# A New Bi-Objective Classic Transportation Model Considering Social Justice

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**Abstract**
Today, accessibility is an important issue in the field of transportation that has a significant impact on urban development and progress, and it's very important for people in the community who use transportation. Transportation involves a lot of costs that we can provide urban transportation policies and plan with social justice, which is one of the issues of sustainability. Social justice in transportation has seven methods. In this article, we examined social justice with minimal variance for additional benefits and presented a linear model of an extended two-objective integer programming method, which we have generalized and solved according to the exact epsilon-constrain method. We have reviewed the results in different situations and used the opinion of domain experts for validation. Experimental results reveal that the best way to increase justice is to increase access routes, and in the other case, to increase available resources, which is much more efficient than increasing areas.

**Keywords:** accessibility, space-time curves, social justice, epsilon-constraint, minimum variance, transportation

## 1 Introduction

Many associations, organizations, and professionals use the principles of sustainable transport planning in an effort to balance economic, social, and environmental goals. This requires a more comprehensive impact analysis, including consideration of social justice. Space-time curve variables are a good measure of the availability of a network. When a person needs to be available in a location, space-time curve networks apply network-based constraints such as fares and fuel costs based on other sources. Fig.1 shows the space-time charter for a person who wants to travel from origin to destination [1]. The "accessibility" variable of distributive benefits is used in these models. This framework can be used to address social justice concerns in many issues related to infrastructure investment. This framework provides a practical way to integrate social justice attitudes into transportation modeling and economic evaluation, linking the social sciences with quantitative analysis [18]. Theories of social justice define the rights and obligations of the people based on different economic and political ideologies. These can be economic (distributive), political, organizational /administrative, cultural rights, education, legal, and judicial /judicial.

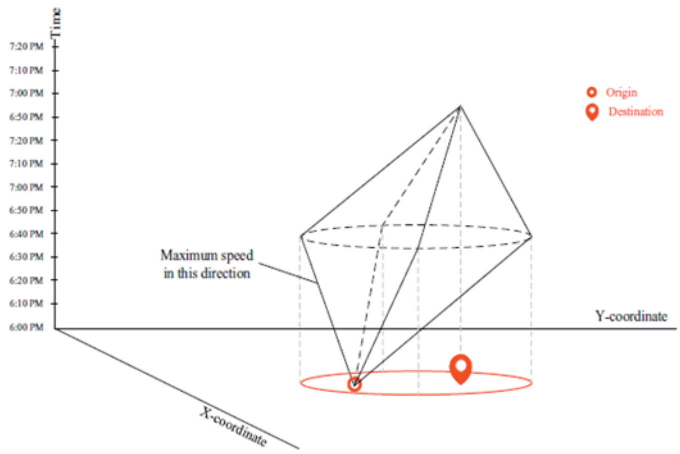


**Fig.1.** Space-time curve for a person who wants to go from one origin to another

### 1.1 Social justice

In this article, the social justice method of limiting variance for added benefits is used, which consists of several sections, which include theories of socialism, psychological liberalism, John Rawls' theory, and Sadr's theory. Socialism means political, economic, and social thought that seeks to establish a social order based on universal cohesion, a society in which all sections of society have an equal share in the common good. Psychological liberalism is also rooted in modern liberalism in the Enlightenment. In general, liberalism places a strong emphasis on the rights of individuals and equal opportunity. Different branches of liberalism may propose different policies, but they are all generally united on several rules, including the expansion of freedom of thought and freedom of expression, limiting the power of states. The important role of the law includes the free exchange of ideas, the market economy or the mixed economy, and a transparent system of government.

### 1.2 John Rawl's Theory

In justice theory, Rawls writes: (Justice is the first virtue for the social institution, just as truth is for the system of thought.) Justice, according to Rawls, precedes happiness. Happiness and prosperity are then seen as a positive value that is justified. Hamid Behbahani et al. [2] Justice is a framework in which different people have the opportunity to pursue their desired aspirations and values. The two principles of Rawls' revised theory of justice are as follows:

(A) Everyone is entitled in full equality to a fair and public hearing by an independent and impartial tribunal, in the determination of her rights and obligations and any criminal charge against her.

