SENSITIVITY ANALYSIS OF STRATEGIC INDICATORS IN PRICING MODEL FOR INTERCITY PASSENGER SERVICE

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Abstract: Since Road transportation accounts for a large portion of total displaced passengers of different types it is the most important mode of passenger services in Iran. The costs considered are depreciation, investment, insurance, tax, fuel, tires, main repairs, unexpected repairs, oil filter, break shoe, lubrication, batteries, commission, wages and other miscellaneous costs. These are classified into two categories of fixed and variable costs that were analyzed. The data used is obtained from the Iranian passenger transportation co-operatives based on their real costs in year 2002. The methodology of determination rate of return and Passenger Transportation Price are described and these parameters are calculated. In this paper, a price model based on the economic techniques and sensitivity analysis is presented for operators and managers. Pricing model of passenger service is prepared by the authors by the name of “Development of Pricing Model of passenger Services in Intercity Roads”. This research is pointing to “Model Sensitivity Analysis Dependent on Various Indicators.”

1. INTRODUCTION

In economy, the services which causes the transportation of sources, have economic value, and they are part of the draft production. Transportation is a kind of production in which the sources of production are substructure installation and carrying tools that have an economic value. Increasing the cost of the substructure and the specific quality of transportation (conservable) it causes the agents; in spite of the technical out look they study the economic systems studies too. Appointing the model of setting the price is not possible without recognition of the expense indicators and measuring the costs and pay attention to politics and limits. So simply because of this, setting the price in transportation have different parameters which each of these parameters can be very suitable in the model of setting the price[1].

2. METHODOLOGY

In the methodology of this research, first parameters of costs of passenger transportation in the intercity road is defined, that after determination of indicators of roads and vehicles and inspect the economic models is considered, for price setting in Iran’s condition design. Of course, the result of this research is the compilation and structure of the model of price setting, for buses in the intercity roads. If we want to use this model for highways and different modes of transportation the developed model will be qualified extension and generalize for these modes of transportation. In this situation, the definite parameters must be extended and the specific situation in the city according to different ways of transportation and old models should be considered and collected.

3. THE STRUCTURE OF MODEL

One of the most important instruments in policy and economic decisions is using the economic engineering methods. In economic engineering, a collection of mathematical methods which is for simplifying the economic comparisons of projects or in the simple words for choosing the best project is used. With using the present value method which is one of the propounded method in economic analysis
and simulation of projects. With using the return rate of investment and the life cycle, the present value of each expense item is accounting and if (P) proper to the received in lieu of each person-kilometer or person-mile (the price of passenger service) the annual income of passenger service will be like this:

\[ I_{A} = D_{T} \cdot S_{N} \cdot f_{S} \cdot P \]  

\( I_{A} \) = The annual income of passenger service according to monetary unit.  
\( D_{T} \) = The annual distance traveled by vehicle according to distance unit.  
\( S_{N} \) = The total number of seats on vehicle.  
\( f_{S} \) = The occupied coefficient of seats or load factor of vehicle.  
\( P \) = The price of passanger service according to person-kilometer or person-mile based on monetary unit. With equalizing the total present value of expenses and present value of incomes, the numeral quantity of price of passanger transportation is accounted according to person–kilometer or person–mile according to the first formula.

4. RECOGNITION OF COST INDICATORS

For setting the price of passanger service, it is necessary that all of the costs of the investment in transportation should be recognized. These costs are consisting the fix and variable. They are as follows: [5,9,10]

**The fixed costs are:**
- The fees of driver, co-driver, host.
- The tax costs, according to tax rules, the received tax quantities from some economic activities, because of its difficulties in accounting and also the scarcity of correct information, it accounts as a fixed parameter.
- The cost of insurance, such as employees, body and third party insurance fees.
- The repairing and keeping the extra equipment costs like the annual costs of cooler, seats and so on.
- The cost of electric and mechanic repairing such as: the total annual costs of repairing and exchanging the electric and mechanic tools with full consumption and lack consumption like: lamp, battery and antifreeze.
- Miscellaneous costs are consist of the annual costs of clutch and oil and the other spare parts or the expences of washing, servicing, rope, veil, food and so on.
- Costs of investment profit.

