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Modeling the Optimal Capacity of Tehran's Imam Khomeini Subway Station for Minimizing the Spread of Infectious Respiratory Diseases

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Abstract: - The main goal of this study is to provide a model to determine the optimal capacity of the metro station with the aim of minimizing the incidence of infectious diseases. At first, the studied area of Imam Khomeini metro station in Tehran was investigated. After collecting the information, effective demand indicators and statistics of the years before Corona, as well as structural observations during the outbreak of Corona, were identified and their information was reviewed. After confirming the reliability and validity, the factor analysis was evaluated and classified and prioritized in the conditions of Corona. According to the results of the factor analysis in order to categorize and reduce the variables in connection with the model for determining the optimal capacity of this station in the conditions of Covid, the most important of them are: sample percentage. Number of employees per day, people's access to metro by taxi, percentage of car owners, percentage of business and service trips, average income, percentage of office trips and crowding index on footpaths with respect to social distance with more important priority in factor analysis in measuring optimal capacity. Metro station was measured.

Keywords: subway station capacity; contagious diseases; multi-factor modeling; capacity analysis; rail transportation

I. INTRODUCTION

Urban planning and policy-making in most countries across the world in the past decades were employed to sacrifice public priorities, especially welfare services, for some policies and measures aimed at increasing urban economics and efficiency, while some approaches as creative cities, urban regeneration and the like were abandoned. Now, most cities have lost their functions in confronting a predictable crisis, as many people have lost their lives. With the expansion of societies and development of communications between various cities worldwide, modern life is not simply related to a city, as each and every city affects the other. Moreover, "communication between humans" lays the foundation for the formation of cities, which may leave adverse impacts in the occurrence of some crises such as the prevalence of diseases, although contributing to managing the entirety of crises. The recent spread of Covid-19, which started from Wuhan, China, and has affected many cities across the world, indicates that, in addition to analyzing cities as distinct elements, it is essential to specifically view global developments in other cities and countries across the world in order to identify and prevent possible dangers facing cities and to provide proper measures against them. One of these areas is the public transportation system where observing social distance is highly difficult. As the number of Coronavirus cases goes up, more public transportation employees fall ill, which necessities necessary planning for the transportation system. As a consequence, a plan should be introduced to reduce the level of services provided by trains, buses, etc. in the network.

People's commuting in subways and its effects on the spread of coronavirus, as well as the behavior of passengers and stations in crowded areas is a hot topic that has received less attention in countries. Therefore, the removal of limitations at stations to bring this disease under control and the prevention of serious damages to economies are critical questions. For this, an agent-based method was used to analyze this effect. The global prevalence of Covid-19 has affected trip behaviors and transportation activities, as cities are grappling with policies related to this issue, which can help restore activities and social distancing. This study aimed to optimize the capacity of subway stations to minimize the development of Covid-19 and present an agent-based simulation model. It also uses real-

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time imaging processing to measure social distances via cameras at stations. In the meantime, the agent-based model can easily reveal the two-way effects between agents and the surrounding environment. In addition, the model presents various behaviors done by agents across simulations. Agent-based modeling provides a framework that can test and respond to real errors without attention to real costs, because it is just a simulated environment of real conditions. Zheng, Son, and Chiu (2013) used this method to calculate station capacities, as the accurate determination of the type and characteristics of the agents can help provide a comprehensive model. In the agent-based system, two factors of time and places can be examined and modeled alongside each other. For this, the effects of components can be used to achieve overall results that help optimize the capacity of subway stations to prevent the prevalence of contagious diseases such as Covid-19.

Literature Review

Tamannaie and Vali (2018) did a study "Presenting an Algorithm to Optimally Remove Railway Network Bottlenecks to Explain the Electrification of Axes (Case Study: Railway Axis of Iran's Shomal Railway". Here, researchers provided an algorithm that could be used in modifying railway network capacities, which would economically explain the railway axis electrification. The railway axis intended for electrification was Iran's Shomal Railway. This axis has a high potential in attracting railway loads. This study adopted various scenarios and considered the increased railway load attraction and cost-benefit economic analyses as the most important comparison criteria. Results indicated that the development of the said railway axis electrification could not be explained alone and without removing capacity bottlenecks in other areas of the network, as the said axis failed to attract considerable railway loads. In the meantime, findings underscored the removal of capacity bottlenecks to increase the attraction of loads in the northern areas. The algorithm proposed by this study can be used in decision-making about the efficacy of the axis electrification projects and help experts and railway managers to adopt relevant measures.

In a study "Presenting a Framework to Improve Railway Passenger Satisfaction Using Structural Equation Modeling", Khodabakhsh (2019) measured passenger satisfaction with the provision of public railway services. In this study, he used the structural modeling and factorial analysis to achieve the framework under consideration. To meet the results, a questionnaire was devised and given out to passengers (as the statistical population of the study). Findings referred to the factors that most affected passenger satisfaction, which included safety, peace and quality of services. Also, the quality of services, together with three components of services, information and personnel were found to have the highest effects on passenger satisfaction.

In a study "Examining Various Concepts of Public Transportation Systems for Long distances", Li et al. (2017) did a detailed study of new busses within the new long-distance public transport buses (LPPT), which could strengthen the abilities of urban communities and trip touring diversity. This public transport system (LPPT) mostly focused on providing fixed-transport stations along highways and urban services in a hierarchy for greater stimulation of trip demands and infrastructure, as well as expanding utilization along non-critical traffic areas and greater development. Using the SWOT-AHP quantitative analysis, this study estimated the priorities of threats and weaknesses of the LPPT to be relatively low, while reporting the compatibility ratio of less than 0.1. Thus, the LPT's capability of implementing the system was well demonstrated. In sum, the study showed that new potential routes within this type of public transport system at different time intervals could bring about more economic development and balance in cities, which would create justice in business environments and desirable economic advantages in different areas.