(B) Social and economic inequalities are acceptable in two conditions:

1) They must be reserved for positions and positions that are open to all under the conditions of fair equality of opportunity.

2) These inequalities should benefit the most deprived members of society (principle of difference). Rawls sees justice as the crystallization of justice and says that in the

original position, which is somewhat similar to the concept of the natural state, people want to form civil society and inevitably agree on reasonable and fair principles. The role that these principles play in the separation of rights, duties and the distribution of social benefits is what is called the concept of justice [19, 20]. In the individual sphere, justice means observing the limits of moderation and perseverance in the Shari'a. In the field of collective life in connection with the general human development, social justice includes the two pillars of social balance and social security, the second pillar is done in two ways, popular and governmental. From an individual point of view, justice means observing moderation and perseverance in the Shari'a. From collective life to the general human substitution, social justice includes the two pillars of social balance and social security, the second pillar of which is done through the people and the government. We can use the mathematical model to estimate each of these and use it to increase social justice and provide more capital for all people with special needs and it is also possible to study land areas and use efficient methods for investment.

We examined the transportation networks with reference to space-time curves and the observance of social justice, where we have used the social justice model with minimal variance for different groups. We examined our model using the generalized Epsilon-constraint method. Figure 2 shows a comparison of the objective function for 14 repetitions with efficient answers, which is important to increase cost management justice [21]. Figure 3 illustrates the Pareto answers to the problem. In studies in the field of space-time curve networks due to limited resources, it is the first time that a two-objective model is considered to reduce the costs of space-time curve and increase social justice that all areas of a transport network can access the transport network as much as possible and justice be done.

Accessibility is defined as the ease of access to a destination, activity, or service in an environment. Miller [3] mentioned that not only time but also other sources of restrictions can affect access. Road capacity, transportation cost budgets, energy regulations, emission restrictions, and shared subscription services are some examples of resource constraints that have been studied using STP and NTP. Lee and Miller [4] examined the design of space-time transport networks and the extent of access to the health network in Columbus, Ohio. Chen et al. [5] investigated the space-time network in the case of time uncertainty. Zhou and Zhu [6] developed an integer linear model to examine a space-time network for bicycle transportation routes so that the cost of the barrier is also reduced. Ho [7] examined the access of workers to work and the job situation in a city. Lee et al. [8] studied Laplacian matrices in space-time curves. Kook et al. [9] examined the accessibility of the transportation network in the three cities of Cape Town, Gothenburg, and Chisumu, and examined the policies of shareholders and policymakers. Ghomami [10] examined electric cars over a long distance and examined the charging power and number of stations for minimizing social costs. Shui [11] suggested that the transportation network includes social, economic, environmental, energy, and financial indicators of sustainable transportation. Cheng et al. [12] studied the dynamic traffic of a system to find environmentally friendly routes and have used the Lagrangian release method to solve it. Waller and Duttie [13] investigated the network and the impact of environmental justice on the low-income group of society and have used genetic algorithms to solve it. Farahani et al. [14] comprehensively reviewed transportation networks and solved models and compared them.

Feng and Zhang [15] examined justice in the road transport network and the interests of shareholders. Manoug et al. [16] addressed two related questions: how social rights are prioritized over environmental and other conceptual, operational, and other goals. How can social rights be more effective in urban transportation programs in North America? They critically analyzed how social rights are incorporated into transportation programs in 18 major North American metropolises, in terms of the quality of related goals, how they are achieved through the selection of measures or performance indicators, and they prioritize evaluation over other items. Zhang [17] solved the design problem of hybrid transportation networks in the form of a mixed-integer model. In this study, we examined transportation networks for space-time curves and the observance of social justice. We have used the social justice model with the least variance for different groups.