**The variable costs are:**
- Tire costs.
- The oil cost and fuel and greasing.
- The cost of fax-belt and motor-belt.
- The cost of filters (oil and gas oil).
- The cost of lining (front and back).
- The cost of the depreciation (the part that maybe worn out).
- The cost of the commission.
- The cost of the maintenance during the annual and fourth and fifth year period (the general repairment of motor) and the reason of choosing the above periods was interviewing the servitors of intercity passenger services in road network of country and this period were chosen according to their experience and according to the above process the necessary information for analysis were collected.

After introduction of activity costs they separated according to the similarities between the period of time of happening and the natural quantities of each of them. [5]

1) The cost of the exchanging and consumptive tools.
2) The cost of repairment and particle keeping.
3) The cost of repairment and basic keeping.
4) The cost of insurance, tax, driver’s fee.

5. EFFECTIVE INDICATORS ON COST TOOLS

These costs separated to two parts, fixed and independent. The independent costs are depended to activity quality of vehicles in passanger service
and the quantitative quantity that is not fix and is under effect of regional and non regional indicators.

5.1. Non regional indicators
Indicators that we named them non regional indicators, are indicators that are dependent to keeping methods and keeping the vehicles. The way of driving and exact time of repairment of vehicles can be effective in quantity quantitative and the time of the happening of activity costs. The obvious definition of these indicators is their controllability.

5.2. Regional indicators
All of the indicators that can effect on some costable tools and the source of them is the outside environment, they called them regional indicators. The most popular indicators that we can mention them are the kind of the route (plain, hill, mountain) and the season of the travel (temperate, tropical, cold region) that without the method of keeping and controlling the vehicles, under any condition they slow their effect. The effective indicator of cost tool is that they are controllable because of cost items they inspect. The consumption is that the not regional indicator control (with the specific policy).

5.3. Identification of regional indicators and their effective costs
The regional indicators has the ability to effect on some costable items, we can see the result of this change of the yearly quantitative quantity. Although some of the cost items, have the most affect in lieu to some other and at the end they produce the considerable change on price of the passanger transportation.

The slope of the road is one of the most regional indicators that can be different according to different route. This indicator has very effects on all of the tools. For identification of regional indicators and achieving the quantitative quantity and cost tool the procedure steps are as follows:

A) Identification of the regional indicators: first step in achieving the quantitative quantity certainly their identification. In this process actually the regional indicator that have high priority (as appoint of effect on cost tools) in the proportion of other indicators were chosen.

B) Identification of cost tools affected by regional indicators: In this process the cost tools which have the ability of to be effected by regional indicators and the yearly cost of them is high, were chosen and inspected.

If we consider these mentioned indicators finally we receive the relationship between regional and some cost tools which has the determiner condition and we discuss about them. According to the result of part A, the regional indicators, which have the ability of effect on the proportion of others, are:

1) The kind of the territory of traffic route in regard to the quantity of slope (plain, hill, mountain).
2) The degree of temperature of journey environment (temperate cold region and tropical).

The cost of tire and fuel are proposed as the determiner tools. [8]

5.4. The effect of the slope on erosion of the tire
Between parts and consumption tools in vehicles, tire has the most annual cost. The erosion is increasing depended on road, and in the high slope roads. So the annual cost of tire for all of the vehicles in different routes is not the same.

Although the different indicators can be effective in erosion of tire , in this part we only discuss about the quantity of effect of the slope on erosion of tire, the kind of region of traffic route classify to three parts:[7]

A) Plain roads (level): the roads, which their slope is lower than 3 percent.
B) The hill roads (rolling): the route, which their slope is between 3 and 7 percent.
C) The mountain roads: the slope of these roads is higher than 7 percent.

The method of achieving the effect of the slope on erosion of tire is interviewing with the owner or drivers of vehicles.