In April of 2020, the WHO estimated around 7 million cases of Coronavirus and 300.000 deaths. International concerns are on the rise due to high prevalence rates and consequently the rising number of mortalities. Iran also registered the first cases of Covid-19 in March 2020. A study with a statistical population of 99 Covid-19 cases in the city of Wuhan, China, including 67 men and 32 women, with an average age of 55, had the following data: Fifty-one percent of the patients had a history of chronic diseases. The patients also recorded the following symptoms: fever (83%), coughing (82%), and shortness of breath (31%), myalgia (11%), vertigo (9%), headache (8%), sore throat (5.5%), chest rib pains (2%), diarrhea (2%), vomiting and nausea (1%) (Cheng et al., 2019).

De vos (2020) investigated the effects of Covid-19 and social distancing on trip behaviors, concluding that officials in charge of transportation systems should focus more on using the safe transfer of passengers at the time interval when social distancing was implemented This subject was very critical because many people did not have personal cars or suffered from physical problems, and this resulted in providing public transportation, which facilitated better commuting conditions. This made people have greater tendency to using public transportation.

Golboum and Cook (2020) suggested that although public transportation services could be affected by these conditions, providing better subway and bus services, reduction of distances and stops at stations could help maintain the transportation capacity, while protecting social distancing. Of course, the government should also engage at this time. Policymakers and planners are also suggested to provide more safe spaces in cities to help people go to their workplace more easily (on foot, bicycle, motorcycle, etc.).

Chinazi et al. (2020) argued that on of the major factors contributing to the spread of Covid-19 was the ineffective management of transportation systems. They also investigated the spread of the disease in China and examined all trips to and from Wuhan from Jan. 23, 2020 onwards. Then, they investigated Chinese measures to ban the trips and found that the imposition of the bans could reduce the number of affected people by 50%. Also, they simulated a reduction of 90% in all the trips and determined the effects of transports on the relationship between people and the prevalence of the disease.

Objectives of the Study

The main goal of this study was to provide a multi-agent-based model of determining the optimal capacity of subway stations to reduce the development of contagious diseases. This study investigated the optimal capacity of subway stations using an agent-based model and analysis, while seeking to reduce the development of contagious diseases and presenting ways that affect it.

Determining Criteria Affecting Capacity

The method of this study was aimed to achieve a model to measure the type and effects of the behavior of passengers commuting in subways during Covid-19 on capacity indicators of subway stations. For this, the study did a review of the past literature to state hypotheses and goals and to collect data required for the study. Modeling was based on the characteristics of people behavior as seen in images prior to and after the onset of Covid-19 at stations under study. In multi-agent modeling, which is a modeling approach to capacity measurement, peoples' independent actions and interactions are examined to evaluate their effects on the system in general. The present study used library and field survey methods, while collecting data from books, articles, theses and questionnaires. In the library method, data about the agent-based model and the optimal determination of subway stations aimed at minimizing the development of Covid-19 prior to the ratified proposed plan were collected by studying books, articles and the past literature. The first step to meet the study objectives was to collect data and delve into their realities, as this method could be used in all scientific research when it comes to library methods. To collect data in theoretical foundations and literature review, books, articles, and databases, both domestic and foreign, were extracted and used.

Based on a review of articles concerning determining the capacity of public transportation stations, especially subway transportation stations in various countries, this section considers 19 initial variables to optimally determine stations under Covid-19; these variables were extracted for 30 days of 30 observations each day based on subway station demands on special days and Covid-19 limitations using statistics and environmental surveys, as well as the level of crowdedness at stations. This yielded a final 900 observations and samples for the capacity determination under the special conditions. In the following, these indicators are statistically investigated. Also, after examining the reliability of the data observed, factorial analysis s used to select the most important variables too model and present the capacity determination model (Table 1).

Table 1. Changing evaluation variables to determine the optimal capacity of Subway stations under Covid-19 conditions.

Row	Variable name
1	Variable affecting the determination of optimal capacity under Covid-19 conditions
2	Percentage of sample employees per day

3	Percentage of trips-commercial and service uses
4	Indicator of crowdedness on pedestrian zones by observing social distance
5	Acquiring public access to subways by taxi
6	Average income levels (20 for very low and 100 for very much)
7	Acquiring public access to subway by foot
8	Percentage of the number of car owners
9	Quality of access to stations from the working place or home
10	Acquiring individuals' use of subways per week
11	Percentage of trips-office uses
12	Percentage of trips-recreational and tourism uses
13	Acquiring people's access to subway stations via driving
14	Acquiring people access to subways by BRTs
15	Average sample individual age per day
16	Percentage of trips-residential uses
17	Quality of services provided by subways-expected service capacity
18	Percentage of the number of students
19	Acquiring public access to subways by buses

II. MATERIALS AND PROCEDURE

Factor Analysis

Factor analysis is a general term to refer to some multi-variate statistical methods, mainly aimed at data summarization. This method investigates the internal consistency of a large number of variables and finally categorizes and explains them in the form of some limited general factors. Factor analysis is a correlated method, which simultaneously considers all variables; in other words, it is divided into Q and R types, with each of the variables considered as a dependent variable.

Initial Foundations of Factor Analysis

Galton was the first one who founded the cornerstone of factor analysis. He was followed by Carl Pearson who, in the early 20th century, presented factor analysis based on a multi-dimensional geometric space. Later, this method was employed by McDonald to identify crimes and their relation with people physical characteristics. In 1904, Spearman introduced the mathematical models of this method. These measures led to the formation of the very pillars of factor analysis, which is today used in various disciplines such as psychology, economics, sociology, management, medicine, etc.