We have reviewed and analyzed our model using the Epsilon-constraint method. In the field of space-time curve networks, due to limited resources, it is the first time that a two-objective model to reduce the costs of space-time curve and increase social justice are examined. The remainder of this study is as follows. In Section 2, the model description is discussed with the model assumptions of the generalized Epsilon-constraint method. Section 3 presented numerical examples and in Section 4 conclusions are examined.

## 2 Mathematical model

Transportation is one of the most important issues that develop a society and space-time and space-time networks with limited resources are the most basic transportation networks, which is a very important issue considering social justice and that all groups of society use transportation networks equally. Should be examined in this section the developed mathematical model is presented.

In this paper, we present a dual-objective model that you can see in the parameters and model below.

| | |
|---|---|
| $(i,i')$ | Number of links between adjacent nodes I and $i'$ |
| $TT(i,i',t)$ | Link travel time from node I to node $i'$ at time t |
| $T$ | Time horizon end time |
| $r,r'$ | Corresponding resource level at the top $(i,t)$ and $(i',t')$ |
| $O$ | Source node |
| $D$ | Destination node |
| $\Phi$ | Sink node |
| $c_{i,i',r,r',t,t',k,k'}$ | The cost of the bow $(i,i',t,t',r,r',k,'k)$ when $r=r'$ |
| $x_{i,i',t,t',r,r',k,k'}$ | Equal to 1 if the person enters from node $(i,t,r,k)$ to node $(i',t',r',k')$, otherwise equal to 0 |
| $(AC_k)$ | Distributable profit for group k |
| $\Delta AC_k$ | Additional benefits for group k |
| $(k,k')$ | Number of groups in the community |
| $m2$ | Chat parameters |

$$\min z_1 \sum_{i,i',t,t',r,r',k,k'} c_{i,i',t,t',r,r',k,k'} \times x_{i,i',t,t',r,r',k,k'} \quad (1)$$

$$\max z_2 \sum_{k} AC_k \times x_{i,i',t,t',r,r',k,k'} \quad (2)$$

s.t

$$\Delta AC_k > m2 \times \Delta AC_{k'} \quad (3)$$

$$\sum_{i',t',r'k,k'} x_{i,i',t,t',r,r',k,k'} = 1 \forall i = o, t = 0, r = r_{\max} \quad (4)$$

$$\sum_{r,k,k'} x_{i,i',t,t',r,r',k,k'} = 1 \forall d, i' = \Phi, t = T, t' = T+1, r' = 0 \quad (5)$$

$$\sum_{i',t',r',k,k'} x_{i,i',t,t',r,r',k,k'} - \sum_{i',t',r',k,k'} x_{i,i',t,t',r,r',k,k'} = 0 \forall i, t, r \quad (6)$$

$$x_{i,i',t,t',r,r'k,k'} \in (0,1) \forall i, i', t, t', r, r', k, k' \quad (7)$$

The First objective function (1) shows the minimization of time-dependent costs and resources at different times and regions for the transportation network. The second objective Function (2) is used to increase the social justice of people in different areas to get the most benefit in different areas. Constraint (3) indicates the minimum score for the poorest group and the limitation of class differences among all areas of society. Constraint (4) shows the Flow balance constraint for the origin vertex. Constraint number (5) Flow balance constraint for the sink vertex. Constraint (6) shows the Flow balance constraint at intermediate vertexes. Constraint (7) indicates Binary definitional constrain.

