MALAK MAJED SHATNAWI

Assessment of the Impact of COVID-19 Crisis on Transportation Users –
Analysis of Passengers Satisfaction and Frequency of Mobility Use
Before and During the Pandemic: Budapest versus Amman

Professor Dr. Rajnai Zoltán

Doctoral School on Safety and Security Sciences

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Summary

The purpose of the research was to make an ssessment of the Impact of COVID-19 Crisis on Transportation. The pandemic of COVID-19 has had a substantial impact on a variety of industries, including the transportation and mobility sector; the purpose of this research is to examine the effects of COVID-19 on various modes of transportation for outdoor activities, as well as how transportation patterns and mobility options have changed and will continue to change as the situation evolves. Additionally, it investigates whether the applied restrictions and procedures limited the spread of the disease from the user's perspective and affected the mobility options and people's cognitive behavior towards travel. A survey questionnaire method has been chosen and implemented in two capitals, Budapest- Hungary, and Amman – Jordan, to assess the future impacts and risks of the pandemic on transportation sustainability; the first part of the survey characterizes the frequency of using the non-motorized and motorized modes of transportation such as walk, ride a bike, private car, taxi services, auto-sharing, and bus or metro/ train and tram, before and during COVID-19 pandemic for certain activities including commuting for work, education, leisure, social mobility, and shopping. The second section discusses the perceived risks of getting COVID-19 as a result of various means of transport modes; moreover, the survey measure and evaluate the impacts of mobility mitigation due to the transformation to e- (work, study, and services), additionally assesses the degree of satisfaction with Public Transport PT and how the participants rate the digital transformation that associated with the pandemic, to make the necessary assessments, the study utilized several variables based on the frequency of usage for each transport mode and mobility activity, the data and the hypotheses were processed and tested using SPSS v.26 and AMOS software. The findings revealed that the different demographical, spatial categories and characteristics significantly impacted the COVID-19 pandemic for each city. The collected data, the resulting analytical and statistical information, including the Exploratory Factor Analysis EFA, Confirmatory Factor Analysis CFA, and the Structural Equation Models SEM, emphasized what was stated in the hypotheses; it has been found that the impact of the pandemic on transport modes go beyond the traditional boundaries and the applied restrictions, although they are essential in the current stage, as the resulting models showed the extent of the strong correlation between the variables of the hypotheses, which will have the most significant role in determining the future influences. Such studies can benefit researchers and decision-makers responsible for developing mobility strategies, designing intervention mechanisms to manage the current pandemic, and planning for future risks.

Summary in Hungarian Language – Magyar nyelvű összefoglaló

A COVID-19 világjárvány jelentős hatást gyakorolt számos iparágra, beleértve a közlekedési és szállítmányozási ágazatot is. Ennek a kutatásnak a célja annak vizsgálata, hogy a COVID-19 milyen hatással van a szabadtéri tevékenységekre, a különböző közlekedési módokra, valamint arra, hogy a közlekedési szokások és a szállítási lehetőségek hogyan változtak és változnak a helyzet alakulásával. Ezenkívül azt vizsgálja, hogy az alkalmazott korlátozások és eljárások korlátozták-e a betegség terjedését a felhasználó szemszögéből, és befolyásolták-e a szállítási lehetőségeket és az emberek utazással kapcsolatos kognitív viselkedését. Két fővárosban, Budapest en (Magyarországon) és Ammanban (Jordániában) kérdőíves felmérési módszert választottak és alkalmaztak a járvány közlekedési fenntarthatóságra gyakorolt jövőbeli hatásainak és kockázatainak felmérésére. A felmérés első része a különböző szárazföldi közlekedési módok használatából eredő COVID-19-fertőzés észlelt kockázatait taglalja a nem motorizált és motorizált közlekedési módok használatának gyakoriságának jellemzésével, mint pl. séta, biciklizés, személygépkocsi használata, taxi szolgáltatások, automatikus megosztás, busz, villamos és metró/vonat bizonyos szabadtéri tevékenységekhez, beleértve; ingázás munka, oktatás, szabadidő, szociális és vásárlási mobilitás miatt a COVID-19 világjárvány előtt és alatt. A felmérés második része a mobilitás mérséklésének hatásait méri és értékeli a távmunka, tanulás, kézbesítés és szolgáltatások átalakulása miatt; ezen túlmenően a tömegközlekedési PT-vel való elégedettség mértékének felmérése, és a résztvevők hogyan értékelik a világjárványhoz kapcsolódó digitális átalakulást. A vizsgálat az egyes szárazföldi szállítási módok és az egyes szabadtéri tevékenységek használatának gyakorisága alapján számos változót használt a szükséges értékelések elvégzéséhez. Az adatok és a hipotézisek feldolgozása és tesztelése Excel, SPSS v.26 és AMOS szoftverrel történt. Az eredmények felfedték, hogy a különböző demográfiai jellemzők és területi kategóriák jelentősen befolyásolták a COVID-19 világjárványt minden városban. Az összegyűjtött adatok, a kapott analitikai és statisztikai információk, köztük az Exploratory Factor Analysis (EFA), a Confirmatory Factor Analysis (CFA) és a Strukturális Egyenletmodellek (SEM) hangsúlyozták a hipotézisekben megfogalmazottakat. Megállapítást nyert, hogy a járvány közlekedési módokra gyakorolt hatása túlmutat a hagyományos határokon és az alkalmazott korlátozásokon, bár ezek a jelenlegi szakaszban elengedhetetlenek, mivel az így létrejött strukturális modellek megmutatták a hipotézisek változói közötti erős korreláció mértékét, amelynek a legjelentősebb szerepe lesz a jövőbeni hatások meghatározásában. Az ilyen tanulmányok a mobilitási stratégiák kidolgozásáért, a jelenlegi világjárvány kezelésére szolgáló beavatkozási mechanizmusok kidolgozásáért és a jövőbeli kockázatok tervezéséért felelős kutatók és döntéshozók hasznára válhatnak.

