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Urban transportation development model based on mode (vehicle) with goal programming

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The purpose of this article is to investigate the modes of vehicles based on the type and number of urban travel facilities for passengers, determine the type and number of vehicles according to the existing restrictions in the city. This technique is for studies studied in Tehran city and expansion to other cities. As you know, to divide transportation models based on goal programming, is to divide all transportation modes for urban station routes by type and region.The main objective of this is to present the best mode (vehicle) of transportation based on travel modeling in transportation areas of urban trips for multi-objective transportation goal programming. In this case, the type of transportation solution is determined in the desired area on the way to the stations, according to which the pollution reduction, travel time reduction, cost reduction, availability, maximum safety and comfort of the means of transportation are reduced, increased or liminated. In this article, the number of buses, subways, taxis, and BRT is calculated according to the strategic conditions of the city from the defined model. With the existing conditions, the desired number is small or large according to the need of the area, or the same number is maintained.

Keywords: *Transportation planning, trip generation, trip distribution, modal split, mode (vehicle) ,urban areas of Tehran, planning parameters (travel time, distance, cost, comfort and safety), logical layout, goal Programming.*

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1. Introduction

Traffic congestion is one of the topics that impose environmental consequences and costs in transportation planning. Therefore, decision makers and policy makers should focus on appropriate transportation planning models. Since the most important problem of urban transportation is the congestion of vehicles, it is necessary to plan to face this problem. In recent years, due to the increased availability of vehicles and traffic volume, driving offences and accidents have increased significantly. the location-allocation model of traffic patrols in suburban road networks was proposed. It is to maximize the

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demand cover and the amount of traffic and vehicles crossing the roads and at the same time to minimize the total cost, Moghadas poor et al. [3].

For this purpose, policy makers and decision makers have two solutions for transportation, which include, increasing the construction of lines and imposing restrictions on the use of busy streets Babaei et al. [1]. According to Chattaraj [4], transportation is the backbone of urban areas. It enables urban areas by providing access and functionality. Passenger transportation has an important effect on the performance of the city. Transportation planning and infrastructure development is one of the most important factors for the system, especially for urban areas where urbanization is currently at a high level and faster Masser et al. [21]. The government has long recognized that improving transport infrastructure and services is a critical prerequisite for increasing competitiveness and achieving long-term sustainable economic growth. In addition to investing in the development of transportation infrastructure, the government also invests in the development of transportation infrastructure, improving the efficiency and quality of transportation services, and reducing negative effects, including in the development of transportation planning to specific goals and parameters such as the shortest travel time, the least pollution, the most in It considers availability and minimum distance, minimum cost, maximum comfort and safety of travel in vehicle transportation. What is the reason for the government's participation in optimizing transportation? Investing in transport infrastructure shapes transport choices due to its longevity, and hence potentially locks in the long-term trajectory of transport costs.

Transportation planning and infrastructure development affect spatial development, the generation of agglomeration economies, and consumer choices and behavior. The long lifespan of infrastructure can have a permanent effect on the emission intensity of the transportation system. The development of transportation infrastructure, which reduces the cost of transportation, ultimately encourages the spatial concentration of production centers. International experience also shows that this increases the economic weight of big cities and as a result the productivity of the macro economy increases. Urban land use policies particularly influence the choice of lower emission modes in a multimodal transportation system. Transportation infrastructure has a long lifespan, so its vehicle type mix has a permanent impact on the pollution intensity of the transportation system.

1.1 Objective: To reduce the total cost of transport:

To reduce the costs of transport The main objective of the combined vehicle transport policy framework is to reduce the total cost of transport including all direct and indirect costs while maintaining the total social welfare benefits. Direct and indirect costs incurred by private parties are reduced through infrastructure improvements and fair competition between modes and operators. Indirect costs borne by society are reduced by mechanisms that internalize measurable external costs. Increased demand for transportation increases local fuel-related pollution, which increases health costs and other environmental impacts for citizens. Increasing congestion levels increase travel time and safety risks. If fuel remains the main source of energy for transportation, there will still be problems with displacement of discontented citizens and economic growth will be limited by the current account deficit. Finally, the increase in pollution and dissatisfaction of citizens and transport system operators will cause new conflicts.

1.2 Principle: Influencing and improving consumer choices:

At the heart of transportation is the consumer's choice about whether to move, when to move, what route to take, which mode and vehicle to use, and so on. In sum, the decisions of transportation users determine the degree of transportation, which in turn affects the levels of environmental impacts and economic development, national dependence on petroleum products, air pollution, transportation costs, and labor productivity. Affect. Therefore, the government should adopt policies that provide incentives for superior transportation and improve the options available to consumers. This paper proposes a policy framework that influences the choices of transport users and improves them in ways that support environmental sustainability and economic development. Conditions have progressed significantly towards a market economy, so an important policy objective is to minimize the negative environmental and economic impacts of users' transport choices, but without undermining the market economy. This requires government intervention to correct market failures and inefficiencies by influencing choices without imposing solutions.