**Table 1**. Efficient results of the problem in 14 replications by the generalized Epsilon constraint algorithm

| Rep | Min z1 | Max z2 |
|---|---|---|
| 1 | 1288 | 667 |
| 2 | 1287 | 671 |
| 3 | 1286 | 674 |
| 4 | 1283 | 677 |
| 5 | 1281 | 678 |
| 6 | 1280 | 680 |
| 7 | 1278 | 681 |
| 8 | 1277 | 683 |
| 9 | 1275 | 684 |
| 10 | 1272 | 687 |
| 11 | 1269 | 688 |
| 12 | 1266 | 689 |
| 13 | 1262 | 690 |

## 3 Numerical Results

In this section, we use random data and the aim is to show the performance of the model in Gomez software with the Epsilon-constraint method [22-30], which is done in a system with an i7 processor and 8 GB of RAM under Windows 10. Table 1 illustrate the empirical results by the generalized Epsilon constraint methods after 14 iterations in 0.81 seconds. The minimum value for the first objective function, which is related to reducing the costs of the transport network, in the last efficient answer of the algorithm is equal to 1262, which gave the best answer. Also, the second objective function, which is related to increasing social justice, which is the best answer, is equal to 690. Fig.2 depicts a comparison of the objective function for 14 repetitions with efficient answers and Fig.3 illustrates the Pareto answers to the problem.

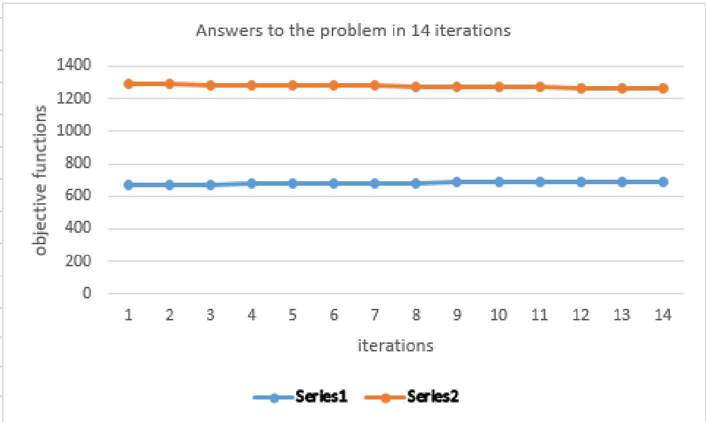


**Fig.2.** Answers to the problem in 14 iterations

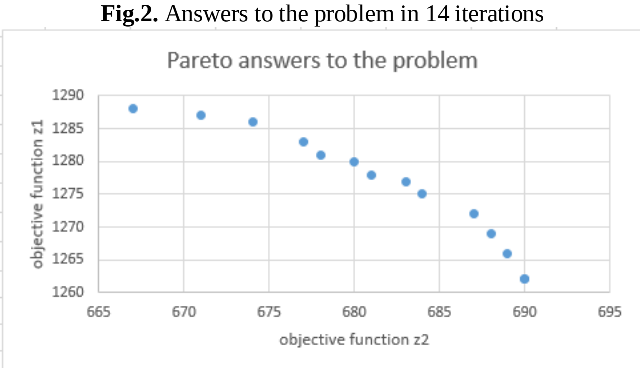


**Fig.3.** Pareto answers to the problem

### 3.1 Sensitivity analysis

When (r) our available resources for different areas increase, the costs to the network are also increasing, and so are the benefits to different areas of social justice. Fig.4 shows a comparison of Pareto answers after increasing the sources. When (k) the areas in the network increase, it is observed that the costs increase more than the number of benefits to increase justice, so we see the comparison of the answers for the two objective functions in the case of more areas in Fig.5.