A COVID-19 válság közlekedési felhasználókra gyakorolt hatásának értékelése – Az utasok elégedettségének és a szállítmányozás-használat gyakoriságának elemzése a járvány előtt és alatt: Budapest kontra Amman

1   Introduction

One of the major issues nowadays, the COVID-19 pandemic it is among the top subjects in both the world and Europe; all countries are in the same tragedies' crucible is that the COVID-19 pandemic is causing an inevitable disruption for sustainability in most vital sectors; the highly contagious coronavirus has been associated with numerous deaths and losses in the trades, tourist, transportation, and education industries, among many others [1]. However, the degree of risks varies depending on several factors related to the comparative advantages of each country. The pandemic is causing an inevitable disruption in most vital sectors; one of these is the public transport sector which struggles to maintain the safety of passengers by all available means, the transportation system's major concern is to reach an ideal and integrated transport sector which implies the provision of more efficient services that maintain public health and welfare with a cost-effective system to reduce the negative environmental impacts [2], such sector is capable of fighting any pandemic, facing the challenges, and ensuring continuity by establishing solid pillars wherever and whenever necessary; accordingly, this can only be achieved when the foundation is free from deficits and the infrastructure meets the criteria of health and safety with sustainability conditions. This research, through a questionnaire survey, will investigate the impacts of the COVID-19 pandemic on transport and mobility in two capitals, Budapest- Hungary, and Amman- Jordan; the central part of the study will be to understand the passengers' cognition towards traveling during the COVID-19 by assessing the impacts of the pandemic, analyzing the sustainability of mobility and the frequency of transport usage before and during the pandemic. The first part of the survey will characterize the frequency of using non-motorized and motorized transport modes before and during COVID-19, also the impacts on certain mobility activities such as work, education, free time, social, and shopping. The second part deals with the perceived risks of catching COVID-19 due to using different transport modes; moreover, the survey measures the effectiveness of mobility mitigation and the impact of the digital transformation and rates the degree of satisfaction with public transport PT from the users' perspective.

Researchers and decision-makers responsible for formulating mobility policies, planning, and designing mechanisms might benefit significantly from the survey results and analytical and statistical information. The present study will examine several main sections: theoretical research, methodology, data analysis, results, discussion, and conclusion.