Most societies now have well-developed automobile transportation systems, but fewer transportation options for non-drivers. This dependence on the car creates various problems, many of which public transport can help solve, as summarized below. 1- Traffic congestion 2- Parking congestion 3- Traffic accidents 4- Road and parking infrastructure costs. 5- Car expenses for consumers. 6- Insufficient mobility for non-drivers 7- Excessive energy consumption 8- Emission of pollution. Public transportation can help solve all kinds of transportation problems. One of these problems is that transportation systems have a significant impact on the environment, for example, urban transportation is a major contributor to air pollution. The increasing use of transportation in daily life to meet our needs leads to a wide range of problems such as global warming, environmental degradation, health consequences and greenhouse gas (GHG) emissions. Transport systems are more effective along dense urban routes where these problems are more severe Victoria Transport Policy Institute Gallivan et al. [10].

1.3 Influencing choices:

The government should implement measures for the demand side that include incentives for transport users to choose more optimal transport, mainly by strengthening the regulatory and financial framework, there are market inefficiencies in several sub-sectors including urban transport. These inefficiencies reward consumer choices to the detriment of transport users to the detriment of society as a whole. For example, a transportation service provider that operates older vehicles is likely to incur a lower cost of capital due to the lower value of the vehicles. However, the services provided by such vehicles create greater externalities, as they emit more pollutants and the possibility of vehicle breakdowns that can threaten road safety, compared to newer vehicles (therefore cleaner and less consuming) is more. While capital cost savings are enjoyed by transport users who pay lower fares, external costs in the form of health costs, inconvenience, environmental degradation, injuries and fatalities from traffic accidents and potentially affected individuals and taxpayers are borne by society. Depreciation of land value This discrepancy between two final costs - one from society and higher, and the other from users and lower - should be limited. This actually forces users to consider not only their own benefits, but also the negative externalities for society that their choice of transportation options may cause.

1.4 Improving Choices:

On the supply side, the government's role is critical to infrastructure development, accelerating innovation and technological advancements that provide users with more optimal transportation options. First, how the transportation network infrastructure is built and connected determines how each mode of transportation operates and how transportation services are provided. Long-term plans for transportation network development and investment priorities must consider how transportation options are created and impacted. For example, good intermodal communication combined with an appropriate pricing policy to influence consumer and provider choices can provide multimodal transportation options that are cheaper than monomodal options. High-quality public transport services can compete well with the use of private vehicles. Second, innovation and technology such as new vehicle technologies, alternative fuels, new modes of transportation, new approaches to urban development, and innovations in transportation logistics help foster optimal transportation. The government can initiate and implement innovative measures. Perhaps more importantly, government can be a catalyst for innovation and adoption by creating the right environment for industry and rewarding good solutions and practices.

1.5 urban travel demand model

The travel demand forecasting process basically involves a four-step model . 1) Transportation services production. 2) Trip distribution. 3) Division of the type of transportation. 4) Travel allocation .This process has been described by Kadyali and Lal [17] and Mathew et al. [23] and Kadyali et al. [18]. Next, the four-step modeling is explained. Kevin and Modi [19]. The decision to travel for a specific purpose is called travel production. The decision to choose a destination from the origin is the directional distribution of trips, which forms the second stage of travel demand modeling. The trip distribution is determined by the number of end-trips originating in region-i to the number of end-trips attracted to region-j , which can be understood by the matrix between regions. The matrix is called Origin-Destination Matrix Mathew et al. [24].

The third step in travel demand modeling is dividing the type of transportation. The division of the type of transportation is determined by the number of trips processed by people with different travel modes. In other words, the transport mode division sub-model of travel demand modeling is used to distribute the total travel demand in two or more mode categories. These categories are public transport passengers and private/private vehicles. Demand can be further divided into different modes. According to Mathew et al. [25], Patel [30], socio-economic demand variables used to explain mode choice behavior include: income, vehicle ownership, household size, residence, etc. Supply variables in vehicle time are waiting time, travel time, travel cost, transfer time etc. Mathew et al. [26].

Transportation planning involves many iterative models and large road networks that cannot be solved manually. Trip allocation is the last step of the four-step transportation planning. The multipath routing model seems to be the most realistic among all those models Mathew et al. [27]. In Section 3, the goal programming model proposed by While Ijiri [15] had introduced is reviewed. Section 4 presents our integrated goal programming model. Goal programming planing are demonstrated in Section 5. Finally, some remarks are made in Section 6.

2. Introduction to goal Programming

This Schniederjans [32] is designed to provide students, faculty and researchers a perspective and review of the total body of published goal programming (GP) research to date. The objective of this book is to present a comprehensive overview of goal programming methodology and applications, past and present, as they are reflected in journal publications and books. It is assumed that readers will have some basic knowledge of GP. With the exception of this chapter, the remaining chapters in this book are fairly independent of each other and can be referenced or read independently of the others.

2.1 A point of origin

The original idea of GP was traced by Romero (1992, p. 2) to a study by Chames et al. [7] on executive compensation. While the term goal programming did not appear in this 1961 paper, this paper introduced the idea of bounded regression that represents an approach to minimizing the inherent deviation in GP. According to Newman and kenworthy [29] and Romero (1992), it was not until Charnes and Cooper [6] wrote the book Linear Programming, Management Models and Industrial Applications Linear Programming in 1961 that Bastehzadeh and Mehrabian [2] the term objective programming appeared. Interestingly, this method is not presented as a unique or revolutionary method, but as an extension of linear programming (LP).

