



## Evaluating and Ranking of Travel Mode in Metropolitan A Transportation Economic Approach

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Received 16 February 2018; Accepted 20 May 2018

### Abstract

Nowadays metropolitans' planners faced with a significant growth of private cars and consequently, creation a lot of environmental costs. To tackle the problem, the planners should find the best suitable way with due to the stakeholders' views and other affected criteria to encourage the passengers for using the public transportation instead of their own cars. This paper has been performed to identifying and verifying main criteria affecting travel mode selection; getting different point of views; identifying the most effective travel mode from stakeholders' point of view and finally evaluating and ranking of travel modes in in Tehran metropolis. This study is a quantitative research based on survey and two structured questionnaires for passengers, experts and managers. In order to have an accurate data analysis, AHP as an MCDM models has been used to evaluate and ranking of travel modes. By identifying main criteria (variables) affecting travel mode selection, also collecting and analyzing stakeholders' different points of views, the weight of each related criterion has been identified and determined and consequently the priority of effective travel mode in Tehran metropolis has been achieved. Finally, the managerial report has been prepared.

*Keywords:* Metropolitan; MCDM; Decision Making; Travel Mode; Public Transportation.

### 1. Introduction

It seems that metropolitan planners should have proper facing with transportation issues, they should consider stakeholders' views as considering other criteria such as cost, budget, safety, resources, etc. to dominance these complications too. Also, they have to use suitable and scientific methods for their decision-making. To proper facing with transportation issues, they should take suitable decisions by using suitable methods. Moreover in order to provide effective services to passengers, it's necessary to determine how public transportation should be and what feature it should have. So, due to lack of studies about mentioned issues, current research has been performed as: "Evaluating and ranking of travel mode in a metropolitan". It has been performed to identifying and verifying main criteria (variables) affecting travel mode selection; getting all stakeholders' different point of views; identifying the most effective travel mode from stakeholders' point of view; evaluating and ranking of travel modes in Tehran metropolis. This research attempts to enrich the knowledge and criteria affecting to travel modes in metropolitans for traffic planners. Here we would like to remind that current research specially performed for Tehran metropolis and it is possible that based on culture and existing infrastructures in other metropolitans, identified passengers' point of view in this case be different with passengers in other. Besides, maybe travel modes in other metropolitans have different forms. For instance

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 <http://dx.doi.org/10.28991/cej-0309174>

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riding a bicycle is a form of travel in Beijing in China, while it is not used as a form of transportation in Tehran. Hence, due to the structure of each metropolitan, proper research should be formed. By identifying main criteria (variables) affecting travel mode selection, also collecting and analyzing stakeholders' different points of views, we determined the weight of each affected criterion; we identified effective travel mode from passengers' point of view as an important group of transportation stakeholders. Also, we and finally, by using AHP as a MCDM model, we evaluate and ranked the travel mode in Tehran metropolis and propose suitable related alternatives to transportation managers.

The structured approach of the decision making process is specified by this fact that a decision takes by decision maker after passing mentioned above phases. "Conditions for such a rational and structured process have been formulated by several authors, (e.g. Drucker, Mintzberg, Raisinighani and Theoret, Nutt, Koopman and Pool and Johnson, Scholes, and Whittington (Drucker (1967) [1], Mintzberg et al. (1967) [2], Nutt (1999) [3], Koopman and Pool (1992) [4] and Johnson et al. (2005) [5]: The issue or problem is properly identified and the objectives of the decision are well defined by the decision-maker, The decision-makers actively search for information on potential alternatives, They carefully weigh the advantages and the disadvantages of these alternatives and the changes of success for each of them, Even when a preliminary solution is in sight, new information or expert judgment is accepted, studied and analyzed, even if it contradicts earlier ideas and preferences, Before a final decision is made, positive and negative consequences of all alternatives are re-examined, Provisions for implementation of the decision are prepared, (including a contingency plan that might be required if the implementation fails), A procedure is defined for follow up of the decision to judge if the purpose has been achieved or has to be reconsidered. In some cases that can still be considered, a rational process, not all of these conditions have to apply fully, e.g., when only one valid option for a decision can be identified" [6]. Also, Harvey says: "As organizations globalize their operations, managers are finding that making decisions in a global context is more complex" [7]. "Complex business problems, characterized by the presence of conflict of values, require the inclusion of some of decision-making process to deal with the multiple and often opposing perspectives". [8] Many scientists believe that Decision-Making is one of the basic parameters in management. On the other word, Decision Making is the result of a process which helps to attain a decision, but those who are not directly involved in this process, can only witness the result of the decision. For instance [9] says: "Decision-making is an important factor in management. This mechanism is used in a wide range of subjects. It should be emphasized very important role of decision-making in all over the managers' tasks and organizational processes."

Citroen says: "A number of strategic managements take the position that executives should reach strategic decisions based on a well-structured process & careful consideration of circumstances, alternatives and this approach is known as a rational process. An important theme in research into strategic decision-making concerns the process or approach that is followed in making a decision and the structure of this process." [6] Here we should note that personality traits and feedback both play important roles in the decision-making process. According to [10], "decision-making consists of three stages: evaluating the options, the actions, and the experience of the outcome. Each of these stages is influence by different personality traits as well as feedback following the decisions made". "Personality traits affect how a person evaluates the options and the actions. Feedback plays a role of monitoring previous results and influencing subsequent choices" [11].

