10 minutes (1)
- ○ 10-20 minutes (2)
- ○ 20-30 minutes (3)
- ○ More than 30-40 minutes (4)
- ○ More than 40 minutes (5)

Q12 How many transfers does it take to reach the final destination?

- ○ None (1)
- ○ 1 transfer (2)
- ○ 2 transfers (3)
- ○ More than 2 transfers (4)

Q13 Which modes of transport do you use in combination with the tram? (select as many as apply to you)

- ▢ bike (1)
- ▢ bus (2)
- ▢ train (4)
- ▢ metro (5)
- ▢ I don't combine the tram with other modes of transport (6)

Display This Question:

If Which modes of transport do you use in combination with the tram? (select as many as apply to you) != I don't combine the tram with other modes of transport

Q14 How often do you experience delays in the timetable when using mixed transportation modes?

- ○ Rarely (1)
- ○ Occasionally (2)
- ○ Sometimes (5)
- ○ Frequently (6)
- ○ Almost always (8)
- ○ I don't use mixed modes (4)

Display This Question:

If How often do you experience delays in the timetable when using mixed transportation modes? != I don't use mixed modes

Q15 How inconvenient are these delays?

- ○ Not inconvenient (1)
- ○ Slightly inconvenient (2)
- ○ Moderately inconvenient (3)
- ○ Very inconvenient (4)
- ○ Extremely inconvenient (5)

End of Block: Money related

Start of Block: Travel

Q16 Which tram line do you use primarily?

- ▢ 1 (Muiderpoort Station) (1)
- ▢ 2 (Oudenaardeplantsoen) (2)
- ▢ 3 (Flevopark) (3)
- ▢ 4 (Drentepark) (4)
- ▢ 5 (Amstelveen Stadshart) (5)
- ▢ 7 (Azartplein) (6)
- ▢ 12 (Amsteldijk) (7)
- ▢ 13 (Geuzenveld) (8)
- ▢ 14 (Javaplein) (9)
- ▢ 17 (Osdorp Dijkgraafplein) (10)
- ▢ 19 (Diemen) (11)
- ▢ 24 (De Boelelaan/VU) (12)
- ▢ 25 (Westwijk) (13)
- ▢ 26 (IJburg) (14)
- ▢ 27 (Osdorp Dijkgraafplein) (15)

Q17 At which stop does your journey start?

____

____

Q18 At which station does your journey end?

____

____

Q19 Do you pass through a major station on your trip?

- ☐ Amstel (1)
- ☐ Bijlmer ArenA (2)
- ☐ Central (3)
- ☐ Schiphol Airport (7)
- ☐ Sloterdijk (4)
- ☐ Zuid (5)
- ☐ None (8)

Q20 If your primary tram line were to be disrupted for a prolonged period of time, would you have an alternative tram line to use, that does not significantly increase travel time?

- ○ Yes, without significant time delays (1)
- ○ Yes, But travel time is significantly increased (4)
- ○ No (2)

Display This Question:

If If your primary tram line were to be disrupted for a prolonged period of time, would you have an... = Yes, without significant time delays

Or If your primary tram line were to be disrupted for a prolonged period of time, would you have an... = Yes, But travel time is significantly increased

Q21 Would you consider adjusting your daily schedule or routines to accommodate the prolonged tram line disruption?

- ○ Yes, definitely (1)
- ○ Yes, maybe (2)
- ○ No, probably no (3)
- ○ No, definitely not (4)

Q22 What would be your alternative transportation mode if the primary tram line were to be disrupted?

- ☐ Other tram line (please specify) (1) ____
- ☐ Bus (2)
- ☐ Train (3)
- ☐ Bike (4)
- ☐ Car (5)
- ☐ Walk (6)

Q23 How many additional transfers would you require for one trip, if the primary tram line were to be disrupted?

- ○ 0 (5)
- ○ 1 (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4+ (4)

Q24 How would you rate the inconvenience caused by the increase in the number of transfers?

- Not inconvenient (1)
- Slightly inconvenient (2)
- Moderately inconvenient (3)
- Very inconvenient (4)
- Extremely inconvenient (5)

Q25 How would a prolonged disruption of public transportation services affect your daily routine?

- Not at all (1)
- Slightly (2)
- somewhat (3)
- Significantly (4)
- Extremely (5)

End of Block: Travel

Start of Block: Block 4

Q26 By how much would your travel time increase in the event of a disruption?

- 5 minutes (4)
- 10 minutes (5)
- 15 minutes (6)
- More (9) ____

Q27 Would long term tram line disruptions affect your punctuality at work or learning spaces?

- Not at all (1)
- Slightly (2)
- Somewhat (3)
- Significantly (4)

Q28 How much would these delays affect you?

- Not at all (1)
- Slightly (2)
- Moderately (3)
- Significantly (4)

End of Block: Block 4

Start of Block: Block 4

Q29 In your opinion, what measures could authorities undertake to mitigate the inconvenience caused by the prolonged tram line disruption during bridge renovations?

- Improved alternative transportation options (e.g., temporary buses) (1)
- Enhanced communication about the disruption and alternative routes (2)
- Implementation of temporary stops near disruption points (3)
- Accelerated completion of the bridge renovations (4)
- Other (please specify) (5) ____

Q30 Any additional remarks? please state question number and remark.

____

____

End of Block: Block 4