In the Cbarnes and Cooper [5] (pp. 215-221) book, goal programming was suggested for use in solving unsolvable LP problems (e.g., infeasible LP problems). Indeed, GP was not even cited as a term in the index of the Charnes and Cooper [5] book, Kizilats et al.[20].

Goal Programming as an Extension of Linear Programming Since the origin of GP can be traced to LP, a starting point for the GP model can be found by restating the LP model, its assumptions and modeling notation. One version of the LP model can be stated in what is called the canonical form:

$$\min z = \sum_{j=1}^{n} c_j x_j$$
$$\text{subject to: } \sum_{j=1}^{n} a_{ij} x_j \geq b_i \text{ , for } i = 1, .., n$$
$$x_j \geq 0, \text{for } j = 1, \dots, n. \tag{1}$$

Where the $x_1, x_2, .., x_n$ are nonnegative decision variables or unknowns and the $c_1, c_2, \dots, c_n$ are contribution coefficients that represent the marginal contribution to Z for each unit of their respective decision variable.

While Charnes and Cooper [5] did not present a general GP model statement in their book, a generally accepted statement of this type of GP model was presented in Charnes and Cooper [6]:

$$\min Z = \sum_{i=1}^{m} \left[\left(d_i^{+} + d_i^{-} \right) \right] \tag{2}$$
$$\textit{subject to:}$$

$$\sum_{j=1}^{n} a_{ij}x_j - d_i^{+} + d_i^{-} = b_i , for, i = 1, \dots, m$$

$$. x_j, d_i^{+}, d_i^{-} \geq 0 \text{, for } i = 1, \dots, m, j = 1, \dots, n$$

The transportation problem is one of the most important special structures in linear programming. Chhibber et al. [8], considered a fuzzy solid transportation problem under an intuitionistic fuzzy environment. They obtained a Pareto-optimal solution for a multi-objective fixed-charge solid transportation problems with linear, hyperbolic, and exponential membership as well as non-membership functions. The world of commerce today is world of uncertainty, especially uncertainty in transportation systems. Optimization in the transportation process can increase customer satisfaction and profit and make the economy better. Uncertainty exists in variables related to the demand, supply, costs and other variables that investigating these problems in uncertain and fuzzy conditions is of great importance for researchers nasseri and Ramznnia [28].

2.2 Summary of the story of rail in return bus:

The key differences between bus and rail transport are summarized below. Rather than debating which one is superior overall, it is better to consider which one is more appropriate in a particular situation. Buses are the best service to areas with scattered destinations and less demand. Rail is best for corridors with concentrated destinations and passengers, such as large business centers and urban areas. Rail tends to attract more passengers in an area, but buses can cover a larger area, so the overall impact of the ride depends on the conditions. If combined with supportive policies that improve service quality, create more supportive land use patterns, and encourage ridership, both become more efficient and effective in achieving planning goals Tamiz and Jones [33] and Jones and Tamiz [16].

The rail transit system can only serve a limited number of stations. These stations stimulate more intensive development by increasing density (residents, employees, and business activities per acre), transit system per capita and walking trips, and vehicle ownership per capita and fewer trips. A bus transit system can serve more destinations, including some scattered suburban activity centers, but attracts fewer riders per capita and by itself has little or no impact on land use patterns. Which one attracts the most riders and is the most cost-effective depends on the situation: rail tends to attract more passengers in the area it serves, but buses can go directly to more destinations in the same area serve bigger.

3. Analysis of model parameters

Since the most important problem of urban transportation is the congestion of vehicles, it is necessary to plan to face this problem. For this purpose, policy makers and decision makers have two solutions for transportation, which include 1- preserving and maintaining lines and increasing the construction of lines 2- imposing restrictions on the use of busy streets. According to the experiences gained, it was proved that the second solution provides a good opportunity to solve the traffic problem. In urban areas, suburban systems, railways, subways, and rail systems are preferred for public transportation due to their high capacity, reliability, and high speed. Suburban trains are heavy rail systems that connect long distances with high capacity. Metro is a form of urban transportation that provides underground public transportation with high capacity, reliability, and speed. Metro is an eco-friendly and recently popular means of public transport that runs on its own unique route and climbs over the pillars towards the vehicular traffic. Multi-criteria decision-making methods (MCDM) are approaches that help to determine the most appropriate option among the options according to the set criteria and objectives. In this structure, criteria that are generally independent and expressed in different forms are considered. MCDA method of AHP and Analytic Network Process (ANP), TOPSIS (Technique for order priority with similarity to ideal solution), Electre (Elimination meat Choix Traduisant la Reality) Promethee (Preference ranking organization method for enrichment evaluation) are often used. Hamurcu.M [11]. The general steps of the AHP method, which is based on pairwise comparisons, are as follows Saaty [31]:

Step 1: Identify the problem and create a hierarchy of goals, criteria, and alternatives.

Step 2: Pairwise comparisons between criteria and between options according to each criterion.

Step 3: Normalize the generated comparison matrices and find the eigenvectors.

Step 4: Determine the weights of the criteria and calculate a consistency value to determine the appropriateness of the decisions.

