International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

Tariff Planning in Urban Bus Transportation for Pristina

Bashkim Çerkini[1], Thoma Mitre[2]

[1]KBR, Cost Management – Project Control, Camp Bondsteel, Ferizaj, Kosovo

[2]University of Tirana, Department of Applied Mathematics, Faculty of Natural Sciences, Tirana, Albania

Abstract: ***In this research paper we present the optimization of public urban transport network based on the techniques of applied mathematics and operational research. The efficiency of any public urban transport system can be enhanced by making a new design of urban bus transportation network with tariff zones for the Pristina city. Currently in urban bus transportation network in Pristina, there are no tariff zones and the ticket prices are set up arbitrarily. We will propose two designs of urban bus transportation network with tariff zones for Pristina city. We will find the new fares and will make comparison for operator incomes between two new designs and actual urban bus transportation network in Pristina city.***

Keywords: Tariff Zones, Ticket Price, Urban Bus Transportation, Design and Operator Incomes**.**

1. Introduction

Ticket price is one of the most important issues in urban bus transportation. Projection of the tariff system in urban bus transportation is a very complex problem. When using a bus in urban bus transportation, a user usually has to pay ticket for his trip. There are several ways for defining prices for ticket in urban bus transportation. Unit tariff and zone tariffs are the most popular ones. In the tariff zone counting system the whole zone of the urban bus transportation network is divided into tariff zones.

In order to find out the ticket price for a trip, we should count the zones passed by the trip and make calculation based on the number of the passed zones. Changing tariff system in the Pristina City to a zone tariff system should be done in the way that the new system is still accepted by the passengers and does not decrease the income of the operator.

2. Tariff Planning Zones

We have introduced two models of tariff zones for the Pristina city. The first model consists of four (4) tariff zones and the second consists of three (3) tariff zones. In the maps below we have presented the main bus stations for simple calculation. These two proposed designs have different number of tariff zones and different partition structure, as seen in the figure1 and 2 below:

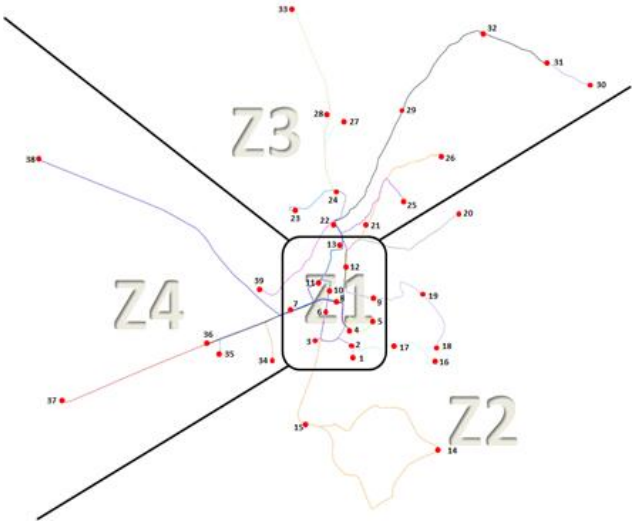

Figure 1: Design with four Tariff Zones

So let the partition zones Z = {Z_1, Z_2, Z_3 dhe Z_4}. Suppose we have the same weights W_{uv} = 1 for all (u, v) ∈ V x V referent prices d_{uv} are given.
Optimal tariffs $c^*_{max}(p)$ respective objective values $b^*_{max} = b_{max}(Z, c^*_{max})$ and K^*_{max} will be found using the following established formulas:

$$c^*_{max}(p) = \frac{1}{2}\left(\max_{(u,v)\in M_p} d_{uv} + \min_{(u,v)\in M_p} d_{uv}\right) \quad (1)$$

$$K^*_{max}(p) = \frac{1}{2}\left(\max_{(u,v)\in M_p} d_{uv} - \min_{(u,v)\in M_p} d_{uv}\right) \quad (2)$$

$$b^*_{max} = \frac{1}{2}\max_{p=1,\dots,L}\left(\max_{(u,v)\in M_p} d_{uv} - \min_{(u,v)\in M_p} d_{uv}\right) \quad (3)$$

Now we find $c^*_{max}(p)$, $K^*_{max}(p)$ and $b^*_{max}(p)$ for zones p = 0,1 and 2 [4].

When the route is within one zone and not passed on to any other zones we do have:

$c^*_{max}(0) = 0.40$
$K^*_{max}(0) = 0$

When the route passes between the two zones that's mean the route passes one tariff zone:
$c^*_{max}(1) = 0.45$

$K^*_{max}(1) = 0.05$
When road passes two tariff zones:
$c^*_{max}(2) = 0.45$

$K^*_{max}(2) = 0.05$
When road passes three tariff zones:
$c^*_{max}(3) = 0.45$

$K^*_{max}(3) = 0.05$
Whereas the corresponding objective values $b^*_{max} = 0.05$ is the same for all cases crossings tariff zones.