Correlation Matrix

The first and the most important point in using factor analysis is to calculate the correlation matrix. To do this, it should be determined whether the goal is to calculate correlation between variables or between respondents; if variable summarization is intended, the correlation between variables must be calculated. In this case, the technique used is factor analysis of Type R. If the goal of factor analysis is to combine and classify respondents in various groups, the correlation matrix between respondents must be calculated and used, which is labeled as factor analysis of Type Q. This method is, however, less used to its difficulty, while such methods as cluster analysis and hierarchical grouping are used instead.

Selecting Appropriate Variables for Factor Analysis

One of the methods to select appropriate variables in factor analysis is to use correlation matrix. Since factor analysis is based on non-causal inter-variable correlation, the correlation matrix between variables is calculated in this method. This matrix represents the relationship between variables to form clusters, with the variables inside each cluster being correlated together; however, there is no correlation between the variables in various clusters. Other methods by which the researcher can determine the appropriate data for factor analysis is the KMO (Kaiser-Meyer-Olkin) Test. The statistical value of this test constantly ranges from 0 to 1; if the value is less than 0.5, data will not be appropriate for factor analyses, and if the value ranges from 0.5 to 0.69, factor analysis can be performed with greater care; meanwhile, if the value is over 0.7, data correlation will be appropriate for factor analysis.

Statistical Modeling

The general linear model relates together a number of various statistical models; Analysis of variance, analysis of covariance, multivariate analysis of variance, multivariate analysis of covariance, ordinary linear regression, student's t-test and F-test. The general linear model is a generalized form of the linear regression model of over one dependent variable. If Y, B and U are column vectors, the above matrix equation will represent linear regression.

Hypothetical tests using general models can be done in two ways: multivariate in the form of various independent univariate tests. In multivariate tests, Y columns are examined together, while in univariate tests, Y columns are independently examined. For example, univariate tests of identical design matrices.

Multi-linear regression is a generalized form of linear regression, formed by considering over one independent variable and a special case of general linear models by limiting the number of interdependent variables. A basic model of linear regression is as follows:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_p X_{ip} + \epsilon_i. \quad (1)$$

In Equation (1), there are n observations of a dependent variable and p independent variables. Thus, Y_i is the i*th* observation of the dependent variable, X_{ij} is the i*th* observation of the i*th* independent variable where j_1, p_2, …=. β_j values represent estimated variables and εi is the i*th* ordinary independent error, equally distributed.

Data and Case Study

Imam Khomeini Subway Station

This station officially opened in June 1999, and is considered the main subway station in the city of Tehran, which became the most crowded subway station after the Sadeghiyah station. This station is constructed in the depth of 19.25 m of the ground level and has an area of 17965 m^2. This station is also equipped with elevators for the commuting of disabled people.

Entrances

One of the entrances to this station is Sardar Ghourkhane. This station has five entrances of northern corner, southwestern corner, western corner of Imam Khomeini Sq. Imam Khomeini St. and Khayyam St. Entrances to this station lead to Imam Khomeini Sq. and Bab-e-Homayoun Ave.

Public Facilities of the Station

Some of the public facilities include card telephone, escalators, emergency sections, missing objects, ramps (for the disabled), elevators, cool water systems, bus terminals, signal and messaging systems, taxi terminals, bicycle stations, etc.

Tourism Attractions and Location

The following image shows the location of the Imam Khomeini Station. As noted, some of tourism centers around it include Kakh-e-Masoudiya, Kakh-e-Golestan, Moqaddam Meuseum, Park-e-Shahr, Champs Elysees Mall, Imam Zade Yahya, old Lalehzar and Sarcheshmeh Neighborhoods, etc. which play key roles in terms of tourism attractions and historical sites of the city of Tehran.

Passenger Statistics and Data

Some of traffic data in the station are illustrated as follows (Figures 1, 2).

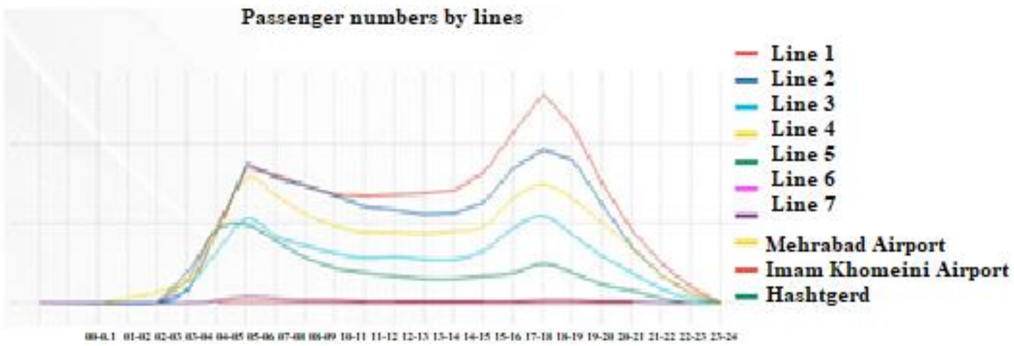

Figure 1. Passenger numbers in various lines at time intervals.