Step 5: Multiply the importance ranking matrix of the options found for each criterion by the weight of the criteria and find the significance levels of the options.

Step 6: Order or select the options according to their importance.

The aim is usually to minimize the total transportation cost. The classical transportation problem model, the Hitchcock transportation problem, may have limitations in dealing with real world problems, because it has only a single objective where for certain practical problems, multi-objective models turn to be relevant. For example, the objectives may be minimization of the total cost, the total time, consumption of energy, or total deterioration of goods during the transportation. In most investigations, the entire existing objectives in both single and multiple transportation problem (MOTP) are considered by quantitative information. For real-world problems, however, there exists a variety of important qualitative information such as public health, safety, climate change, comfort and security. Consideration ofqualitative information in an MOTP is scarce in the literature, Zangiabadi and Rabie [35] .

4. The problem of choosing the best vehicle and mathematical model

This section presents the formulation of an integrated multi-objective optimization model based on objective programming (MOP) for sustainable and improved transport systems of the best means of transport. The decision parameters and variables used in the mathematical model are defined as follows. A goal planning model has been developed that collects different goals under one goal for the problem. There are several objectives in this problem, such as achieving the budget objective, maximizing the benefits, combining the maximum security, credit and score, combining the longest distances, and achieving the minimum travel time objectives. It is one of the goals, The goal planning model of the problem is given below. In the mathematical model, the objective function that minimizes the deviation from the objectives is defined as satisfying the mandatory objectives, ensuring the AHP weight and ensuring the budget constraints. Constraints include providing maximum security, access to maximum stations, combining long distances, minimum cost, minimizing emissions, guaranteeing minimum travel time. According to the method of transportation, vehicles are divided into different groups according to the opinion of the experts of the Urban Transportation Planning Department and the literature on the subject. Each group is weighted based on capacity, time, safety, emissions, reliability, availability and cost criteria. AHP method is used for weighting. The objectives are set as budget objective, maximum security, minimum emissions, linking maximum availability points, combining longest distances, minimum travel time and high AHP weight. Our goals are the rail and urban combined regional transport system of Tehran metropolis, which is the maximum benefit of security, maximum access to most stations, access to the longest areas, providing the minimum travel time and pollution using the minimum budget. The process flow diagram is given in Figure 3.