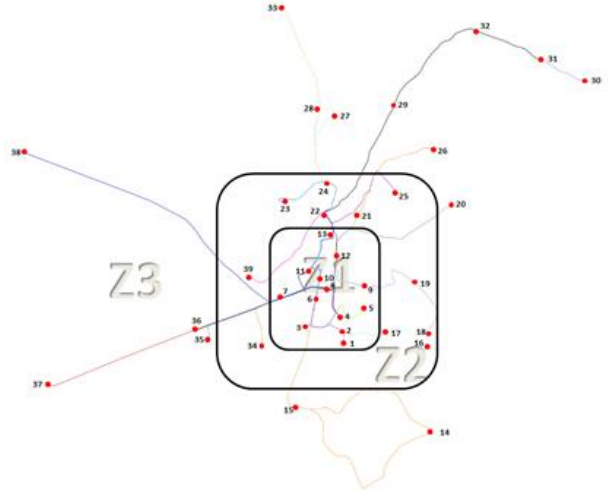

Figure 2: Design with three Tariff Zones

We have the same results in the case of division into three tariff zones with different structure and therefore we have:
$c^*_{max}(0) = 0.40$

$K^*_{max}(0) = 0$

$c^*_{max}(1) = 0.45$

$K^*_{max}(1) = 0.05$

$c^*_{max}(2) = 0.45$

$K^*_{max}(2) = 0.05$

$c^*_{max}(3) = 0.45$
$K^*_{max}(3) = 0.05$

$b^*_{max} = 0.05$

In this new system of charging the fare found through counting zones from origin to destination. For example, the ticket price for the trips within the zone will be 0.40 euro and where we pass one, two or three tariff zones then the ticket price will be 0.45 euros.

3. Operator Incomes for two new designs and actual urban bus transportation network

The number of passengers who use public urban transport in Pristina for each bus line is taken on the basis of a research department of Public Services in the Municipality of Pristina. Through these data's we have calculated the operator's income for the current network of public urban transport with current prices as follows:

$$I = N * P \quad (4)$$

I - Operator Incomes
N – Number of passengers
P – Ticket Price.
Results for each line are presented in tabular form for the current model of public urban transport network without tariff zone (Table 1).

Table 1: Operator Incomes for Current Design of Public Urban Transport Network

Lines	Ticket Price	Number of Passengers on Daily Bases	Operator Incomes
1	€ 0.40	4031	€ 1,612.40
2	€ 0.40	2531	€ 1,012.40
3	€ 0.40	2326	€ 930.40
3A	€ 0.40	1811	€ 724.40
3B	€ 0.40	909	€ 363.60
4	€ 0.40	1678	€ 671.20
5	€ 0.40	1207	€ 482.80
6	€ 0.40	536	€ 214.40
6A	€ 0.40	920	€ 368.00
7	€ 0.40	1729	€ 691.60
7A	€ 0.40	1576	€ 630.40
7B	€ 0.40	1542	€ 616.80
8	€ 0.40	314	€ 125.60
9	€ 0.40	480	€ 192.00
10	€ 0.50	2922	€ 1,461.00
Daily Total		24512	€ 10,097.00
Annual Total		6,882,970	€ 2,835,237.60

The number of passengers who use public urban transport in Pristina from 06:00 to 22:00 is 24,512 and operator incomes on daily bases are €10,097.00. The total number of passengers who use public urban transport in Pristina for one year is 6,882,970 and operator incomes are €2,835,237.60 [3]. To calculate operator incomes for new design of urban transport network public tariff divided into three zones, we have the following formula:

$$I = N(0)*P(0) + N(1)*P(1) + N(2)*P(2) + N(3)*P(3) \quad (5)$$

I - Operator incomes
N(n) - The number of passengers passing n - tariff zones on their way
P(n) – The ticket price for n - tariff zones on their way.

Table 2: Operator Incomes for Digital Public Urban Transport Network with Three Tariff Zones

Lines	Number of Passengers	Number of Passengers that Pass n-Tariff Zones on Daily Bases				
		0 Zones (€0.40)	1 Zone (€0.45)	2 Zones (€0.45)	3 Zones (€0.45)	Operator Income
1	4031	4031	0	0	0	€ 1,612.40
2	2531	230	24	2277	0	€ 1,127.45
3	2326	500	1646	180	0	€ 1,021.70
3A	1811	250	822	700	39	€ 802.45
3B	909	225	609	75	0	€ 397.80
4	1678	800	378	500	0	€ 715.10
5	1207	700	507	0	0	€ 508.15
6	536	400	100	36	0	€ 221.20
6A	920	380	515	25	0	€ 395.00
7	1729	600	529	600	0	€ 748.05
7A	1576	781	795	0	0	€ 670.15
7B	1542	300	372	826	44	€ 678.90
8	314	160	154	0	0	€ 133.30
9	480	291	140	20	29	€ 201.45
10	2922	2200	722	0	0	€ 1,204.90
Daily Total	24512					€ 10,438.00
Annual Total	6882970					€ 2,930,990.40

With the applying of new design of public urban transport network divided into three tariff zones so the operator incomes on daily basis from sold tickets are €10,438.00 while the total annual incomes of the operator is €2,930,990.40.The calculating of the operator incomes of the design of public urban transport network divided into four tariff zones, has same results and follows the same procedure as the design of public urban transport divided in three tariff zones, presented in tabular forms as follows.