These are the questions about the information of kind of route, the period of time for exchanging pair of tire and the start and destination of journey. After collecting the statistics and primitive information for the quantitative quantity of slope on erosion of tire the acting is like below:

A) Classifying the information in three parts: mountain, hill, and plain (flat).
B) Draw the diffusion chart

After classifying the information, for achieving the average period of time of consumption of tire in
different route, the diffusion chart should be designed according to the distance of the route to look the diffusion of period of time.

If we introduce Y for the period of time of consumption of pair of tire according to kilometer (the consumption period of time) and X for length of the route according to kilometer, this chart show the diffusion of Y in the proportion of diffusion of X. [2]

C) According to the average period of time for consumption in lieu to the length of specific distance.

In the erosion, one specific X, show the different quantity of Y. If Y didn’t fit we locate the mathematical average of Y, as a period indicator of consumption.

D) Draw the chart of X, Y:

After accounting the average of Y in lieu to specific X, we have mainly some pair X, Y. For estimate the changes Y in lieu to X and also achieving the equation line forecast, we help the from X, Y charts. In this chart each pair (X, Y) will change to one point in the page X, Y and after connection to each other we can forecast the changes of Y process.

E) Estimating the equation forecast:

To forecast the equation for estimating the variable unstable Y in lieu to independent unstable X, maybe give help from the different curve.

\[ Y = a \text{ unstable from quantity (constant)} \]

\[ Y = ax + b \text{ linear equation} \]

\[ Y = a.e^{bx} \text{ exponential equation}. \]

The way of deciding about the kind of equation to forecast regression between dependant unstable Y and independent unstable X.

The result, which produced form-lined regression, are:

\[ a \text{ : constant} \]

\[ b \text{ : coefficient} \]

\[ R^2 \text{ : correlation coefficient} \]

The correlation coefficient of \( R^2 \) is between 0, 1 (0<\( R^2 \)<1) whatever \( R^2 \) approaches to 1, it shows the forecast equation on the observant line as \( R^2 = 0 \), the quantity of Y is independent or the changes in and it is equal with fixed quality a. The algebraic sign b shows the falling and rising route in the changing process of Y and also seems logical that with increasing the length of the road, the period of consuming a pair of tire decreases, in other words the sign b is negative.

F) According to the average period of time of consumption of pair of tire in different roads:

If the steps of A to F are as follows, the equation consumption of period of time of pair of tires according to length of roads achieved. Now, with putting the distance of route in the equation of quantitative quantities (period of time of consumption of pair of tires) is achieved.[2]

6. THE EFFECTIVE INDICATORS ON FUEL CONSUMPTION

The fuel different indicators affect on consumptive quantity of fuel in vehicles. Some of the condition of road are traffic, atmospheric condition, the way of driving, changing in weight of vehicles, extra equipment, the condition and technical imperfection and … , also some of the regional indicators consider as non regional indicators located in good condition because they are controllable.

6.1. The temperature

The temperature has very effects on quantity of fuel consumptions. In the simple words increasing or decreasing of temperature of environment has an opposite relationship with the quantity of fuel, because with increasing the temperature, the motor consume much more fuel for receiving to suitable heat.

The experiment which was worked in cities shows that in zero degree centigrade situations the 8 percent and in –30 degree centigrade, average adds 30 percent to quantity of fuel consumption and also the fuel consumption in winter can be 50 percent more than the fuel consumption in summer.

6.2. The roughness roads (having ups and downs)

The roughness roads, not plain and bumpy increases 35 percent the fuel consumption, because when you pass through these routes, the soft and weak roads motor lost some of its energy.

6.3. Slope of the roads

The slope of the roads increases the consumption of fuel up to 30 percent.

During coming up the slope, the motor lost much energy but versus coming down, the negative slope
of roads help to the energy of motor so the consumption of fuel is decrease very much.