2 Theoretical Framework and Antecedents of the Research

The current dissertation, through the theoretical part, will discuss previous studies and research that assessed the impact of the COVID-19 crisis on the transportation sector; the review began with the previous research and studies tracking what has been achieved so far, investigating and verifying the theories to enrich the study and to build on what is necessary. As the transport sector is continuously affected by changes, it requires an efficient technical design with sustainable considerations. Transportation risk management was brought to the surface during the COVID-19 pandemic to make the mobility sector safer, more secure, and protected against pandemics by adapting the appropriate measurements; the main challenge is to monitor human behavior through implementing developed methodologies, including identifying risk assessment tools, emphasis on the expected evaluated process, supported by concepts that specified and designed as guidelines, followed by communication and consultation in each phase [3]. The original survey that investigated the COVID-19 pandemic was conducted by analyzing the frequency of usage of each transport mode for outdoor activities and assessing the risks of catching the disease in light of the restrictions followed at the time [5]. The study states that the pandemic had a negative impact on the levels of services, health, and safety [6]. Several observations, qualitative and quantitate analysis found that to make a comparison between before and during the COVID-19 pandemic, one of the suitable scenarios is to measure the change in mobility and the frequency of usage for each transport mode [7]. A chi-square test was performed in many kinds of research to assess the relation between commuting days and type where the relationship between these variables was significant; the observations emphasized that the passengers for short-distance trips shifted to non-motorized modes such as walking and cycling [8], [9], many others have changed their modes of transport from public to private vehicles during the COVID-19, this shift will worsen the situation from the environmental point of view [10]. Previous studies in American, Canadian, Australian, European, and Asian cities show that private transportation modes consumed more than twenty times the energy consumed by public transport modes [11]. Moreover, COVID-19 led to a significant decrease in the frequency of trips during weekends since moving only for non-mandatory trips; in addition, the existence of a modern delivery system urged the use of digital facilities during the pandemic and accelerated the growth in delivery, services and e-shopping [12], [13], [14] It should be mentioned here that comprehensive companies that used more than one means of transportation to carry out their services achieved sustainability in transportation activities even with the COVID-19 pandemic [15]. To verify the structure of the survey and

become familiar with the analysis many studies adopted a conceptual model to find the impact of COVID-19 on transportation and logistics; the hypotheses were implemented and formulated by Structural Equation Modelling SEM, analysis comprising of Confirmatory Factor Analysis, CFA and path assessment [16], on the other hand, to identify the variables and implement statistical analysis; tests were applied such as normality, validity, reliability; multivariate statistical technique; structural relationship analysis; regression forecasting methods; path analysis; t-test and r- squared [17], [18].

The most positive global impact of COVID-19 was accelerating the digital transformation for sectors and individuals, smart infrastructure and intelligent transportation are considered one of the main objectives that have comprehensive approaches using advanced applications, AI, cyber technology, and autonomous technologies to evaluate the cities and transportation capacity [19], using smart applications will enable emerging technologies such as cameras, visions, and sensors for recognition to identify people, assessing the situation, checking social distances and physical situations by using Deep Neutral Network DNY [20]. throughout the day. Using public transportation during COVID-19 posed a threat to health; this should make planners seriously think of solutions using modern technology and smartphone applications for choosing the suitable transport mode and means during the day for certain activities, encouraging non-motorized modes as much as it could be by implementing certain services with suitable infrastructure and facilities [21]. There is a global focus on implementing digital acceleration by constructing smart cities with environmentally friendly situations, enhancing transportation quality, generating cost-effective commuting, reducing carbon emissions, and providing a safe and dependable transportation environment, [22]. As a result, investments must be made in virtual infrastructures that allow dual communication with and without transportation to make the future safer and more intelligent [23]. It appears that during COVID-19, transit users shifted to use private vehicles regularly instead of public transport, while those who have no choice but to use public transportation use it only for essential and urgent trips, mainly previous studies results showed that the behavior of passengers varies according to the different segments of the society [24], change in transportation behavior during a pandemic should not be underestimated because it has a long-term effect, for this many studies consider the activities and transport mode frequency of usage by comparing post and pre of COVID-19 mobility as the primary indicators; moreover, implementing mobility restrictions during the pandemic shifted to the preference of private vehicles over public modes [25], [27]. A survey to assess the effect of COVID-19 on the transportation sector, from respondents' perspective, was distributed during 2020 and implemented in ten countries around the world, done by (Mobility and perceived risk associated with mobility in Australia, Brazil, China, Ghana, India, Iran, Italy, Norway, South Africa, and the United States) is considered one of the essential studies that assess the relationship between the degree of catching the disease, the transport mode and the type of activity that the individual practice also the investigated the effectiveness of the applied

measurements and restrictive instructions, the study showed a significant relationship between transport mode, activities' frequency and have a direct connection with the distinctive features of each city [5], although the COVID-19 pandemic affected the whole world without discrimination, the impact was not the same for the developed, and developing countries, i.e., culture, attitude, economic level, and population density have a significant influence [28], per contra pandemic may enhance sustainability and improve the environment, for example, but not limited, people in New York City without cycling backgrounds have turned to cycling to minimize the exposure period [29], Australia [30], and Bogota, Colombia [31], during the pandemic did the same for short trips.