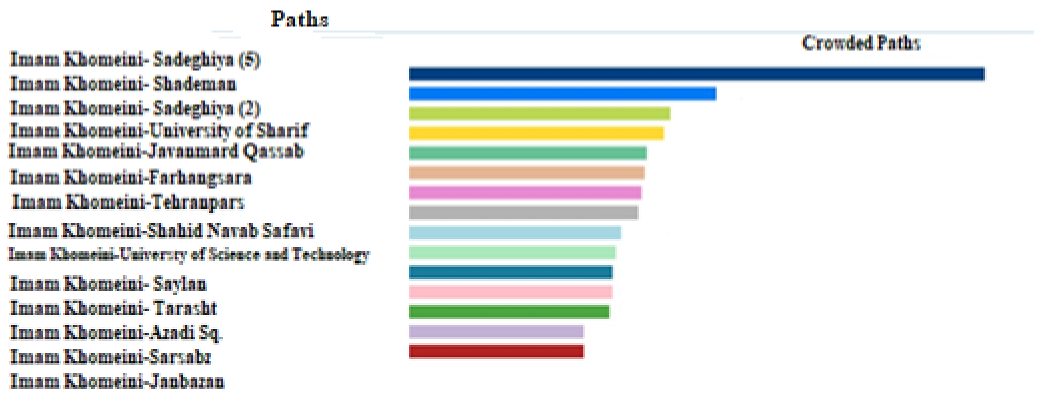

Figure 2. High frequency routes leading to Imam Khomeini Station.

Field Survey at Imam Khomeini Subway Station

This survey consists of short questions and involves some personal characteristics. The main goal of this type of data collection was to investigate the dominant and mixed modes used at the Imam Khomeini station, which are considered as mixed transportation mode options for tourist accessibility to services around the station.

Gender

Distribution of respondent gender presented in Table 2.

Table 2. Distribution of respondent gender.

Gender	%
Male	64.2
Female	358
Total	100

Age

Distribution of respondent age provided in Table 3.

Table 3. Distribution of respondent age.

Age	%
20 years and lower	7.4
21-30 years	46.5
31-40 years	32.2
41-50 years	9.1
51 years and above	4.8
Total	100

Occupation

Distribution of respondent jobs presented in Table 4.

Table 4. Distribution of respondent jobs.

Jobs	%
Employees	25.2
Self-employed	31.6
Worker	14.7
Academic student	17.3
Student	4
Pensioner	4.1
Housewife	2.3
Others	1.8
Total	100

It is noted that 25.2% of the respondents were employees, 31.6% self-employed, 14.7% workers, 17.3% academic students, 4% students, 3.1% pensioners, 2.3% housewives and 1.8% others.

Education

Distribution of respondents' use of subway stations provided in Table 5.

Table 5. Distribution of respondents' use of subway stations.

Education	%
Under diploma	5.8
Diploma	36.6
Associate's	9.5
B.A.	37.1
M.A	4.4
Ph.D.	6.6
Total	100

It is noted that 5.8% of thee respondents held under diploma degrees, 36.6% diploma, 9.5% associate's, 37.1 B.A., 4.4 M.A. and 6.6% Ph.D.

Level of Using the Subway

Table 6 shows the distribution of respondents' use of subway stations.

Table 6. Distribution of respondents' use of subway stations.

Level of using subway station	%
Once a day	14.3
Several times a day	1.7
Several times a week	26.3
Several times a month	17.7
Total	100

It is noted that 14.3% of the respondents used the subway station once a day, 41.7% several times a day, 26.3% several times a week, and 17.7% several times a month.

What (vehicle/tool) was used to access to the subway station?

Table 7. Distribution of respondents by the type of vehicle to access the subway station.

Type of vehicle	%
On foot	30.2
BRT	17
Taxi	39.7
Bus	9.2
Bicycle	0.9
Motorcycle	0.2
Personal Car	2.8
Total	100

It is noted that 30.2% of the respondents access the subway station on foot, 17% used BRT, 39.7% taxi, 9.2% bus, 0.9% bicycle, 0.2% motorcycle and 2.8% personal cars (Table 7).

Survey of Trips at the Station at various hours

To examine demands under various states in 2017 and 2018 as ordinary and non-coronavirus conditions and also in 2020 and 2021 as coronavirus and social distancing conditions at the station, demands in two days under ordinary days were examined, with various time intervals illustrated.

Figure 3. Average passenger demands at the Imam Khomeini Subway station at various hours in 2017 and 2018 (before Coronavirus).

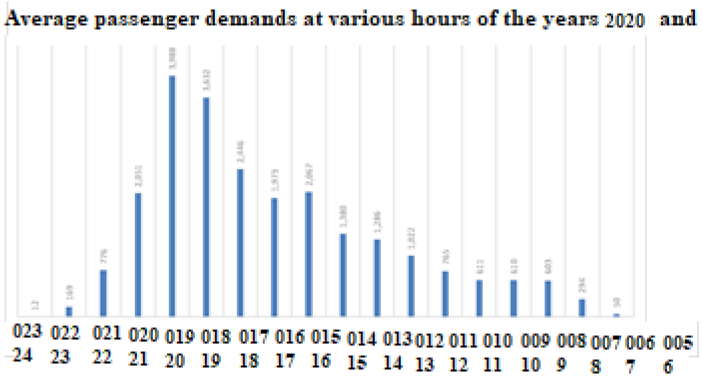

Figure 4. Average passenger demands at the Imam Khomeini Subway station at various hours in 2020 and 2021 (During Coronavirus).

According to Figures 3 and 4, demands at the subway station had reduced to 50% during the coronavirus pandemic, indicating that disease conditions and social distancing can affect the subway station's capacity. For this, using field surveys and observations and polling people during coronavirus conditions, the study aimed to present a standard model based on various significant factors to measure the capacity model under covid-19 conditions or contagious diseases.

Determining Minimization and Sample Demography

Cochran formula is one of the most applicable methods for calculating statistical sample volumes. Determining sample volumes using Cochran formula requires the knowledge of the population volume. The main formula to calculate the Cochran sample volume is as follows:

Cochran formula

Cochran formula is generally used for sampling a sample volume and is one of the widely used methods for calculating statistical sample volumes.

$$4\text{-}1)\, n = \frac{z^2pq}{d^2} \Big/ \left(1 + \frac{1}{N}\left(\frac{z^2pq}{d^2} - 1\right)\right)$$

(2)

Where n is the sample volume, N is the volume of the statistical population (population of a city, province, etc.), Z is the value of the normal variable of a standard unit, p is a ratio of the population with a certain characteristic, q= (1-p) is a ratio of the population without a certain characteristic, d is the permissible mistaken value or a percentage of error, Z is the normal variable value of a standard unit at the confidence level of 95% as equal to 1.96, d is the permissible mistaken value usually equaling 0.01 or 0.05 and P is the p and Q value, which can be 0.5, in which case the variance reaches its maximum.