6.4. The atmosphere condition
In rainy weather, because of increasing the rotation resistance of vehicles, 10% approximately increase the quantity of fuel.[14]

7. THE METHOD OF ACCOUNTING OF OCCUPATION OF SEATS OR LOAD FACTOR INDICATOR

The applicants of the transportation system are the passengers who have an intention of journey in different route with the specific vehicles. The applicants of journey is not equal for all routes and because of similar economic activities, must be have enough desirability of governor so in the passenger service all of the conditions for making income has very effection on the price of transportation until there will be equal stimulate for choosing the route to preparing the maximum service for applicants. Because of this, the coefficient is defined as an occupation of seats coefficient.

This coefficient of passenger service price adjust the price of passenger transportation in the full applicants route and in lack of applicants route in this case the rate of returning the investment in different routes will be equal. Occupation of seats coefficient, is percent of whole seats in vehicles (full capacity) that is occupied with the persons. In the other words the sum of portion of number of passengers on vehicles is depend on full capacity of vehicles.

In order to pay attention on setting the price on passenger service and proposing its system, the occupation of seats coefficient should be set in the entire existing route. On the other hand, the demand for journey in a specific route is not equal in all of the seasons or days of the year and has a perceptible difference. Because of this in this part a practical example in setting the occupation of the seats coefficient for the specific route is mentioned.

And because the occupation of seats coefficient is not equal all of the year, so they collect the samples by chance in two periods and the average of occupation of seats coefficient of samples is mentioned as an index of occupation of seats coefficient in that route.[2]

A) The period that the request of journey is more than the rest of the year (the first period, the peak period).
B) The period that the request is less than the rest of the year (the second period, off peak period).

After collecting the information about route and setting the limit of high and low confidence with the help of statistics methods for each average period the occupation seats coefficient is accounted like below:

\[ UCL_{jk} = P_{jk} + 3 \delta P_{jk} \]  \hspace{1cm} (2)

\[ LCL_{jk} = P_{jk} - 3 \delta P_{jk} \]  \hspace{1cm} (3)

In other words

\[ UCL_{jk} = P_{jk} + 3 \sqrt{ \frac{P_{jk} (1 - P_{jk})}{n_j} } \]  \hspace{1cm} (4)

\[ LCL_{jk} = P_{jk} - 3 \sqrt{ \frac{P_{jk} (1 - P_{jk})}{n_2} } \]  \hspace{1cm} (5)

After calculation of confidence limit, the points which are out of this limit will be omitted, after omitting the non confidential statistics the new \( P_{jk} \) will be introduced for index average occupation coefficient.

\[ \bar{P} = \frac{1}{n_i} \sum_{j=1}^{k} P_{jk} \]  \hspace{1cm} (6)

\( \delta P_{jk} \) = The out of confidence level statistics percentage (the supposed confidence level is 99.73 %).

\( n_1 \) = The number of samples taken in peak period.

\( n_2 \) = The number of samples taken in off peak period.

\( P_{jk} \) = The percent of full seats in vehicles \( j \) in the \( k \) period. (the \( k \) period means the peak and off peak
period). On the other hand, the demand is different in peak and off peak period.

For setting the index of seats occupation in general, the weight average must be taken between $P_1$, $P_2$. If the unit of peak period and off peak period were similar (for example month) we have:

$$f_s = \frac{(T_1 \cdot P_1) + (T_2 \cdot P_2)}{T_1 + T_2}$$  \hspace{1cm} (7)

$T_1$ = The number of times of happening the peak period in a year.

$T_2$ = The number of times of happening the off peak period in a year.

$f_s$ = The average of load factor which are occupied.

8. COMPARING THE PROPOSED PRICE WITH THE EXISTING PRICE

The price of passenger transportation in 2002 is achieved in lieu to each person – kilometer 23 Rials. It is necessary to say that set forth price is for the buses with the supposed condition. Of course the price of transportation with out the equipment will have a very little difference with the received price and also the coefficient of occupation of seats which is one of the appointed elements for the cost of the transportation and in the entire route is supposed equal but it is not actual.

Suppose the route Tehran – Mashhad (one of the Iran cities), if it has a coefficient of occupation seats equal with (80 percent) instead of (65 percent in the model) it will have another price of transportation.