In this research attempts to enrich the knowledge and criteria affecting to travel modes in Tehran for traffic planners. Hence, the important objectives of this research are: Identifying the main criteria (variables) affecting travel mode selection, Getting all stakeholders' point of view. Describing basic subjects like metropolitan, decision-making models, transportation and public transportation, display stakeholders' different points of views and propose related alternatives. Finally, the ultimate goal of current research is evaluating and ranking of travel modes in a Metropolitan.

## 2. Materials and methods

The AHP is one of the most common methods in solving Decision-Making problems. The purpose of using it is selecting an alternative from the range of available alternatives. It is possible that some of the criteria are quantitative and some others are in accordance with decision-makers personal judgments. This method was first presented for individual decision-making. However, after a while, in decision-making group this method was welcome. Moreover, this method makes a suitable structure on group Decision-Making by effecting discipline on the process of group thinking. In this method, preservation of coherent group thinking models by determining problem's numerical variables so Decision-Maker group reach the same conclusion. This will improve coordination and consistency of individual judgments. During using AHP method, four principles should be established: Reciprocal Condition; Homogeneity; Dependency; Expectation. Contrary to what was observed in compensatory techniques, non-compensatory techniques have been used, if weakness in selected criteria unable to compensated with the strength of another criterion. In the first stage (called Outranking stage) Non-compensation technique with having a set of alternatives and criteria, compare pair alternatives. In second stage with regard to pair comparing of alternatives, overall rating will be formed. One of the goals of this study is to find out the factors influencing the adoption of Travel Mode from stakeholder point of view. As we mentioned before survey is the strategy of this research. Based on extended literature review we have developed an appropriate research construct which had been validated in prior especially in Travel Mode intention research.

Despite the relative relation, but due to the different audiences and effects, identified criteria are considered as independent criteria.

**Table 1. Brief description of criteria**

No.	Abr.	Criteria	Effects	Audience
1	C1	Energy (Fuel) Consumption	Fuel consumption, Environmental pollution, Cost, Human health	S
2	C2	Safety & Reliability	Protection & Comfort	S
3	C3	Travel Cost	Passengers' satisfaction	S
4	C4	Traffic Avoidance	Travel speed, Travel time, Vehicular queuing, Safety	P
5	C5	Flexibility & Accessibility	Value delivery & Satisfaction	S
6	C6	Regular Timetable	Passengers' satisfaction	S
7	C7	Travel Time	Passengers' satisfaction	S
8	C8	Popularity (Passenger's Ideas)	Passengers' satisfaction	E&M
9	C9	Air & Sound Pollution	Harm to humans and environment	E&M
10	C10	Land Use	Cost, Congestion, Land distribution	E&M
11	C11	Preliminary investment	Cost, Preliminary capital, Budget	E&M
12	C12	Capacity	Number of passengers, Comfort	E&M
13	C13	Operating Cost	Expenses	E&M
14	C14	Investment Return & Revenue	Delivered services	E&M

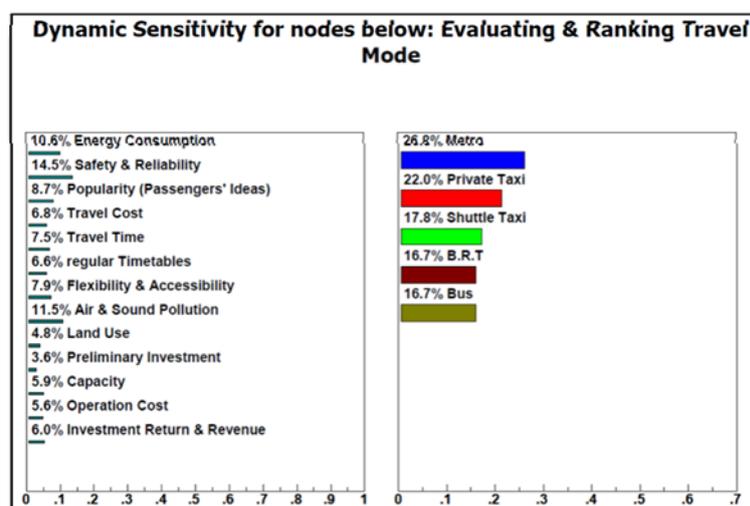
S: Stakeholders P: Passengers E: Experts M: Manage

### 2.1. Data Collection

The survey is based on two structured questionnaires. We will consider a 12'000'000 population for our case (Tehran). Totally, our audiences in this survey consists of travel mode users (passengers), transportation experts and managers (Decision makers), which are the stakeholders of travel system. The respondents will be collected among the transportation stakeholders. Passengers as an important group of audiences will be selected at different routes and different times of day, during one week. Experts and managers as another group of stakeholders will be selected among those who work in bus, metro, taxi organizations. All responses have been checked for their consistency and invalid answers were deleted.

### 3. Results and Discussion

One of the ability of Expert Choice software is that it can provide five different types of sensitivity analysis for criteria. By using this software we can change the weight of criteria and consider the effect on alternatives. These five different types of sensitivity analysis are: Performance, Dynamic, Gradient, Head to Head and Two Dimensional sensitivity analysis. We utilized different types of these methods to analyze acquired results. First, we descended the original criterion's weights and then we ascended it. In the following, we will change all criteria to see the effects of these changes to priority of alternatives. Figure 1 shows the sample status of criteria importance before making any changes.