Because of the sample volume, which is the Subway Station of District 3, the population was considered to be above 100. This study considered the sample volume to equal 384 at the error percentage of 0.05.

General Statistical Indices

As stated, prior to modeling the factors determining capacity under corona conditions, a questionnaire was devised to measure the indices affecting people satisfaction within the area under study. This section concerns the statistics of the variables over the course of years under coronavirus conditions. The questionnaire includes some general questions that pertain to ae, gender, education, etc., which can be statistically examined.

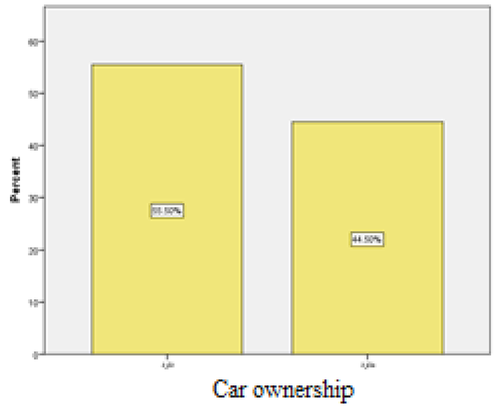

Figure 5. Percentage of car ownership data

As seen, over half of the sample people own a car (Figure 5).

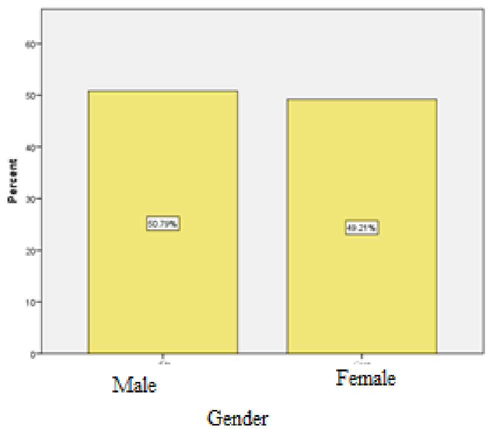

Figure 6. Frequency of people gender data.

The researcher sought to obtain an equal gender ratio to collect and fill questionnaire data (Figure 6).

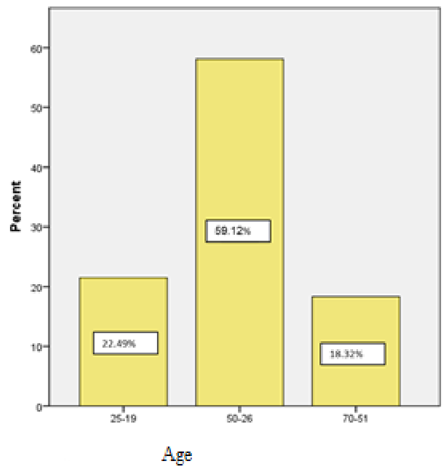

Figure 7. Percentage of people age data.

Two major age groups of 26-50 and 19-25 years were respectively assigned the highest percentages in the statistical sample (Figure 7).

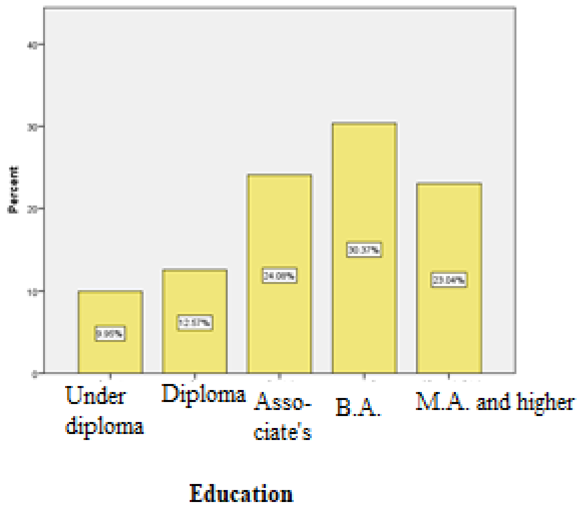

Figure 8. Percentage of education data.

The highest percentage of data collected pertained to the holders of B.A. and above, accounting for 54% (Figure 8).

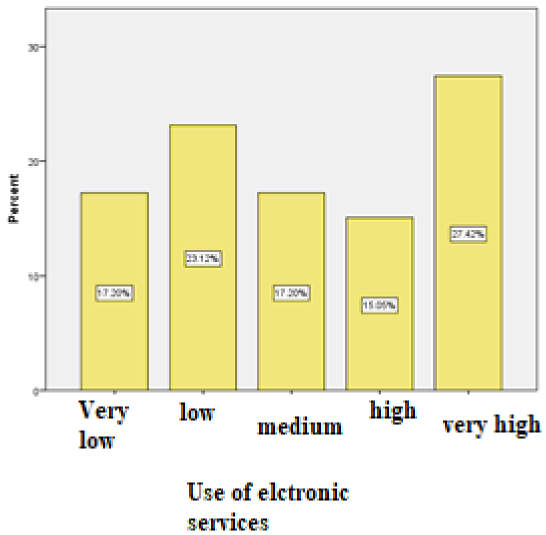

Figure 9. People use of electronic services (mobile phone, etc.).