So in achieving the cost of transportation of the passenger in different routes, we should inspect all of the quality of vehicles and road in the proposed model.

9. ANALYSIS OF SENSITIVITY IN PROPOSED MODEL ACCORDING TO DIFFERENT INDICATORS

Because of the sensitivity of indicators: the coefficient of occupation of seats, the period of time of tire consumption, inflation, the initial price of vehicles, kind of route, the cost for preparation of tire, fuel, bus capacity, the cost of commission, return investment rate on passenger service, we discuss about analysis of sensitivity on each of this indicators.[3]

9.1. The effect of the annual inflation on the cost of passenger service:

If we suppose the rate of yearly inflation 15% the effect of inflation can show itself on active costs. In below the tools which can be inflated is proposed:

- The present price of bus.
- The price of bus at the end of life.
- The initial investment of extra equipment.
- The annual total cost of exchanging tools.
- The total cost of partial repairment and keeping.
- The total cost of annual basic repairment and keeping.
- The total cost of fourth repairment and keeping.
- The total cost of fifth repairment and keeping.
- The ratio of increasing the yearly inflation price is comparing with the inflation price of 5, 10, 15 percent (Table 1) and you see that if the yearly inflation price is %15, the price of passenger service increases to %12.

$$P_i = \text{Percentage of Increase in Economic Inflation}$$

$$C_P = \text{Cost of Passenger Transportation}$$

According to sensitive analysis of SPSS software and results given by this package it has an

<table>
<thead>
<tr>
<th>The percent of increasing the inflation</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>The price of passenger transportation.</td>
<td>24.2</td>
<td>25.15</td>
<td>26.22</td>
<td>27.29</td>
</tr>
<tr>
<td>The percent of increasing the price.</td>
<td>0 %</td>
<td>4 %</td>
<td>9 %</td>
<td>12 %</td>
</tr>
</tbody>
</table>
exponential regression shown in Figure 1

\[ C_P = 24.185135 \times e^{0.008043 \times P_i} + 0.081773 \times e^{(8.2982 \times 10^{-5}) \times P_i} \]  
(8)

9.2. The route types
The net road of country separated to three-group plain, hill, and mountain according to the slope. The slope of the route is very effective on active cost of bus. The approximate ratio of increasing the price of passenger service is in hill route ratio is even to 3 % and in mountain road ratio even to 10 % and in mountain road ratio to 7 %.

9.3. The cost of tire
According to collective information, the annual cost of tire has very difference with other exchanging and consumptive tools. The yearly cost of tire is increasing very much as the preparation of pair of tire from 1374 to 1380 is doubled.

9.4. The cost of fuel
Nowadays the cost of one liter of fuel (gas oil) is 120 Rial if it is doubled, it causes difficulties for owner of buses. As it is often increase the price of transportation ratio to increasing the cost of fuel as the cost of each fuel liter increase from 120 Rial to 240 Rial (100 % increase) only the passenger service price increase to 9 % (Table 2).

\[ C_f = \text{Cost of Fuel} \]

According to sensitive analysis of SPSS and results given by this program it has a linear regression shown in chart 2:

\[ C_P = 21.963 + 0.00178 \times C_f \]  
(9)

8.5. The capacity of the bus and the occupation of seats coefficient
Generally, the basic determined element of the price of services can be its applicant form customer. In the problem of passenger service we can say the applicant as the occupation of seats coefficient in vehicles is one of the determiner indicators of the price passenger service.

If the occupation of seats coefficient increase from 55% to 90%, the price of transportation of passenger will decrease. And also if this coefficient increases from 65% (the present quality) to 70%, the price of transportation will decrease to 71%. It is clear that we fix the occupation of seats coefficient to 80% and the capacity of bus decrease from 45 people to 27 people, the price of the transportation increases to 66%.

\[ P_O = \text{Percentage of vehicle’s seat Occupation} \]

\[ C_P = \text{Cost of Passenger Transportation} \]

According to sensitive analysis of SPSS and results given by this program it has a cubic regression (Between 0 and 100%) shown in Figure 3:

Table 2. The percent of increasing the price of passenger transportation ratio to increasing the cost of the fuel.