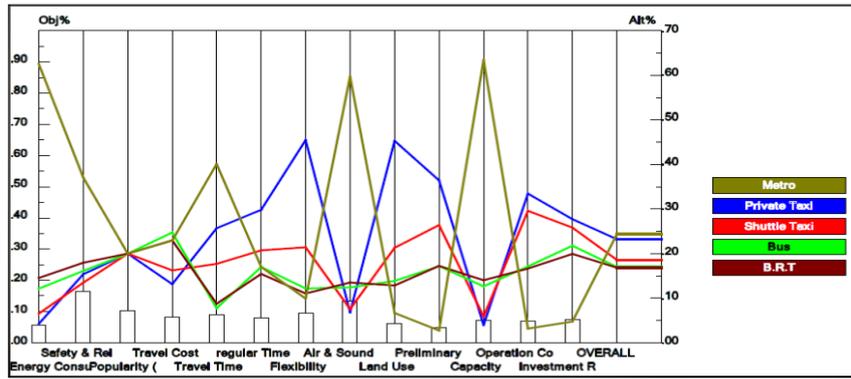


Figure 1. Ranking of alternatives before making any changes and Ranking of alternatives after descending weight

**3.1. Acquired Comparison between Different Travel Mode**

With respect to criteria' weights, here we perform a pairwise comparison between all alternatives. Expert Choice software has been used for this comparison. Results are as follows:

• **Comparison between Private Taxi vs. Shuttle Taxi**

Figure 2 shows a comparison between private taxi and shuttle Taxi with respect to all criteria. This acquired as an Expert Choice Software result.

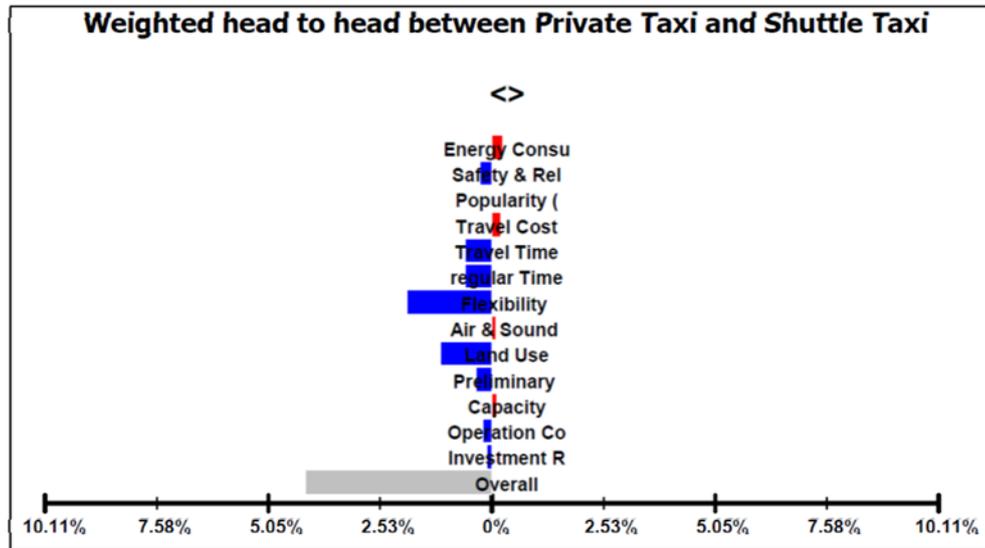


Figure 2. Comparison between Private Taxi & Shuttle Taxi

A private taxi can provide a better travel time, better revenue and providing better safety for passengers in comparison with shuttle taxi, while considering other important criteria like capacity, energy consumption, travel cost also air and sound pollution, shows that shuttle taxi has more advantages than a private taxi. Finally, as can be seen in the above figure, it seems that due to high weight of flexibility criterion and the ability of private taxi to well covering of it, generally a private taxi shall be more effective vs. a shuttle taxi.

• **Comparison between Private Taxi vs. Bus**

Figure 3 shows a comparison between private taxi and bus with respect to all criteria. This acquired as an Expert Choice Software result.