As seen, 60% of the statistical population used smart mobile phones (Figure 9).

Reliability of the Evaluation of the Variables

Cronbach's alpha coefficient can be used to measure the reliability of a questionnaire or test by emphasizing internal consistency. In this method, some pars of the questionnaire are used to measure the test reliability. Cronbach's alpha is determined based on the internal consistency of the variables. Cronbach's alpha of over 0.7 to 0.8 is good, 0.8-0.9 very good, 0.9-1 excellent. Table 104 gives the consistency of the variables observed to determine the optimal capacity of the Imam Khomeini Subway Station under Covid-19 conditions, with Cronbach's alpha being at 0.751 (Table 8).

Table 8. Cronbach's alpha for investigating the reliability of the observed variables to determine the optimal capacity of the Imam Khomeini Subway Station under Covid-19 conditions.

Reliability Statistics		
Cronbach's Alpha	**Cronbach's Alpha Based on Standardized Items**	**No. of Items**
0.751	0.752	19

Also, in the following table, Cronbach's alpha is examined if each of the variables is removed (Table 9).

Table 9. Cronbach's alpha when one of the variables is removed.

	Cronbach's Alpha if an Item is Deleted
The general quality of services provided by the subway station- expected capacity of services (Observing guidelines)	0.813
Percentage of sample employees per day	0.735
Percentage of the number of car owners	0.724
Percentage of the number of students	0.674
Average age of sample people per day	0.603
Average income (20 for very low and 100 for very much)	0.743
Quality of access from the working place or house to the station	0.894
Acquiring people accessibility to the subway station by driving	0.580
Acquiring people accessibility to the subway station by taxi	0.779
Acquiring people accessibility to the subway station on foot	0.718
Acquiring people accessibility to the subway station by BRT	0.816
Acquiring people accessibility to the subway station by bus	0.402
Acquiring individual's access ability to using the subway per week	0.528
Percentage of trips-commericla and service uses	0.874
Percentage of trips-residential uses	0.737
Percentage of trips-recreational and tourism uses	0.581
Percentage of trips-office uses	0.788
Indicator of crowdedness on pedestrian zones by observing social distance	0.725
Average gender of man to women	0.861

Considering the non-reliability of observation measurements, such variables as the percentage of the number of students, average age of sample people per day, acquiring people access to the subway by driving and buses, and individual access to the subway per week, percentage of trips-recreational and tourism uses were removed to be subjected to factor analysis.

Validity and Factor Analysis of Variable Prioritization

The KMO test was used to investigate the validity of expert evaluation. This index is a criterion for the sufficiency of the number of questionnaires. In other words, the use of the KMO index helps determine whether an appropriate sampling of the factors (based on the pairwise correlation of the representative samples and their partial correlation) is carried out or not. The smaller the partial correlations, the larger the KMO index will be and vice versa. The closer the KMO index to 1, the better the sampling sufficiency will be in selecting the problem factors. The border value of the KMO index for the sample sufficiency was above 0.7, though values ranging from 0.5 to 0.7 is also acceptable with care. In other word, if the index is above 0.7, the questionnaire's criterion of sufficiency is satisfied; otherwise, it is not satisfied. Results from the validity of expert evaluation are given by Table 5. Because the coefficient of 0.74, calculated in the factor analysis of the SPSS software, the KMO value was above 0.7, with the factors showing desired correlation. Thus, the factor analysis to evaluate the variable correlation in relation to the optimal capacity of the Imam Khomeini Subway Station under Covid-19 conditions had a significant level (Table 10).

Table 10. The KMO test for the validity of the questionnaire evaluation.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.791
Bartlett's Test of Sphericity	Approx. Chi-Square	1075.804
	Df	44
	Sig.	0.000

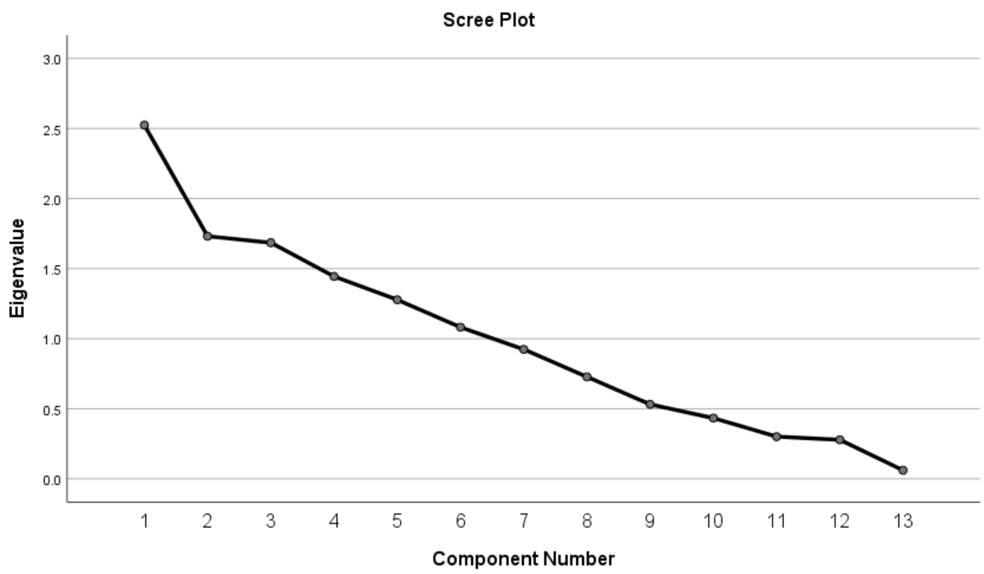

Figure 10. Scree plot for determining the number of factors in relation to predicting the model of determining the optimal capacity of Imam Khomeini subway station under Covid-19 conditions.