Table 3: Operator Incomes for Design of Urban Public Transport Network with Four Tariff Zones

Lines	Number of Passengers	Number of Passengers that Pass n-Tariff Zones on Daily Bases				
		0 Zones (€0.40)	1 Zone (€0.45)	2 Zones (€0.45)	3 Zones (€0.45)	Operator Income
1	4031	4031	0	0	0	€ 1,612.40
2	2531	253	2278	0	0	€ 1,126.30
3	2326	230	2096	0	0	€ 1,035.20
3A	1811	950	861	0	0	€ 767.45
3B	909	300	609	0	0	€ 394.05
4	1678	800	878	0	0	€ 715.10
5	1207	600	607	0	0	€ 513.15
6	536	200	100	236	0	€ 231.20
6A	920	400	415	105	0	€ 394.00
7	1729	800	900	29	0	€ 738.05
7A	1576	781	795	0	0	€ 670.15
7B	1542	720	372	450	0	€ 657.90
8	314	114	200	0	0	€ 135.60
9	480	320	140	20	0	€ 200.00
10	2922	2200	722	0	0	€ 1,204.90
Daily Total	24512					€ 10,395.45
Annual Total	6882970					€ 2,919,042.36

With the applying of new design of the urban public transport network that is divided into four tariff zones so the operator incomes on a daily basis from sold tickets are €10,395.45 and total annual operator incomes is €2,919,042.36. Comparison between the operator incomes on a daily basis and annual total operator incomes for the three network designs is shown in the tables 2 and 3 and diagrams on figures 3 and 4.

Table 4: Operator Incomes on Daily Basis

Daily Incomes on Daily Bases		
Actual Model without Tariff Zones	€	10,097
Model with 3 Tariff Zones	€	10,438
Model with 4 Tariff Zones	€	10,395

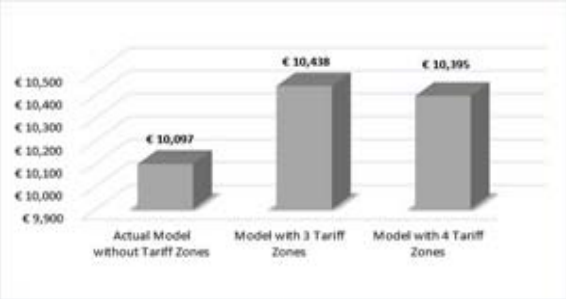

Figure 3: Diagram of Operator Incomes on Daily Basis

Table 5: Operator Annually Incomes

Annual Incomes on Daily Bases		
Actual Model without Tariff Zones	€	2,835,238
Model with 3 Tariff Zones	€	2,930,990
Model with 4 Tariff Zones	€	2,919,042

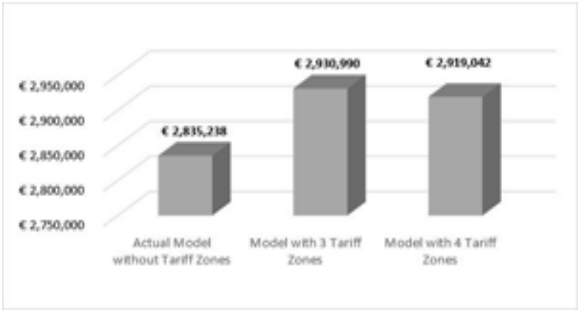

Figure 4: Diagram of Operator Annually Incomes

4. Conclusion

This research is based on the real data about passengers' trips from Pristina Municipality. Based on the results shown in tables and diagrams above, we conclude that operator incomes are almost equal among two new designs with three and four tariff zones. Operator incomes for both new designs with tariff zones are slightly higher than the current urban bus transportation network which is without tariff zones. Public urban transport design with zoning tariff is being applied in most of the world's metropolises and is correct and fair for passenger and operator. Ticket fare system based on the counting zone tariffs should be applied in Pristina city because that is much more practical and fair for passengers and operators.

References

[1] Michal K., Exact Approach to the Tariff Zones Design Problem in Public Transport,
[2] Mitre Th., Godolja M., Spaho A., Matematika e Zbatuar (Ushtrime),
[3] Municipality of Pristina, Department of Public Services, Protection and Rescue,
[4] Schöbel A., Optimization in Public Transportation (2004).

Author Profile

Bashkim Çerkini has received the Master Degree in University of Business and Technology (UBT) in Pristina, Kosovo in 2011. He is a PhD Candidate in University of Tirana, Department of Applied Mathematics, Faculty of Natural Sciences, Tirana - Albania.

Thoma Mitre is Professor in Faculty of Natural Sciences, Department of Applied Mathematics in University of Tirana, Albania.