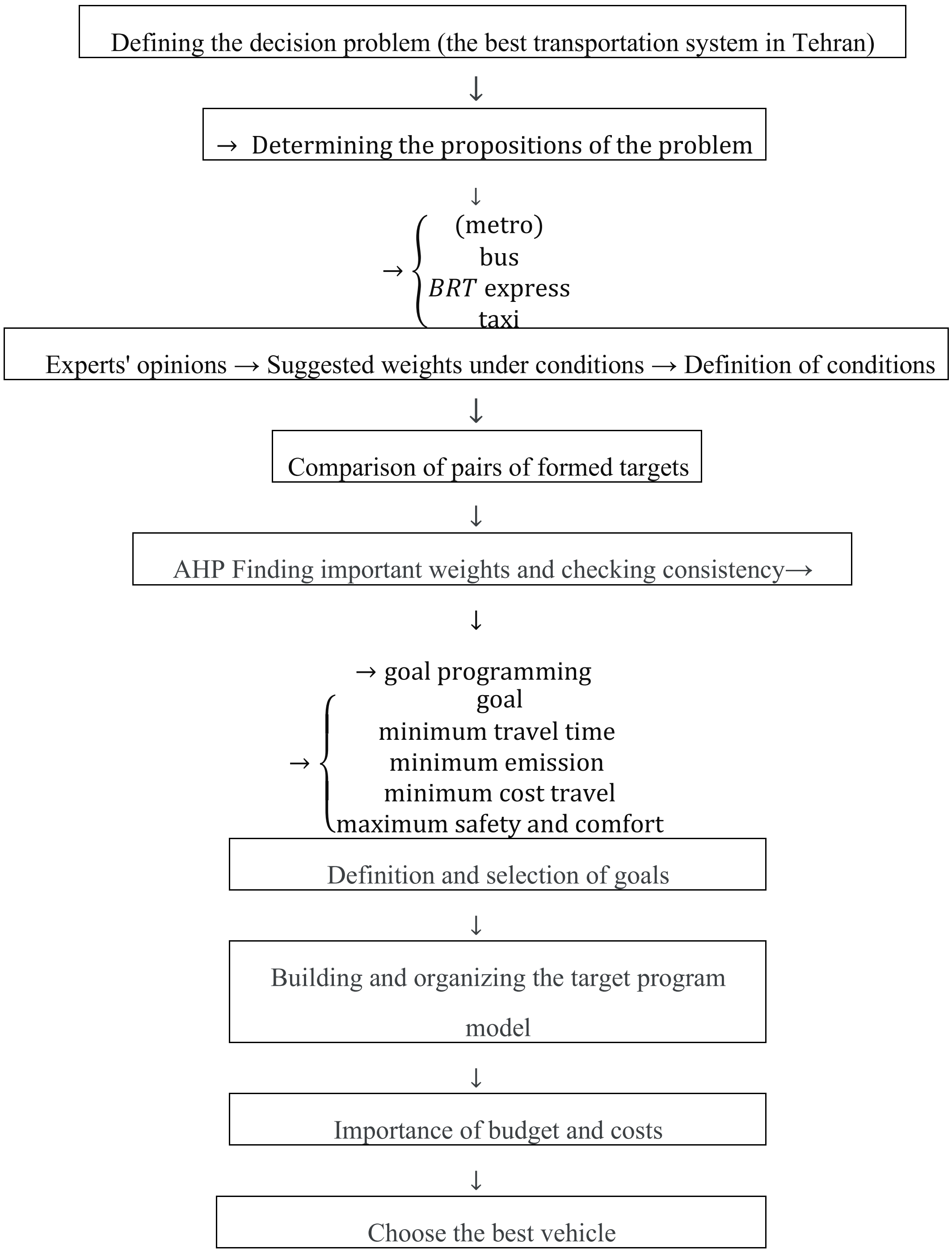

Figure (3) method and modeling.

5. Goal programming planning

Problems encountered in every day life often require multiple objectives to be considered. Some times we want to do many goals at the same time in decision-making and sometimes we want to minimize the negative factors and maximize the positive factors. In both cases, we use multi-objective mathematical models to achieve goals in the same direction or conflict situations simultaneously in realizing our goals. Goal planning is also a kind of mathematical model and tries to minimize the deviation from goals by turning all goals into limits. It is used in many areas such as transportation problems Hamurcu et al. [12]. Tamiz et. al [33]. Tasm et al. [34] and Hamurcu et al. [12] selection of monorail projects for urban transport in Ankara, Hamurcu and Eren [13] selection of urban transportation type, Hamurcu and Eren [14] project selection sustainable urban transportation. The objective function: The collective performance super model can be written as follows:

5.1. Model Assumptions

$$\min Z = \left[p_1 w_1(d_i^{+}, d_i^{-}) + \cdots + p_k w_k\left(d_i^{+}, d_i^{-}\right)\right] \quad .۶$$

$$constraint: \quad .۷$$

$$\sum_{j=1}^{n} a_{ij} x_j - d_i^{+} + d_i^{-} = b_i \quad .۸$$

$$x_j, d_i^{+}, d_i^{-} \geq 0 \quad .۹$$

$$. i = 1, \dots, m, j = 1, \dots, n \; .۱۰ \qquad (3)$$

$\boldsymbol{p_i}$: priority, w_i: weight, $\boldsymbol{d_i}^{+}$: positive deviation, $\boldsymbol{d_i}^{-}$: negative deviation, $\boldsymbol{a_{ij}}$: parameters and $\boldsymbol{x_j}$: decision variables.

5.2. Decision Variables Model sets and indexes

The main decision variables for the objective program are whether passengers are transported by vehicle type k at a given hour. These are binary in nature and are divided into first displacement, continuous displacement and evacuation. Then these key variables provide the possibility to determine other variables such as the number of vehicles including metro and bus and (BRT) and additional taxi passengers:

n': Low interest destinations
m': Low interest origin
i: Origin points
j: destination points
k: Vehicle type index
t: time of travel
h: Availability index

c: cost index
r: Area index
ℓ: Metro line number index
ℓ': Bus line number index
ℓ'': Taxi line number index
ℓ''': BRT line number index
m: origin index
n: destination index
Variable definitions,
y_{ijkr}: The binary variable of vehicle k-th is used, the value is one, otherwise, zero is moved.
x_{ijkr}: The number of passengers who intend to move from the origin r-th tovthe destination j by vehicle k-th in the region r-th.

5.3. Structural Parameters

I estimate the model's structural parameters of step by step below.First, I devised an instrumental variables strategy that uses station and vehicle count data to identify matching areas, Conwell [9].

t_{ij}^{kr}: Travel time from origin i-th to destination j-th with vehicle k in region r-th.
A_k: Pollution caused by the type of vehicle(GHG).
$M_{i'r}$: The number of subways in the region r.
$B_{j'r}$: The number of buses in the area r-th.
$T_{k'r}$: The number of buses in the area r-th.
$(BRT)_{r'r}$: The number of (BRT) in the area r-th.
C_{ijkr}: The cost of current one-way trips from the i-th origin to the j-th destination with vehicle type k-th.
$h_{i,t_{max}}^{kr}$: Availability at origin i-th and maximum travel time in region r-th with vehicle type k-th.

5.3. Public Transportation

Tehran's public transport system includes variety of public transport modes like bus, bus rapid transit (BRT), Metro, Taxi, fixed- route taxi, private taxi and internet taxi. According to Tehran Traffic Organization information in 2021, the Tehran bus system gave service to passengers by 240 regular bus and 10 BRT lines. The bus lines in Tehran are operated by two public and private sectors, and the number of the public and private fleet is respectively 1348 and 4800 buses. The number of bus and BRT stations in 2021 which connected bus lines and gave services to passengers, were respectively 4,785 and 347 stations. The total length of bus and BRT lines is about 3200 km. The 541 million passengers used bus lines to commute in 2020. The first line of Tehran metro began operating in 1999. In 2019 Tehran metro consisted of six lines, with a total 215 km length and 114 stations. The total trips done by the metro lines at 2017, were 723 million trips. One of the most popular public transport modes in Tehran is taxi. There are different kinds of taxis working in Tehran and give service to passengers. They are rotary taxi, fixed- route taxi, private taxi and internet taxi which give service, either through the taxi agencies or mobile applications to the passengers. These types of taxis are registered and supervised by The Tehran Taxi Supervision and Management Organization.vThe Transportation administration The Transportation Deputy of Tehran Municipality is the highest authority in the Tehran Municipality which is responsible for policymaking, coordination, planning and controlling of transportation and traffic performance in Tehran.It should be mentioned that each of 22 districts of Tehran Municipality has own transportation deputy that works under the supervision of the Deputy of the Tehran Municipality, and provide their annual planning according to the guidelines provided by the Municipality.