As confirmed by the table of data variance and y=1 in the Scree plot, the first seven factors can be measured in the modeling (Figure 10). Later, the prioritization of the variables determining the optimal capacity of the Imam Khomeini Subway Station will be discussed.

Contribution of Variables to the Factors

Table 11 gives the effects of variable priorities in predicting the model of determining the optimal capacity of Imam Khomeini subway station under Covid-19 conditions, with the factors iterated five times after rotation. Each variable falls under a factor with which it has significant correlation.

Table 11. Significance of the variables in eigenvalues-prioritizing the prediction of the model of determining the optimal capacity of Imam Khomeini subway station under Covid-19 conditions.

Rotated Component Matrix[a]							
	Component						
	1	2	3	4	5	6	7
Man to woman average (gender)	0.835	0.075	0.289	0.089	0.060	0.197	0.131
Quality of access from working place or home to the station	0.779	0.139	0.322	0.257	0.275	0.185	0.077
Acquiring people accessibility to subway by BRT	0.600	0.46	0.26	0.111	0.408	0.269	0.365
Percentage of trips-residential uses	0.026	0.830	0.240	0.188	0.038	0.064	0.248
Acquiring people accessibility to the subway on foot	0.095	0.674	0.281	0.051	0.410	0.058	0.075
General service quality of the subway station - expected service capacity	0.374	0.568	0.414	0.187	0.108	0.132	0.116
Index of crowdedness on pedestrian zones by observing social distance	0.028	0.026	0.959	0.021	0.004	0.130	0.77
Percentage of trips-Office uses	0.019	0.071	0.112	0.846	0.215	0.117	0.244
Average income (20 for very low and 100 for very high)	0.039	0.028	0.193	0.751	0.279	0.167	0.393
Percentage of commercial and service trips	0.122	0.114	0.017	0.022	0.898	0.031	0.123
Percentage of car owners	0.027	0.279	0.102	0.041	0.202	0.763	0.219
Acquiring people accessibility to the subway by taxi	0.002	0.388	0.037	0.025	0.158	0.758	0.040
Percentage of sample workers per day	0.032	0.163	0.074	0.034	0.96	0.157	0.881
Extraction Method: Principal Component Analysis. *Rotation Method: Varimax with Kaiser Normalization.*							
a. Rotation converged in 11 iterations.							

Consistent with the factor analysis results, the variables for predicting the model of determining the optimal capacity of the Imam Khomeini subway station under covid-19 conditions were respectively classified as follows: The percentage of sample workers per day, people accessibility to the subway by taxi, the percentage of the number of car owners, the percentage of commercial and service trips, average income, the percentage of office trips and the crowdedness index on pedestrian zones by observing social distancing, which ranked higher priorities in the factor modeling.

Presenting the Proposed Model to Determine the Optimal Capacity under Covid-1 Conditions

Following the investigation of indices and factors affecting railway transportation demands, as noted in the prior section, and also the reliability and validity and finally the prioritization of variables by factor analysis, we now attempt to provide statistical modeling (Regression analysis). According to the dependent variable model results, i.e., the optimal capacity of subway stations under covid-19 conditions, which is related to the significance level of the variables, a model dependent on independent variables is one with 7 variables. Table 12 gives overall data on R^2 values that measure the variability ratio of y values, which are expressed by the fit lines. The R^2 statistics is, in fact, the coefficient of determination of the total variability percentage due to regression on x. The subsequent corrected R^2 statistics indicates how much of the total variance of the dependent variables is explained by independent variables, as it stands on 0.799, being acceptable. This value is the standard deviation of model residues, whose value of above 0.7 is acceptable. The Durbin-Watson value of 1.780 (1.5 to 2.5 as being appropriate) indicates that the variables of this model are independent from each other.

Table 12. Total significance of the model of determining optimal capacity of subway station under covid-19 conditions.

Model	R	R Square	Std. Error of the Estimate	Durbin Watson F Change	df1	df2	Sig.F change	
1	.0894[a]	.799	388.340	27.753	7	22	.005	1.780

Also, the model data-to-the residual data ratio of the model is about 27.75, which is a confident ratio for the linearity of the model.

Table 13 gives the coefficients of the proposed statistical model after the main modeling assumptions were confirmed, as discussed in the previous sections.

Table 13. The coefficients of the model for predicting the model of determining the optimal capacity of the subway station under the conditions of Covid-19.

Model	**Variables**	**28303.534**	**9560.269**		**4.007**
	Percentage of sample employee per day	78.401	40.610	0.348	2.582
	Percentage of trips-commercial and service uses	40.348	61.591	0.131	2.605
	People accessibility to subway station by Taxi	4.607	63.901	.0.131	2.665
	Average income	44.241	61.780	0.171	0.716
	Percentage of trips-office uses	86.169	108.069	0.183	0.797
	Number of car owners	0.198.228	157.660	0.288	-2.257
	Index of crowdedness in pedestrian zones	34.247	43.747	0.167	0.783

The regression model of capacity determination also demonstrated that the four variables of the percentage of the sample employees per day, the percentage of trips-commercial and service uses, people accessibility to the subway by taxi, and the number of car owners were considered in relation to predicting the model of determining optimal capacity at the subway station. These variables held a significance level of 0.05, which affected the model.

D (Covid-19) = 28303.534 +78.491EMP+49.348COM+4.607Taxi-198.228PCAR (3)

Where D is the optimal capacity of the subway station under Covid-19 conditions (trips/person), EMP is he sample employees per day, COM is the percentage of trips-commercial and services uses, TAXI is people access to the subway by taxi, PCAR is the [percentage of the number of car owners.

Figure 11 illustrates the histogram of the model regression along with its standard deviation.