3 Objectives of the Research

The study will examine all forms of land transportation in order to evaluate how the COVID-19 pandemic has affected people's behavior in light of various demographic and other factors. The research intends to link changes in the frequency of usage of motorized and non-motorized transport modes and various necessary or recreational activities with the forced restrictions that were applied on transport modes to contain the disease; in addition, users will rate the degree of satisfaction from the public transportation modes and the services. Finally, we will investigate the digital transformation for e-(study, work, shopping, and services) from the participant's point of view).

4 The Research Investigation problem, Research Design, Hypotheses and Methodology

The Research Investigation Problems

Transportation sector is an active focal point for disease transmission it was necessary to study the impact of the pandemic on the transportation sector from the point of view of users and their satisfaction in the light of the applicable preventive measures and applied instructions, and to measure the impact on the sustainability of the transport sector, in addition to anticipating the future of the digital transformation from the users' perspective. Compared to other pandemics, the seriousness of the COVID-19 pandemic is that it is not confined to a certain region to be quarantined and contained as its predecessors; unfortunately, the disease is developed itself, and many waves appeared so that vaccines do not constitute complete protection. In the early stages, it was important to take the necessary precaution, including avoiding crowded places as much as possible to avoid direct contact with others, but unfortunately, some people disregarded safety measures, whether when using transport modes or in other places, this led to serious disasters, especially in societies that have older people [32], [33]. The main feature research is divided into five sections to evaluate the risks of the pandemic and assess the negative impact on the

sustainability of the transportation sector. The current situation will be assessed through a survey questionnaire that has been distributed in the two capitals, Amman and Budapest; such a questionnaire would be the first alternative for mobility studies during the pandemic because this data is concerned with individuals and compare the frequency of movement and mobility through different modes of transportation and for various activities before and during the pandemic, is not available or documented by the authorities concerned with the transport sector in both countries to date, the following Figure 1 shows the variables relevant research
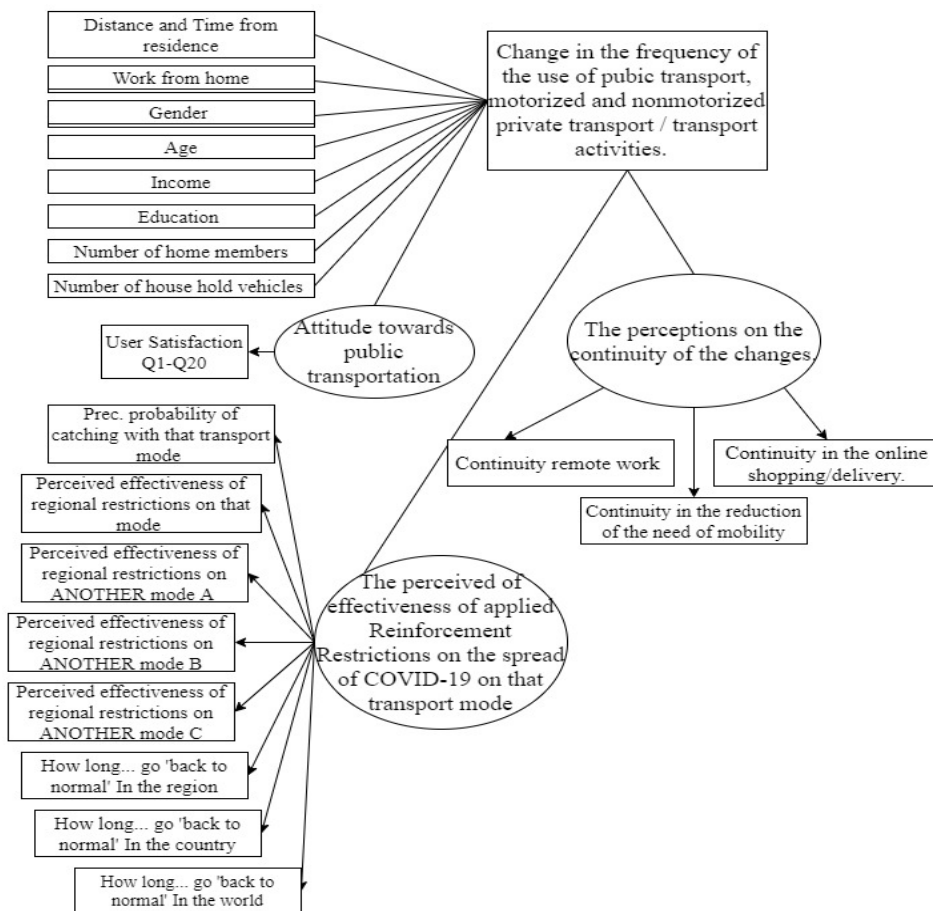