The affiliated organizations of Tehran Municipality Transportation Deputy are:

1) Tehran Bus Company: this company is the top authority of the public bus and BRT systems in Tehran.

2) Tehran Urban & Suburban Railway Operation Company (METRO): This Company is responsible for providing rail services for Tehran and its suburbs.

3) Tehran Traffic Control Company: Tehran Traffic Control Company is responsible for design and implementation of Intelligent Transportation Systems (ITS) and traffic management in Tehran.

4) Air Quality Control Company: This Company is active in planning and researching to reduce and control air and noise pollution in urban and industrial environments.

5) Tehran Technical Vehicle Inspection Bureau: Set up standard centers for vehicle technical examination to provide services in the field of safety and air pollution reduction.

6) Organization of Passenger Terminals and Rider Parks of Tehran Municipality: This organization is responsible to maintain and manage passenger terminals and rider parks all over the Tehran. Developing and improving these terminals and parks and their equipment, construction new terminals and parks are the other responsibilit ies of this organization.

7) Tehran Taxi Supervision and Management Organization: In Tehran, this organization supervises and monitors the registered taxis services.

The Sustainable Transport Planning Efforts The first transportation comprehensive studies of Tehran had begun in 1994 and in order to do these studies, at that time the comprehensive transportation studies company was established. In 2004 and 2014 these studies had been reviewed and updated. It should be mentioned that because of the closure of that company in 2014, the last review of these studies has not been completed yet. Generally, the main approaches of these studies were, moving towards a safe, modern, clean and accessible transportation system in Tehran, which are the sustainable transportation characteristics.As mentioned before the Transportation Deputy of Tehran Municipality is the top authority for managing transportation in Tehran. The strategic theme of the third five-year plan, which has been prepared recently, is “Safe and Smooth Transportation and Traffic” in Tehran.

$$\begin{aligned} \min z = \sum_{t=1}^{n'} w_1 \sum_{i=1}^{m} (d_{t_i}^- - d_{t_i}^+) \\ + \sum_{A=1}^{c'} w_2 \sum_{i=1}^{m} (d_{A_i}^- + d_{A_i}^+) + \sum_{c=1}^{m'} w_3 \sum_{i=1}^{m} \sum_{j=1}^{n} \sum_{k=1}^{s} (d_{c_{ijk}}^- + d_{c_{ijk}}^+) + \sum_{h=1}^{22} w_4 \sum_{k=1}^{s} (d_{h_k}^- + d_{h_k}^+) \\ + \sum_{S=1}^{s'} w_5 \sum_{k=1}^{s} (d_{(s-c)_k}^- + d_{(s-c)_k}^+). \end{aligned} \tag{4}$$

Constraint:

s.t

Minimum trip time:

$$\sum_{i'=1}^{\ell} M_{i'r} \sum_{i=1}^{m}\sum_{j=1}^{n} t_{ij}^{k} + \sum_{j'=1}^{\ell'} B_{j'r} \sum_{i=1}^{m}\sum_{j=1}^{n} t_{ij}^{k} + \sum_{k'=1}^{\ell''} T_{k'r} \sum_{i=1}^{m}\sum_{j=1}^{n} t_{ij}^{k} + \sum_{r'=1}^{\ell'''} (BRT)_{r'r} \sum_{i=1}^{m}\sum_{j=1}^{n} t_{ij}^{k} + d_{t_q}^{-} - d_{t_q}^{+} = Time_{ToTal}. \quad (5)$$

Minimal pollution:

$$\sum_{i'=1}^{\ell} M_{i'r} \sum_{i=1}^{m}\sum_{j=1}^{n} d_{ijr}\left(\sum_{k=1}^{s} A_k y_{ijkr}\right) + \sum_{j'=1}^{\ell'} B_{j'r} \sum_{i=1}^{m}\sum_{j=1}^{n} d_{ijr}\left(\sum_{k=1}^{s} A_k y_{ijkr}\right) + \sum_{k'=1}^{\ell''} T_{k'r} \sum_{i=1}^{m}\sum_{j=1}^{n} d_{ijr}\left(\sum_{k=1}^{s} A_k y_{ijkr}\right) + \sum_{r'=1}^{\ell'''} (BRT)_{r'r} \sum_{i=1}^{m}\sum_{j=1}^{n} d_{ijr}\left(\sum_{k=1}^{s} A_k y_{ijkr}\right) + d_{A_{kr}}^{-} - d_{A_{kr}}^{+} = Emission_{ToTal} : r = 1, \dots, 22. \quad (6)$$