The next issue is the homogeneity variance of the residues. The histogram data, illustrates that the residues have an approximate normal distribution. The P-P curve with critical values *z indicates that there are fewer errors in the model's linear regression.

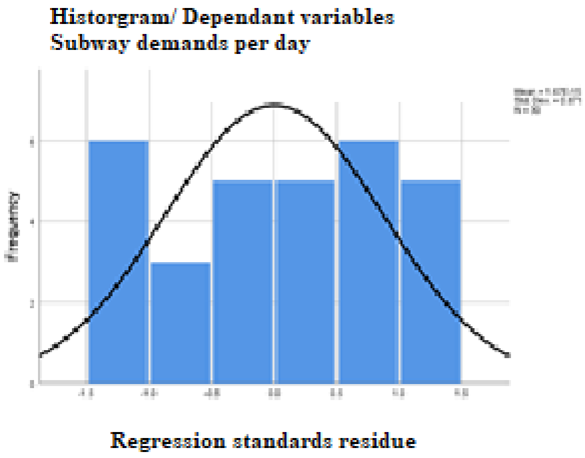

Figure 11. Histogram of the dependent variable.

Figure 12 illustrates that the residues are normally distributed for the dependent variable. Because, as illustrated by the figure, if all points are on the first quartile bisector, the data will fully follow [normal] distribution. According to the following, data almost follow normal distribution.

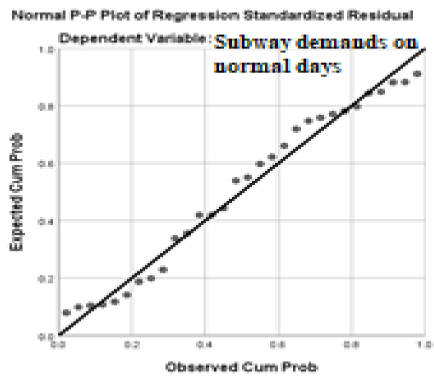

Figure 12. Distribution of the dependent variable and model residues.

III. CONCLUSION

In sum, the prioritization and classification results of variables were determined in factor analysis and statistical modeling. Factor analysis indicated that the percentage of sample employees per day, people access to the subway station by taxi, the percentage of the number of car owners, the percentage of trips-commercial and services uses, average income levels, the percentage of trips, office used and the indicator of crowdedness on pedestrian zones by observing social distancing were among the seven variables that respectively held the highest ranks in factor modeling. The regression model of capacity determination also demonstrated that the four variables of the percentage of the sample employees per day, the percentage of trips-commercial and service uses, people accessibility to the subway by taxi, and the number of car owners were considered in relation to predicting the model of determining optimal capacity at the subway station. These variables held a significance level of 0.05, which affected the model.

Knowledge of passenger transfer in the transportation system provides the most important data needed for planning, design and managing transportation. Any planning that lack an acceptable estimation of demand levels could be undermined by incorrect decisions, which would bring about negative consequences in economic and social areas. As stated, the goal of this subject was to provide a model to predict the optimal capacity of a subway station by considering Covid-19 conditions. As reports suggested, around 18 million urban trips are made each day, which is very significant because of subway station limitations. Considering the contagious diseases, such as Covid-19 conditions, and the low quality of trips and the long duration under train systems are problems that should be focused on to solve shortcomings with urban passenger transportation. In sum, investment in the subway station and using modern technological equipment, together with the development of passenger fleet, increasing train cars and shortening the entry and exit of the trains could considerable contribute to the development of serviced offered specifically under contagious conditions.

Suggestions

- Investigating factors affecting the samrtization of people access to mass transportation in subway stations and reducing crowdedness under contagious diseases
- Using Viswalk software and architecture maps at stations and analyzing the level of access and people crowdedness at stations

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IV. REFERENCES

[1] Cheng, L., Chen, X., Yang, S., Cao, Z., De Vos, J., & Witlox, F. (2019). Active trip for active ageing in China: the role of built environment. *Journal of Transport Geography*, *76*, 142–152.

[2] Chinazzi, M., Davis, J. T., Ajelli, M., Gioannini, C., Litvinova, M., Merler, S., & Viboud, C. (2020). The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science*, *368*(6489), 395-400.

[3] De Vos, J. (2020). The effect of COVID-19 and subsequent social distancing on travel behavior. *Transportation Research Interdisciplinary Perspectives*, *2020*, 100121.

[4] Du, Z., Wang, L., Cauchemez, S., Xu, X., Wang, X., Cowling, B. J., & Meyers, L. A. (2020). Risk for transportation of 2019 novel coronavirus disease from Wuhan to other cities in China. *Emerging Infectious Diseases*, *26*(5), 1049-1052.

[5] Goldbaum, C., & Cook, L. R. (2020). They can't afford to quarantine. So they brave the subway. The New York Times. https://www.nytimes.com/2020/03/30/ nyregion/coronavirus-mta-subway-riders.html?searchResultPosition=5 (Accessed date: 14 April 2020).

[6] Khodabakhsh, P. (2019). Providing a framework to improve railway passenger satisfaction using structural equation modeling. In: *6th International Conference on Recent Advances in Railway Engineering*, Tehran.

[7] Li, T., Zhou, L., Du, W., Sun, Zh., & Zhang, N. (2017). The conceptual discussion of the long-distance public passenger transportation system. In *Transportation Information and Safety (ICTIS), 2017 4th International Conference on.*

[8] Tamannaie, M., & Vali, M. H. (2018). An algorithm for optimally removing rail network bottlenecks to explain axis electrification, (Case study: Iran's Shomal railway). *Scientific Research Journal of Civil Engineering*, *18*(2).

[9] Zheng, H., Son, Y.-J., & Chiu, Y.-C. (2013). *A primer for agent-based simulation and modeling in transportation applications.* United States. Federal Highway Administration.