Figure 1: The variables relevant research

Research Design

A survey with a Google Form questionnaire was distributed in three languages: English, the main language of the original version, Arabic and Hungarian. We used a questionnaire with different scales such as frequency of usage form as a matrix question of several multiple-choice simultaneously in a grid format, multiple choice, Likert scale with seven options, and open-answer questions. The main sections of the initial design concentrated on the frequency of usage of mobility modes and activities before and during the COVID-19 pandemic and assessed the probability of catching the disease through the frequent use of transport modes as posted in the original questionnaire [5], [34], the used mechanism is to measure the frequency of usage before and during the pandemic for non-motorized modes such as (Walk or Riding a bike) and motorized modes such as (Motorbike /Private car, Taxi services /Auto sharing with or without other passengers, Bus, metro/train, and train) and for each activity such as (work/study, free time, social activities, essential shopping, and non-essential shopping) illustrated in hypothesis, H1; the structure design, activities vs. transport mode and the expected attitude and change in activities and modes respectively [35]. Theoretically, it is assumed that either in Amman or Budapest, the pandemic had an impact on human behavior; this will be assessed in the current study to investigate the priority modes of activity choices from participants' perspectives. The plan is intended to generate two separate studies with the necessary comparison between the two cities; each model will assess the mean behavior for all categories.

The requirements for the comparison between before and during COVID-19 undergo several tests; the analysis started with verifying the parametric or non-parametric characteristics[36],[37] and ending with checking variables' the significances and research models [38], [39]. The checks for normality and homogeneity were carefully handled for each assumption separately [40]. The dependent variables identify the main goal of the research which is the frequency of transport mode use for different mobility activities in essence, how mobility manifests and the variables was in the form of a matrix [41] that contains both frequencies with activities before and during the pandemic, for pre and post-COVID-19, the variable was related to the mode chosen and frequency for each activity; a significant relationship between some demographical and other characteristics has been measured; for example, during COVID-19, the distance and the purpose of the trip are significantly correlated with a certain degree with trip purpose either it is an essential or not [42], other variables to measure; the perceived effectiveness of regional applied restriction on the spread of COVID-19 on each transport mode, passenger satisfaction with public transportation, and additional variables to investigate from the participants' perspective whether the digital transformation in e- (study, work, shopping and services) will continue to grow in the future even after the end of the pandemic. The variables are illustrated in Figure 1 above.

Hypotheses

The primary objective of this study is to assess the impact of the COVID-19 on mobility and transportation modes according to the following hypotheses:

1- The First Hypothesis H1

The frequencies of usage of each transport mode for outdoor activities have significant differences before and during the pandemic [43]:

1.1. The First Sub Hypothesis (H1.1)

The frequencies of usage of non-motorized transport modes (Walking/ Riding a bike) for outdoor activities have significant differences before and during the pandemic.

1.2. The Second Sub Hypothesis (H1.2)

The frequencies using of private transport modes (Motorbike/ Private car) for outdoor activities have significant differences before and during the pandemic.

1.3. The Third Sub Hypothesis (H1.3)

The frequencies of usage of taxi services (Taxi services/ Auto-sharing; with or without other passengers) for outdoor activities have significant differences before and during the pandemic.

1.4. The Fourth Sub Hypothesis (H1.4)

The frequencies of usage of public transportation PT for outdoor activities have significant differences before and during the pandemic.

2- The Second Hypothesis H2; rate the probability of catching the disease while using transport modes and the applied procedures and restrictions on transportation to limit coronavirus spread in each mode have significant effects on transport users [44][45].

3- The Third Hypothesis H3

There are significant effects of passengers' satisfaction with public transportation modes and their services [46].

4- The Fourth Hypothesis H4

The trend towards digital transformation e-(learning, work, shopping, and services), even after the end of the pandemic, and the use of smart applications have significant effects and positive impacts on the quality of life [47].

Methodology

The methodology consists of; the pilot study from the Primary Research Sample survey, the main study and research which contain the final survey design, the methodology investigation plan, data collection characteristics, the variables for each hypothesis and the statistical analysis procedures and implementation for the two cities, Amman and Budapest.

To test the hypotheses, the study employed quantitative data from a survey using various statistical techniques; various univariate statistical techniques were employed to test the interaction of demographic variables such as gender, education, online learning or working, age, occupation and income. Using Structural Equation Modelling SEM, variables were ranked based on their strength of impact, the nonparametric tests; Wilcoxon Signed Ranks, Kruskal-Wallis and Mann-Whitney confirmed the findings of statistically significant differences between the particular variables and revealed statistically significant differences between before and during COVID-19.