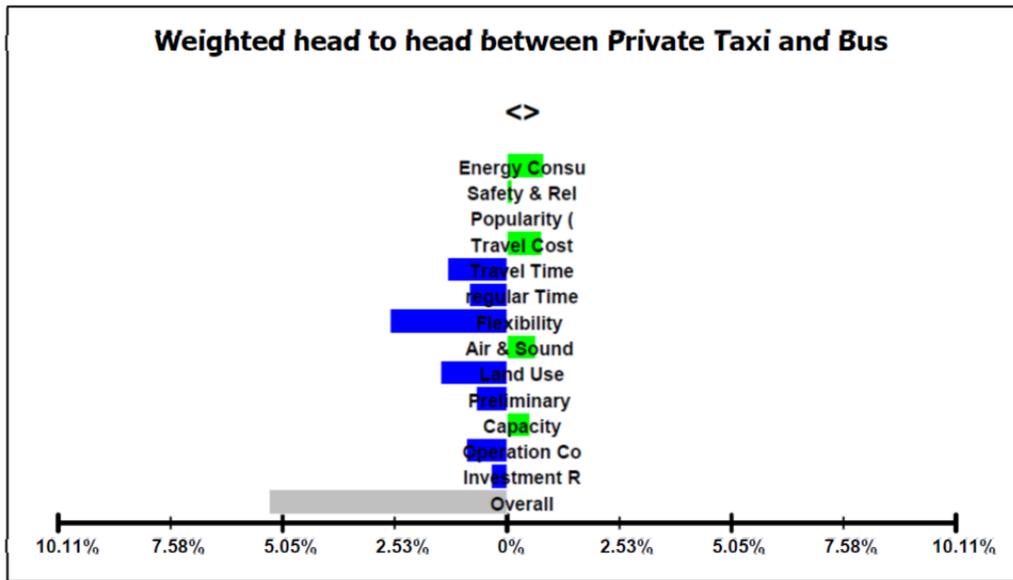


Figure 3. Comparison between Private Taxi & Bus

A private taxi can provide a better flexibility and accessibility, better travel time, better revenue and better safety for passengers in comparison with a bus. While considering other important criteria like capacity, energy consumption, travel cost and air and sound pollution, show that a bus has more advantages than private taxi. Generally, as can be seen in the above figure, it seems that a private taxi is more effective than a shuttle taxi.

• **Comparison between Private Taxi vs. B.R.T**

Figure below shows a comparison between private taxi and B.R.T with respect to all criteria. This acquired as an Export Choice Software result.

Due to ability of private taxis to provide well flexibility and accessibility, better travel time, better revenue and providing better safety for passengers it is in better level of priority in comparison with B.R.T. While considering other important criteria like capacity, energy consumption, travel cost also air and sound pollution, show that a B.R.T has more advantages than private taxi. Generally, as can be seen in the figure 4, it seems that private taxi is more effective than B.R.T.

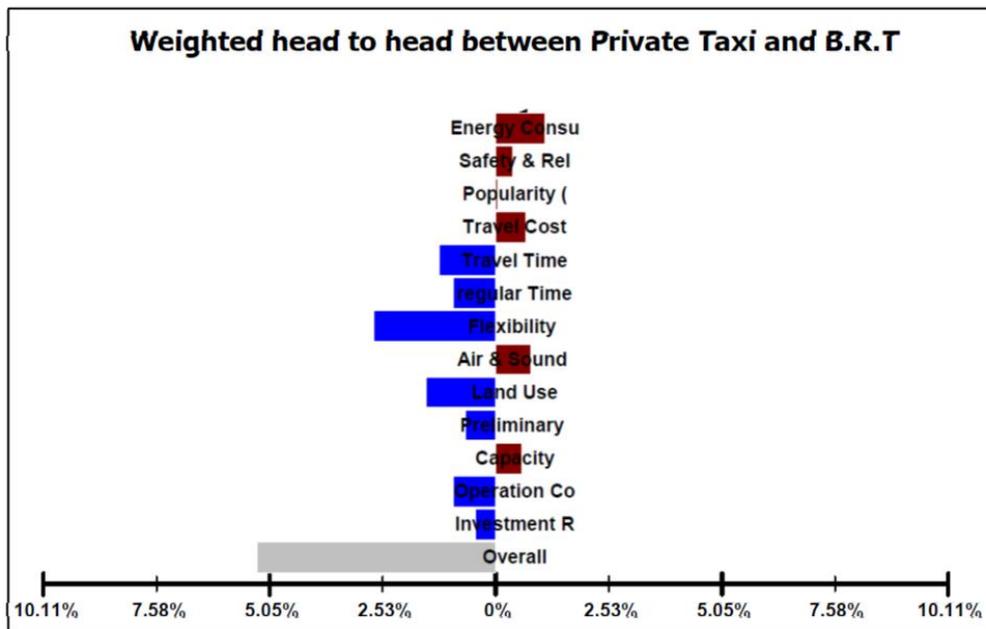


Figure 4. Comparison between Private Taxi & B.R.T

• **Comparison between Private Taxi vs. Metro**

Figure below shows a comparison between private taxi and metro with respect to all criteria. This acquired as an Export Choice Software result.

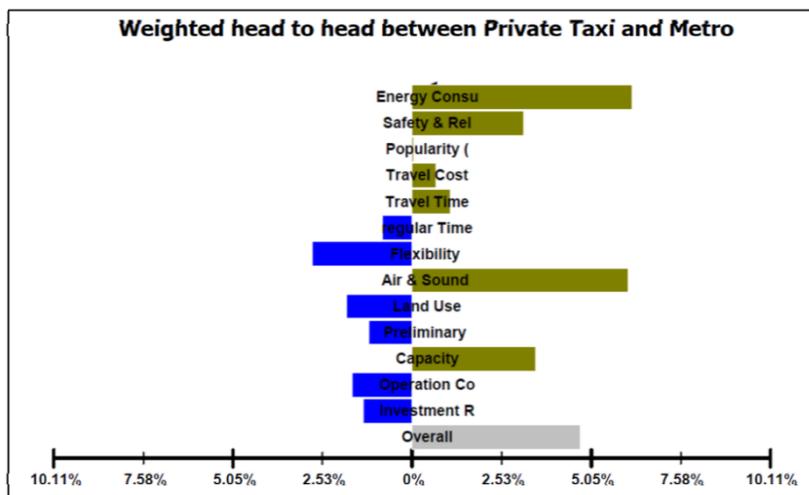


Figure 5. Comparison between Private Taxi & Metro

Regardless of above mentioned abilities that private taxi can provide, metro have a lot of positive points for other important criteria. Meanwhile because of using underground level as the main route by metro and avoiding this system from street traffic jam, it has better travel time. Hence as can be seen in the above figure, metro is more effective than private taxi.