Minimum trip cost:

$$\sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{k=1}^{s} (x_{ijkr} C_{ijkr}) + d_{C_{ijkr}}^{-} - d_{C_{ijkr}}^{+} = C_{ToTal} \quad : r = 1, \dots, 22. \quad (7)$$

Maximum availability to the station and trip distance:

$$\sum_{i'=1}^{\ell} M_{i'r} \sum_{i=1}^{m} h_{i,t_{max}}^{kr} + \sum_{j'=1}^{\ell'} B_{j'r} \sum_{i=1}^{m} h_{i,t_{max}}^{kr} + \sum_{k'=1}^{\ell''} T_{k'r} \sum_{i=1}^{m} h_{i,t_{max}}^{kr} + \sum_{r'=1}^{\ell'''} (BRT)_{r'r} \sum_{i=1}^{m} h_{i,t_{max}}^{kr} + d_{h_{kr}}^{-} - d_{h_{kr}}^{+} = Availability_{ToTal} : r = 1, \dots, 22, k = 1, \dots, s. \quad (8)$$

Maximum comfort:

(9)

$$\sum_{i'=1}^{\ell} M_{i'r} \sum_{i=1}^{m}\sum_{j=1}^{n} x_{ijkr} + \sum_{j'=1}^{\ell'} B_{j'r} \sum_{i=1}^{m}\sum_{j=1}^{n} x_{ijkr} + \sum_{k'=1}^{\ell''} T_{k'r} \sum_{i=1}^{m}\sum_{j=1}^{n} x_{ijkr} + \sum_{r'=1}^{\ell'''} (BRT)_{r'r} \sum_{i=1}^{m}\sum_{j=1}^{n} x_{ijkr} + d^{-}_{(s-c)kr} - d^{+}_{(s-c)kr} = (S-C)_{ToTal} : r = 1, \dots, 22 \quad (4.6)$$

Modal share of active and public transport in commuting, The last OD survey of Tehran resident's trips was conducted in 2014. Based on this data, the total daily work and study trips by different modes, was estimated. As a result, the share of public and active modes of work and study trips were identified. Convenient access to public transport service In order to calculate the convenient access of the inhabitants of Tehran to the public transport services, the GIS database has been used. Since the last Iranian Population and Housing Census was in 2016, this GIS database is formed by this information. The other required data for this indicator was public transportation modes (Bus, BRT, and Metro) information that was collected from relevant organizations. These data include public transportation lines, stations characteristics, their routes and locations. Public transport quality and reliability The last public bus and BRT users' satisfaction survey was conducted by Tehran Bus Company in 2018. The questions which had been asked from the passengers of the bus and BRT in this survey are as Table (1):

Table 1. Public transport quality and reliability

BUS	BRT
Frequency of the service	Frequency of the service
Condition of air & temperature inside the vehicles	Convenience of Boarding & Alighting
Cleanliness of inside the vehicles	Convenience of stops/stations
Cleanliness of outside the vehicles	Cleanliness of inside the vehicles
Personnel courtesy	Cleanliness of outside the vehicles
Satisfaction of vehicles driving	Availability of information inside the vehicles
	Availability of information in the stops/stations
	Personnel courtesy
	Satisfaction of vehicles driving
	Passenger density inside the vehicles
	Condition of air & temperature inside the vehicles

Every year Metro Company conducts a passenger satisfaction survey. The only available information of this survey was the overall satisfaction of Metro passengers, which does not cover all aspects. Hence, three satisfaction surveys for the bus, BRT and Metro passengers, with the questions that cover the other aspects in the , were conducted. For these surveys, three different questionnaires were designed. The questionnaires were completed by asking the questions from the passengers in the bus, BRT and Metro stations.The weighted average of the users' satisfaction level of these three modes, considered as the passengers' satisfaction degree of public transport. Tables (2) to (5) show the calculations Public transport quality and reliability.

Table 2. BUS user's satisfaction level

	Dissatisfied	Satisfied	
Dimension			RESP SATISF
Frequency of the service	25	75	100 75
Condition of air & temperature inside the vehicles	38	62	100 62
Cleanliness of inside the vehicles	27	73	100 73
Cleanliness of outside the vehicles	28	72	100 72
Personnel courtesy	21	79	100 79
Satisfaction of vehicles driving	23	77	100 77
Punctuality (delay)*	50	50	100 50
Convenience of stops/stations	50	50	100 50
Availability of information	84	16	100 16
Fare level	53 47	47	100 47
Responses	399	601	1000 73

Table 3. BRT user's satisfaction level

	Dissatisfied	Satisfied	

Dimension			RESP SATISF
Frequency of the service	18	82	100 82
Convenience of Boarding & Alighting	52	48	100 48
Cleanliness of inside the vehicles	15	85	100 85
Convenience of stops/stations	47	53	100 53
Cleanliness of outside the vehicles	18	82	100 82
Availability of information inside the vehicles	43	57	100 57
Availability of information in the stops/stations	37	63	100 63
Personnel courtesy	32	68	100 68
Satisfaction of vehicles driving	20	80	100 80
Passenger density inside the vehicles	38	62	100 62
Condition of air & temperature inside the vehicles	24	76	100 76
Punctuality (delay)*	67	33	100 33
Convenience of stops/stations	42	58	100 58
Availability of information	83	17	100 17
Fare level	39	61	100 61
Responses	575	925	1500 61.67