The survey items and paragraphs were assessed with statistical analysis, that was processed using Microsoft Excel, statistical program analysis SPSS v. 26 [48], and AMOS [49], all are utilized to discuss the needed statistical tests, viewing the outcomes, testing the hypotheses of the study by several statistical methods to examine the relationship between the variables. The primary and main statistical analysis consists of the following:

- Reliability to measures the stability of the sample [50], by Cronbach's Alpha we measured the internal consistency [51], Validity to measure the correlation between variables, degree, and direction of the relationships using Pearson Coefficient to generate a correlation matrix for all items of the hypothesis [52]; the mean, standard deviance, variance, skewness, and kurtosis [53] were generated to make the necessary comparison, the reliability and Validity results for all hypotheses were acceptable.

- Levene's test shows the confidence intervals and identifies the most relevant variables that have significantly higher (or lower) variances [54], Analysis of Variance (ANOVA), and the normality of the data, which showed that non-parametric techniques are suitable to be implemented, check the skewed and kurtoses.

- Exploratory Factor Analysis EFA [55], explains the relationship between variables, a very important analysis is the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of Sphericity[56], the test measures sampling adequacy for each variable in the model and the complete model, Confirmatory Factor Analysis CFA, to confirm the relationship between variables by test the hypotheses and allow the assessment of fit for the model that specifies the hypothesized causal relations between latent factors and their indicator [57]; finally, Structural Equation Models SEM [58], which is used to describe the connections between variables.

5 Scientific Results

The main objectives and assumptions set during the study were achieved; based on the findings, the hypothesized relationships were postulated for testing and evaluation; these appraisal approaches are needed to evaluate and make decisions more acceptably and beneficially. The results showed differences in mobility modes and passengers' behavior in the two cities since the transport systems are unlike, i.e., Budapest, which has a developed public transport system that meets the passenger's requirement; however, this wasn't a choice in Amman as most of the people use individual means of transports such as private cars or taxis due to lack in public transport systems. The major change in mobility in Budapest shows a negative shift in the use of public transport PT due to reduced activities because of the quarantine and as a precautionary measure to reduce the risk of catching the disease. Analysis of the remote working and studying reflected the satisfaction of the online activities rating as it was higher in Budapest compared to Amman due to a lack of readiness in the digital infrastructure. One of the main purposes of the study was to establish a comprehensive study model that can be utilized for assessing transportation modes during the pandemic.

The variables fulfill the hypotheses requirements in most cases:

Hypothesis H1; there are statistically significant differences between before and during the pandemic, and it was in favor of frequency of use before; additionally, the only transport modes that showed an increase in the frequency of mobility during the pandemic were the non- motorized modes that was for the study and work activities, the PT users in Budapest decreased by 12%, while in Amman the mobility of cars decreased by 9%, which is the main mode of transportation.

Hypothesis H2; the applied restrictions and the probability of catching COVID-19 while using transport modes show that PT for both cities has the highest value; they were ranked as high to extremely high while walking or riding a bike as well as private cars were considered in both cities as a safe mode to avoid catching the disease, the rate of the measures and restrictions that the authorities applied in both cities were in the range of slightly low to average.

Hypothesis H3; it can be seen that according to the satisfaction from PT, the passengers in Amman are (in the range of disagree to slightly agree) compared with (agree) in Budapest; this reflects the quality of the developed PT system in Hungary, on the other hand, the results indicate that the passengers in both cities are dis-satisfied with the fare rate and the distance between the stop-stations and the place of residence[59].

Hypothesis H4; for e-learning and working, the respondents in Budapest completely expected an increase in digital transformation even after the end of the pandemic, while in Amman, respondents disagree that remotely or partially studying and working will continue in the future. In contrast to that, both Amman and Budapest respondents agreed that the global acceleration toward digital transformation and the use of smart applications to obtain e- (payments, delivery, and services) would continue to grow even after the end of this pandemic and the use of smart applications will have a positive impact on the quality of life in the future [59].

Structural Equation Models SEM

The developed models for the two cities achieved
through several analyses process using SPSS v.26 and AMOS software, which were found reliable; the models were run through EFA and CFA factor analysis to determine the best combination of items, the factors, and latent variables with the acceptable fit. The study established the factors that have a significant influence by adequately identifying the impact of COVID-19 on modes, mobility, and passenger satisfaction by using suitable statistical techniques and structural equation modeling.