• **Comparison between Shuttle Taxi vs. Bus**

The figure below shows a comparison between shuttle taxi and bus with respect to all criteria. This acquired as an Export Choice Software result.

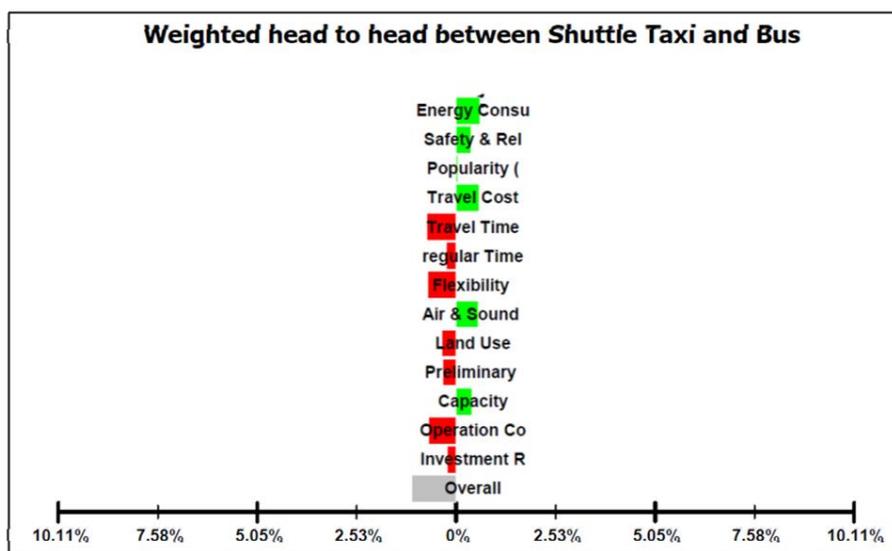


Figure 6. Comparison between Shuttle Taxi & Bus

A shuttle taxi can provide a better travel time, better investment return & revenue and providing better flexibility for passengers in comparison with bus. While considering other criteria like capacity, energy consumption, travel cost, air & sound pollution and safety show that shuttle taxi has more advantages than bus. Finally, as can be seen in the above figure, it seems that due to high weight of flexibility and travel time criteria and the ability of shuttle taxi to cover flexibility criterion, generally a shuttle taxi is more effective than a bus.

• **Comparison between Shuttle Taxi vs. B.R.T**

Figure below shows a comparison between shuttle taxi and B.R.T with respect to all criteria. This acquired as an Export Choice Software result.

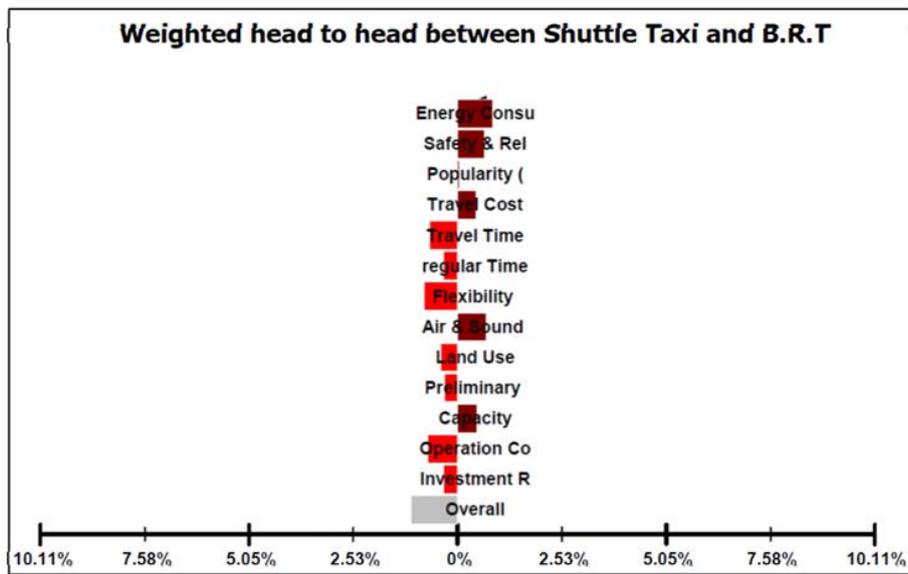


Figure 7. Comparison between Shuttle Taxi & B.R.T

A shuttle taxi can provide a better travel time, better investment return & revenue and providing better flexibility for passengers in comparison with B.R.T. While considering other criteria like capacity, energy consumption, travel cost, air & sound pollution and safety show that shuttle taxi has more advantages than B.R.T. Finally, as can be seen in the above figure, it seems that due to high weight of flexibility and travel time criteria and the ability of shuttle taxi to cover flexibility criterion, generally a shuttle taxi is more effective than a B.R.T.

• **Comparison between Shuttle Taxi vs. Metro**

Figure below shows a comparison between shuttle taxi and metro with respect to all criteria. This acquired as an Export Choice Software result.

