Optimizing passenger waiting time in the intersection stations of Tehran subway
The case of subway line 4

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Purpose: Regarding urban population growth and importance of time and cost in the societies of today, subway systems have faced with demand increase and passengers waiting time have prolonged. In urban transportation systems especially in subways, the passengers waiting time influences the society satisfaction deeply. Since the emersion of rail network, time and scheduling as important challenges have been emerged. Then the periodic train planning as one of the best solutions was introduced to decrease passenger waiting time, reduce travel length, and increase transportation safety. This challenge should be solved by subway managers. Due to the limited number of trains and equipment on subway lines and increase of their cost-effectiveness in reducing passenger waiting times at intersections, an attempt has been made in this paper to reduce waiting time using optimization models that often do not impose costs on the system. In addition, another aim of this paper is to fill the existing research gap in this area.

Design/methodology/approach: This paper aims to calculate the weights of intersections stations in order to minimize the passenger waiting time through goal programming (Khalili Damghani et al. 2015; Mosadeghi et al. 2010). Many studies have been done on train scheduling and transportation mathematical modelling all around the world (Moghaddam and Mahlooji, 2017; Sadeghieh and Dehnavi-Arani, 2019). The aim of this paper is to minimize the deviation from desirable situation through goal programming. The main function of the proposed model is formulated again along with new construction, auxiliary variables and optimum values. It consists of variables with the concept of "deviation of desirable situation". In this paper, both of the deviations of desirable situations are shown by d_{ip} and d_{in} which are undesired and should be minimized to achieve the optimum value. For this purpose, the fourth line of Tehran subway system and its intersections sections are considered as the real world problem.

Findings: The model is solved by Lingo and optimum values are calculated. The model is developed based on goal programming and it can reduce the passenger waiting time and satisfaction which results in increased acceptance of public transportation in society. These findings are compared with current values of time tables for first and last movements. Findings indicated that the proposed model can reduce the passenger current waiting time by 42%.

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Research limitations/implications: In this paper, the accurate amount of passenger population was determined in a day based on lines, separately. Also, it was difficult to collect study data from the Tehran subway system organization. The proposed approach resulted in reduced passenger waiting time. Suggestions for further study include examining and analyzing the factors causing train delay and comparing the results of each single line with another; using simulation method to develop an optimization model for time tabling of train movement in order to optimize energy consumption; calculating and optimizing the number of subway station staff; and optimizing models to design the subway station network.

Practical implications: As Tehran public transportation system is extending to cover more urban regions, the intersection stations will increase. Therefore, the role of these stations will be more tangible. Each intersection station scheduling affects the train movements in other stations and this continues throughout the length of the network. It means that each delay and pause will influence the other intersections, increasingly. The subway system managers can employ this model on other lines and reduce the waiting time of passengers in the whole Tehran subway.

Social implications: As mentioned earlier, the waiting time of passengers in different stations, especially in intersections, is an important factor in using subway system as an effective public transportation system. It will increase or decrease the rate of subway usage. More public transportation usage leads to less air pollution, less traffic and faster travels in the city, which are all desirable for society.

Originality/value: In this paper, a goal programming model was proposed to minimize the deviations in the objective function and subsequently, the passenger waiting time in intersection stations. As the intersection stations are increased, the role of the proposed method can be considered as a solution for public transportation in different cities of Iran.

Keywords: Passengers waiting time, Intersection stations, Optimization models; Intersecting passengers

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