The hypotheses ranked based on the strongest impact models and best fit model from SEM (see Figures 2,3,4 and 5) as well the values and path coefficient were used to assess the links between the estimated variables. Accordingly, all the values followed the proposed expectation of the impact of COVID-19 on transportation and mobility for each hypothesis.

After computing the measurement models and utilizing the fit statistics tests, the results show that the best fit models for Amman and Budapest are significant when joining every two hypotheses since they gave the strongest impact models as follows:

1- Model 1 consists of hypotheses H1 and H2; identify the relationship between COVID-19 and transport mode as the correlation between the difference in mobility for the same activities before and during the pandemic and the probability of catching the disease while using the different transport modes; both hypotheses are statistically significant for Amman and Budapest as depicted the figures 2 and 3 below; by obtaining specific indexes and the p-value (probability) of less than 0.05 when applying for SEM the models were accepted, the findings revealed that the moderate degree of infection or catching the disease is the core factor influencing the respondents in deciding mobility and they matched the theoretical suggestions.

2- Model 2 consists of hypotheses H3 and H4; they have supported the assumptions, and the results improved significantly by utilizing both hypotheses together; the model evaluates the rate of satisfaction with PT and the use of digital transformation during the pandemic; it is essential to point out that the link is vital because generally, most people are dissatisfied with PT, especially in terms related to services, fare rate, or proximity to housing. The desire to keep studying and working remotely and providing e-services, and facilitating transactions electronically are part of people's desire to decrease contact with others by staying away from PT which is considered a hotspot for virus transmit [59].

Figure 2: SEM correlation for change of movement due to COVID-19 for transport modes of Amman

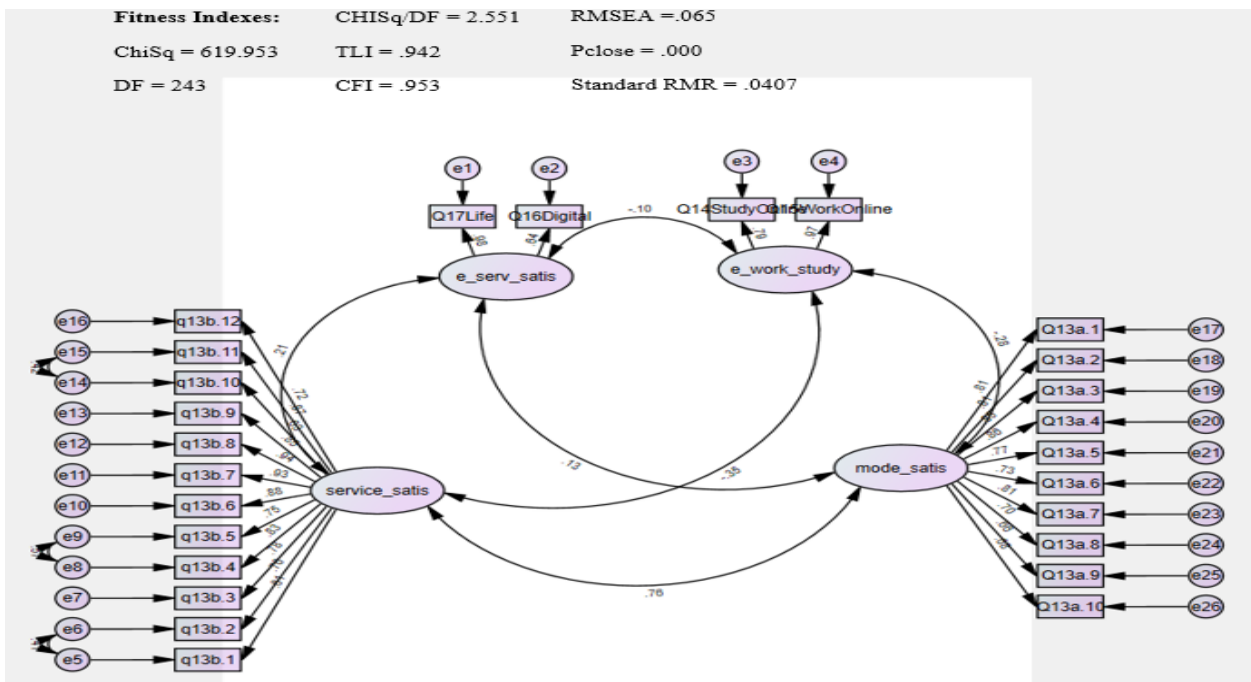Figure 3: SEM correlation for change of movement due to COVID-19 for transport modes of Budapest