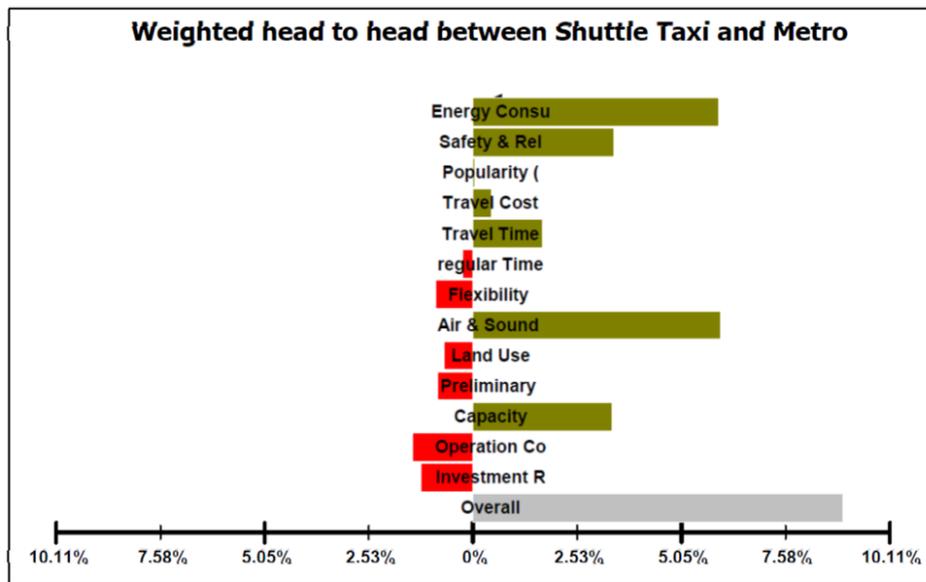


Figure 8. Comparison between Shuttle Taxi & Metro

Although shuttle taxi provides better flexibility, operation cost, investment return in comparison with metro systems but, regarding big gap between this type of public transportation vehicle and metro in some other important criteria like travel cost, travel time, capacity, energy consumption and also safety & reliability, it has been placed in lower priority. As can be seen in the above figure, generally, metro has better level.

• **Comparison between Bus vs. B.R.T**

Figure below shows a comparison between bus and B.R.T with respect to all criteria. This acquired as an Export Choice Software result.

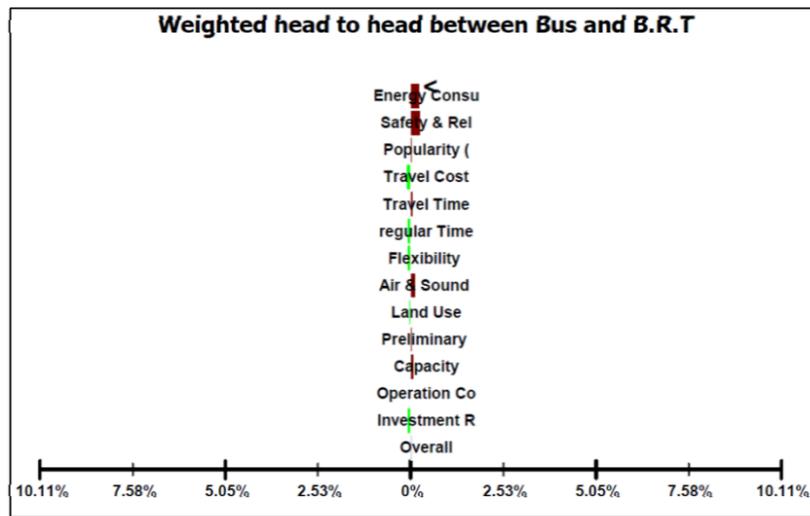


Figure 9. Comparison between Bus & B.R.T

Making a comparison between these two indoor travel modes, show that in many cases they are similar with the little differences. For instance, B.R.T has higher capacity, while buses are cheaper than B.R.Ts. Or considering the higher capacity of B.R.T it can be better in fuel consumption.

• **Comparison between Bus vs. Metro**

Figure below shows a comparison between bus and metro with respect to all criteria. This acquired as an Export Choice Software result.

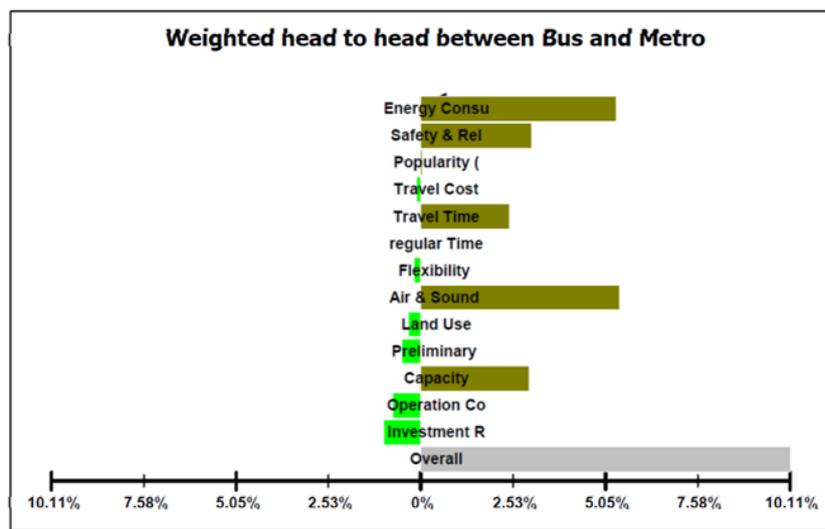


Figure 10. Comparison between Bus & Metro

A bus can provide better operation cost, better preliminary investment, better travel cost and a little better flexibility in comparison with metro but, considering big gap between this type of public transportation vehicle and metro in some other important criteria like travel time, capacity, air & sound pollution, energy consumption and also safety & reliability, it has been placed in lower priority. As can be seen in the above figure, generally, metro has better level.