Table 4. Metro user's satisfaction level

	Dissatisfied	Satisfied	
Dimension			RESP SATISF
Frequency of the service	33	67	100 66.67
Punctuality (delay)*	43	57	100 57.33
Comfort and cleanliness of vehicles	44	56	100 56
Safety of vehicles	41	59	100 58.67
Convenience of stops/stations	55	45	100 45.33
Availability of information	73	27	100 26.67
Personnel courtesy	49	51	100 50.67
Fare level	68	32	100 32
Responses	407	393	800 49.17

Table 5. Public transport user satisfaction level

Mode	SATISF	Mode Share (%)	SATISF
Bus	73	46	33.58
BRT	61.67	39	24.05
Metro	49.17	15	7.38
taxi	60	35	11
			76.01

Affordability- travel costs as share income In order to calculate Affordability- travel costs as share income, a different type of information was collected. This information is:The Average annual income of an urban household of the three lowest Affordability- travel costs as share income The collected data is shown in table (6).

Table 6. Average income of the three lowest decile

Decile	Average annual income of household(RIAL)-2014	Average monthly income of household(RIAL)-2014
1	65,402,000	8,818,444
2	112,225,000	
3	139,837,000	
AVE	105,821,333	

Public transportation modes' ticket price is taken from the bus line ticket price report. In order to derive a general ticket price for the bus and BRT, first the average price of the public & private bus and BRT tickets per kilometer was calculated. Then, the ticket price of the bus and BRT was computed by multiplying the average length and average price per kilometer. As the Metro ticket price per kilometer was not available, the price of a Metro single ticket was used. The number of trips by public transportation modes was derived from Tehran Comprehensive OD Survey . By using the above data, indicator 6 was calculated as shown in Table (7).

Table 7. Affordability- travel costs as share of income

	Monthly Ridership	Market shares	Single ticket price(RIALS) - 2014	Monthly cost (60 tickets)	Weighted monthly cost
Services					
City Bus	1320812	46	4021	241283	110990
BRT	426789	39	3949	23612	92396

METRO	1121111	15	5000	300000	45000
Total	2868712	100	0	0	248386
Mean household income, 2014					8,818,444
					2.8

Air quality (PM10), As mentioned before, the Tehran Air Quality Control Company is one of the affiliated companies of Transportation Deputy of Tehran Municipality, which is responsible to monitor the Tehran air quality. This company has 21 air control stations in various regions of Tehran. One of the pollutants is being monitored by this company is the PM 10. This company publishes the Tehran air quality report every year.The yearly average of PM 10 for all stations in a one year was not available, therefore the total average amount of PM 10 in Tehran in 2018, was applied to calculate Air quality.In table (8), the calculation of Air quality, is shown.

Table 8. Air quality (PM10)

Location	PM 10	Population	Population
Tehran	yearly mean	in area	percentage
	72.1	8872028	100.00
Total city population		8872028	100
Population weighted concentration	72.10	Value to enter In sub-sheet B	

Table (9) presents the calculation results of vehicle information. The number of buses, subways, BRTs and taxis in each area has been checked and the results have been obtained, the calculations have been specified with Lingo software. According to the information given in the collection of Tehran's regions to be added or subtracted to the vehicle and that the region has the required number of vehicles.

Table 9. The result of indicator calculations

Vehicle Urban transportatio n	

destric	k_1	k_2	k_3	k_4	k_5	k_6	k_7	k_8	k_9	k_{10}	k_{11}	k_{12}	k_{13}	k_{14}	k_{15}	k_{16}	k_{17}	k_{18}
Taxi	1	6	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bus	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metro	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BRT	3	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The Results shows, the amount of investment in the public transport systems and air quality in Tehran are also poor. Results show despite of Tehran does have an affordable, easy access with fair quality public transportation system, the modal share of public transport of total daily trips in Tehran is not what is expected.This means to have a convenient public transport system without increasing the using private cars cost, does not make people to use more public transport instead of their own cars.

6. concluding remarks

Tehran is one of the big cities with high population, expansion of urban boundaries and increasing economic development. Many problems arise in the city due to the increase in population and intra-city travel Mojtehedzadeh [22]. At the beginning of these problems is the problem of urban transportation. Changes in passenger density and population growth in the coming years require continuous handling of these problems. When discussing the problem or improvement of vehicle selection, alternatives are first identified and classified by mode of transportation.

The basic steps in regional transportation planning models of Tehran are:

1) evaluation of the existing road network, traffic and travel characteristics of the studied area.

2) Forecasting travel demand until the horizon of 1412 and identifying the requirements of the transportation system.

3) Digitalization of the road network.

4) Perform sample checks for trip rate, mode selection and O-D.

5) Preparation of travel production models and O-D matrices.

6) Allocation of traffic in the selected network and evaluation of vehicle/capacity ratio.

7) Creating a transportation scenario for the future.

8) The best means of transportation in Tehran according to the region.

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