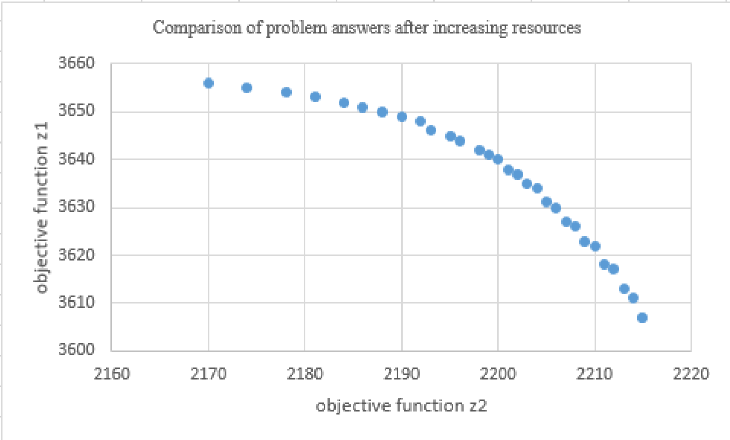


**Fig.4.** Comparison of problem answers after increasing resources

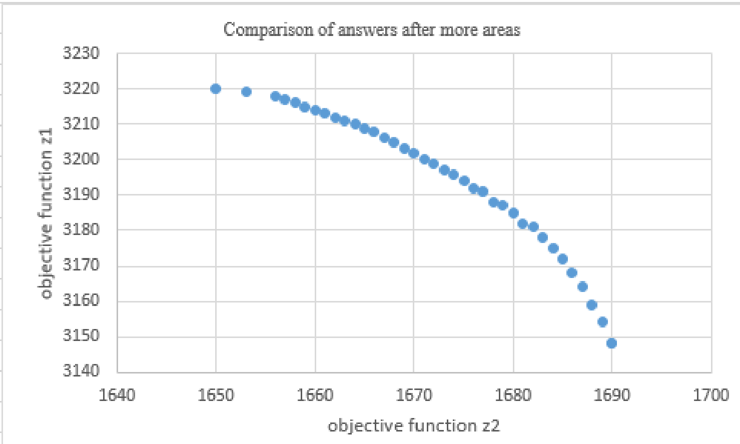


**Fig.5.** Comparison of answers after more areas

When (i) we increase the number of connection routes between two points, which also increases the accessibility between two points, we see that the cost objective function and the social justice objective function increase, which can be seen in the comparison of the solutions in Fig.6. After analyzing the sensitivity and changes in the increase of areas and resources and the communication path between the two points, it is observed that increasing the areas and resources of both in the same range increases the cost, which is evident from Figures 4 and 5. Increasing communication points, further increases the cost. The important point here is that increasing resources leads to greater social justice and greater accessibility than increasing areas. To further increase justice, we can increase the access routes between points, which has the greatest impact, which is clear by comparing the above Figures.

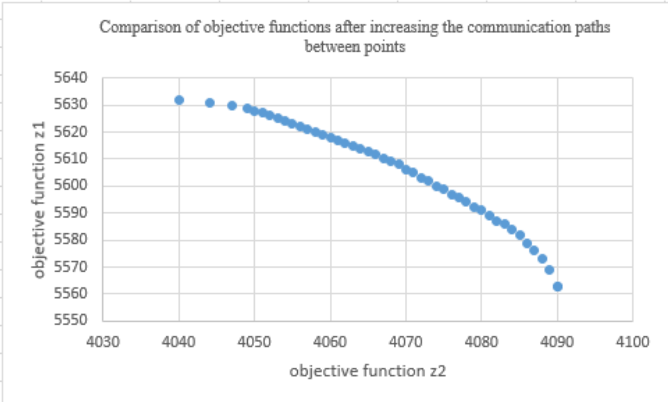


**Fig.6.** Comparison of objective functions after increasing the communication paths between points

# 4 Conclusions

This paper presented a mixed-integer model to reduce transportation network costs and increase social justice. To have a better view of cost management in transportation networks, considering that establishing justice and increasing the interests of people with different needs in different regions can be very important in the sustainability of society. To solve the proposed linear model, we used the generalized constraint-epsilon algorithm to provide us with efficient answers. After 14 repetitions, we reached the exact answer, which reached the maximum of justice with 690 and the minimum cost of 1262. In the sensitivity analysis section, we found that the best way to increase justice is to increase access routes, and in the other case, to increase available resources, which is much more efficient than increasing areas. For future research, long-term planning for a community and transportation system can be done, or from real information and existing examples.

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