• **Comparison between B.R.T vs. Metro**

The figure below shows a comparison between B.R.T and metro with respect to all criteria. This acquired as an Export Choice Software result.

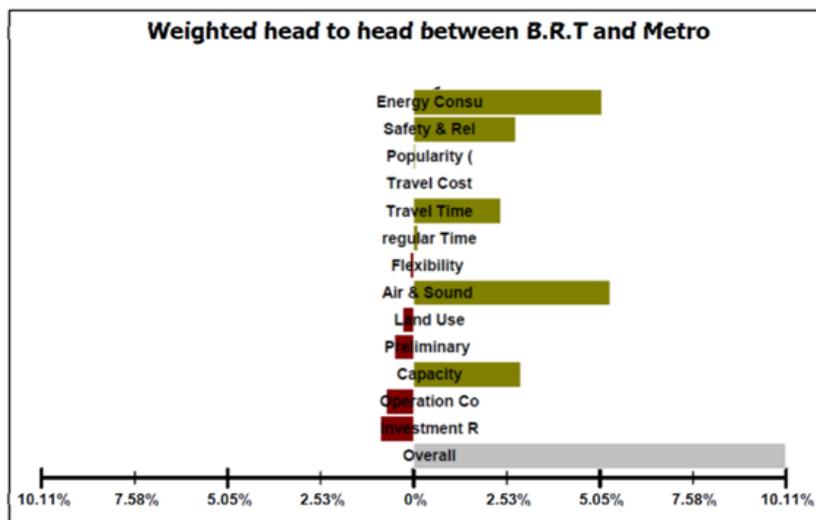


Figure 11. Comparison between B.R.T & Metro

B.R.T can provide better operation cost, better preliminary investment, better land use and a little better flexibility in comparison with metro but, considering big gap between this type of public transportation vehicle and metro in some other important criteria like travel time, capacity, air and sound pollution, energy consumption and also safety and reliability, it has been placed in lower priority like bus. As can be seen in the above figure, generally, metro has better level.

### 3.2. The Remained weight of Criteria after removing the less Important Criteria

To performing an analysis with those criteria that have high priority in choosing travel mode, we remove those criteria which their weights were less than 7%. Acquired result is as follows:

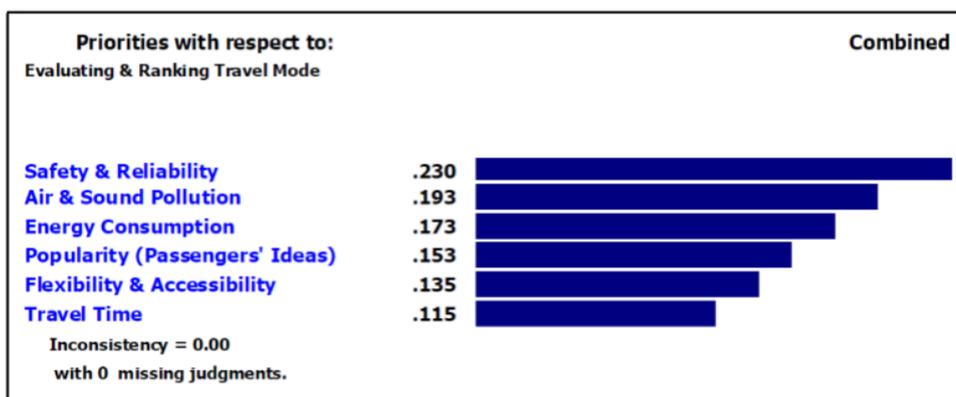


Figure 12. Weight of remaining criteria

Ranking of travel mode with more important criteria is as follows:

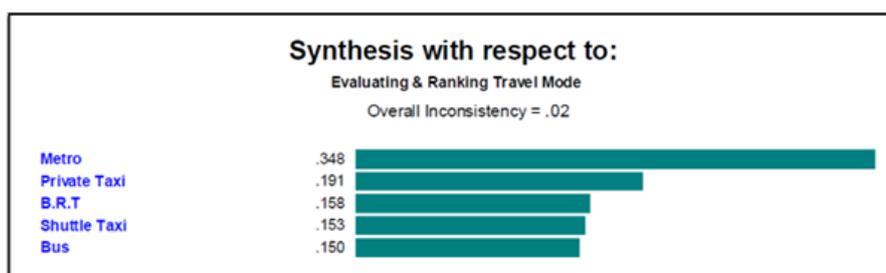


Figure 13. Priority of alternatives with respect to remaining criteria

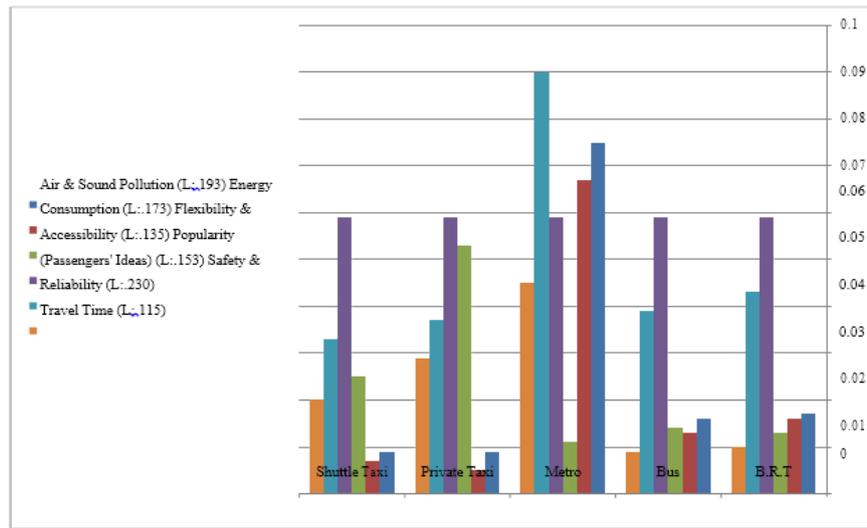


Figure 14. Priority of alternatives for remaining criteria-weights

Finally, following table shows summary of the acquired results caused by changes in four criteria and, effects to alternatives.

As we can see through above table, changes in selected criteria importance did not cause to make any changes in overall results and metro is still on the top priority. Sensitivity Analysis confirms this fact.

Table 2. Summary of acquired results

No.	Modified Criterion	Situation	Weight (%)	Priority of Alternatives (%)				
				Private	Taxi	Shuttle Taxi	B.R.T	Bus
1	Energy Consumption	Primary Ranking	10.6	2	3	4	4	1
		Descending Importance	5.0	2	3	4	5	1
		Ascending Importance	70.0	5	4	2	3	1
2	Safety & Reliability	Primary Ranking	14.5	2	3	4	4	1
		Descending Importance	5.0	2	3	4	5	1
		Ascending Importance	70.0	2	3	4	5	1
3	Popularity	Primary Ranking	8.7	2	3	4	4	1
		Descending Importance	5.0	2	3	4	5	1
		Ascending Importance	70.0	2	3	4	4	1
4	Travel Cost	Primary Ranking	6.8	2	3	4	4	1
		Descending Importance	5.0	2	3	4	5	1
		Ascending Importance	70.0	5	4	3	2	1
5	Travel Time	Primary Ranking	7.5	2	3	4	4	1
		Descending Importance	5.0	2	4	3	5	1
		Ascending Importance	70.0	2	4	3	5	1
6	Regular Timetable	Primary Ranking	6.6	2	3	4	4	1
		Descending Importance	5.9	2	3	4	5	1
		Ascending Importance	70.0	1	3	5	4	2
7	Flexibility & Accessibility	Primary Ranking	7.9	2	3	4	4	1
		Descending Importance	5.0	2	5	3	4	1
		Ascending Importance	70.0	1	2	5	4	3
8	Air & Sound Pollution	Primary Ranking	11.5	2	3	4	4	1
		Descending Importance	5.0	2	3	5	4	1
		Ascending Importance	70.0	4	5	2	3	1
9	Land Use	Primary Ranking	4.8	2	3	4	4	1

		Descending Importance	1.0	2	3	4	4	1
		Ascending Importance	70.0	1	2	4	3	5
		Primary Ranking	3.6	2	3	4	4	1
10	Preliminary Investment	Descending Importance	1.0	2	3	4	5	1
		Ascending Importance	70.0	1	2	3	4	5
		Primary Ranking	5.9	2	3	4	4	1
11	Capacity	Descending Importance	1.0	2	3	4	4	1
		Ascending Importance	70.0	4	4	2	3	1
		Primary Ranking	5.6	2	3	4	4	1
12	Operation Cost	Descending Importance	1.0	2	3	4	5	1
		Ascending Importance	70.0	1	2	4	3	5
		Primary Ranking	6.0	2	3	4	4	1
13	Investment Return & Revenue	Descending Importance	1.0	2	3	4	5	1
		Ascending Importance	70.0	1	2	4	3	5

#### 4. Conclusion

There is a strong tendency to use of private car in Tehran. This has created a lot of problem such as air and sound pollution, increasing in moral rate caused by accidents, heavy traffic jam, and increase in travel time, etc. This could be due to lack of public transportation infrastructures. By having accurate and proper planning, Tehran transportation planners can overcome to these problems. Currently, they engaged in infrastructure development, but it seems that it does not have good speed. Improving passengers' comfort, completion of public transportation network, suitable connection of different travel mode, easy access, increasing number of fleets, appropriate headway, proper schedule ... are factors that can encourage passengers to use public transportation. We collected and analyzed passengers' views, during current research. It can help planners to understand the need of passengers for using public transportation. Thus present paper has researched in the adoption field of travel mode selection inside a metropolitan and tried to identify the factor affecting adoption of it. It mainly designed to answer to this research question: What travel mode is most effective from transportation stakeholders' point of view in Tehran? In order to answer this research question, we applied the proper model of identifying the deriving factors effects on travel mode selection adoption based on the literature. Also, we identified and collected criteria affected on travel mode selection that have already been identified in previous studies. We used AHP as a MCDM model for evaluating and ranking travel mode selection. Acquired results show that, the applied AHP model is a quite good interpreter of evaluating and ranking of travel mode stakeholders' perception toward adoption of travel mode selection.

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