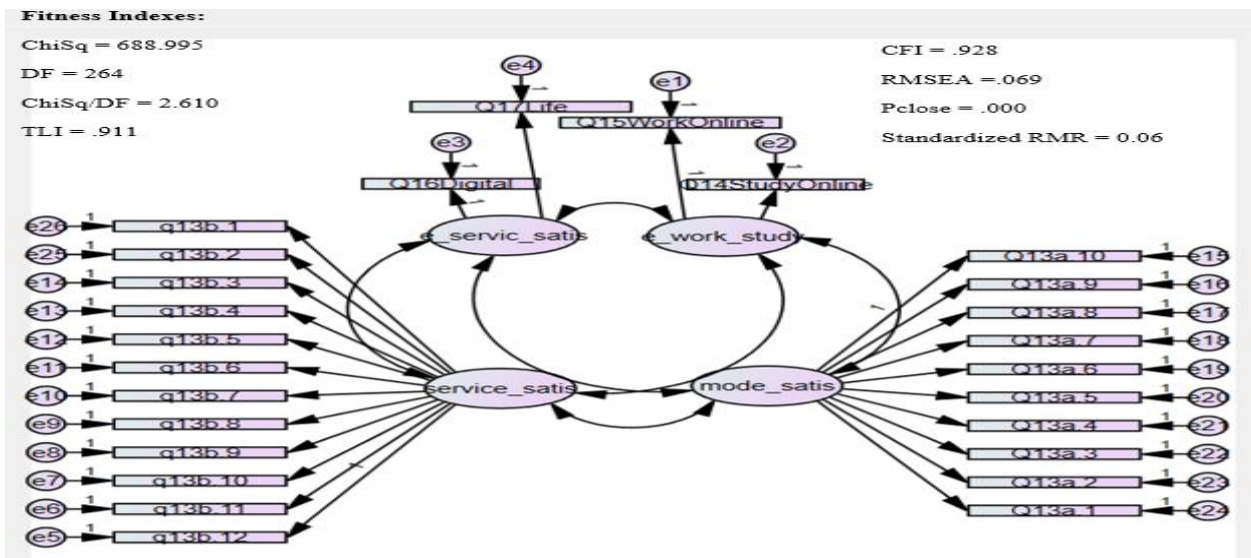Figure 4: SEM correlation satisfaction from PT and digital transformation of Amman

Figure 5: SEM correlation satisfaction from PT and digital transformation of Budapest

6 Contribution and Achievements of the Study

The current research aimed to identify factors that should be considered in a comprehensive study of the transport sector during the influence of the COVID-19 pandemic. After extensive research review and investigations of the previous studies that were tackled from both qualitative and quantitative perspectives, I found out that there is a missing case study framework that should contain a comprehensive model approach that can test the impact of the pandemic on the transportation sector by taking into account several factors including under control human factors and imposed emergency factors, such data was not available or documented by the authorities concerned with the transport sector in both countries.

The major contribution of this research is that it followed a survey questionnaire to identify and validate the required processes using a holistic approach that comprises an individual's behavior, rates the effectiveness of the PT policy, and compares the frequency of movement and mobility modes for various activities before and during the pandemic. Further, the study contains indicators that connect the change in transport modes and mobility activities with the effectiveness and efficiency of the applied restriction to prevent the spread of the disease and link these with digital acceleration and the use of e- (work, study, shopping, and services) even after the end of the pandemic; this had not been investigated previously in one research, all of these are connected with the degree of satisfaction with the PT; however, these appraisal approaches are needed to evaluate projects and make decisions on the more acceptable and beneficial way. By analyzing the impact of the COVID-19 pandemic on the transportation sector and its sustainability, the current research analysis is needed and would be the first choice for mobility studies; it can directly shape the performance of the public transportation sector during any stage of the pandemic and any future pandemic if it occurred.

In addition, the findings of the study, in light of the challenges and continuous updates that occur on the scene without enough risk management precautions, would ensure high preparations for an early alert system to handle critical and vagueness variables.

The current study does support the previous studies, with a particular contribution that involves linking all aspects related to decision-making regarding the behavior of individuals towards transportation and mobility in a comprehensive and unified study that integrate models to reveal all the influential aspects; the study developed a mixed-methods and adopted several statistical techniques including using exploratory factor analysis, confirmatory factor analysis, and structural equation modeling, established models with significant factors and indicators which will enrich future research and influence decision making. Therefore, it is recommended to use similar testing studies of different reliable models to reach a sustainable transport system with continuous performance improvement.

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