<table>
<thead>
<tr>
<th>The price of fuel.</th>
<th>100</th>
<th>110</th>
<th>120</th>
<th>130</th>
<th>140</th>
<th>240</th>
</tr>
</thead>
<tbody>
<tr>
<td>The price of passenger service</td>
<td>23.75</td>
<td>23.93</td>
<td>24.1</td>
<td>24.27</td>
<td>24.44</td>
<td>26.24</td>
</tr>
<tr>
<td>The percent of increasing the price. %</td>
<td>-1.4 %</td>
<td>-.7 %</td>
<td>0 %</td>
<td>.7 %</td>
<td>1.4 %</td>
<td>9 %</td>
</tr>
</tbody>
</table>
This Equation is not a very accurate equation. And it is reliable between 0 & 100% when we can’t have a future estimation.

9.6. The cost of commition
The transportation companies in lieu to proposing the services to owner of vehicles, receive the percent from selling the ticket, for cost of the commission if the price of the commission increases from 5% to 10% (100% increases) the price of transporting the passenger increases to 6%.

9.7. The return rate of investment
If investment in passenger transportation part, naturally the expectation of the giving investment this investment is equal with return rate of investment.

Actually of the return rate of investment is I % and minimum price of passenger transportation is X in lieu to each person – kilometer so the income would be I % higher than I %.

If the return rate of investment increase from 25% (the basic information) to 30% the passenger service increases %6.

9.8. The initial price of bus
One of the most important elements of engineering economic problems is the primitive value of investment, that it allocates the most costs in passenger transportation.

The present cost of bus is supposed 550 million Rials, and rest of life to the salvage value suppose 7 year.

And also according the experts the proper life of bus is 14 years. The result of choosing the life of the bus to 7 periods as the primitive investment, is because it is not suitable for preparing means vehicles. Because if the means of transportation for journey chose for primitive investment according to the collective information the price of the passenger transportation in lieu to each person – kilometer will increase that it is not harmonize with present situation. In other words the investment to preparing the new vehicles with returned 25 percent for 7 year is not economical.

Now the buses in passenger service in the network of country are used.

If the longevity of vehicles is doubled from 7 to 14 with the present proved prices, which set from the passenger transportation co-operatives, the

![Graph of the Relation Between Po & Cp](image)

Fig. 5. The Relation Between Po & Cp

<table>
<thead>
<tr>
<th>The percent of occupation.</th>
<th>55</th>
<th>60</th>
<th>65</th>
<th>70</th>
<th>75</th>
<th>80</th>
<th>85</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>The price of passanger service</td>
<td>28.48</td>
<td>26.1</td>
<td>24.1</td>
<td>23.37</td>
<td>20.88</td>
<td>19.57</td>
<td>18.43</td>
<td>17.39</td>
</tr>
<tr>
<td>The percent of decreasing the price.</td>
<td>18</td>
<td>8.29</td>
<td>0</td>
<td>-7.1</td>
<td>-13.3</td>
<td>-18.8</td>
<td>-23.5</td>
<td>-27.8</td>
</tr>
</tbody>
</table>

Table 3. The percent of increasing the price of passenger transportation ratio to the percent of increasing the occupation of seats coefficient
expedition of giving profit in this part according to investment in selling a new vehicle, and replacing it with the used one is justifiable.

10. CONCLUSIONS

Conclusions for the future studies to improve the transportation, are:
Since this model is prepared by the authors by the name of “Development of Pricing Model of passenger Services in Intercity Roads”. Sensitivity of various indicators on the model is measured and the following results were obtained.
1-Increasing or decreasing the various indicators in the designed model were tested and its increasing percentage is illustrated in graphs and charts.
2-Decreasing or increasing percentage of indicators in the model are not the and his analysis can be used in transporting policies and programming.
3-If the fixed and changing costs, bank rate and the design vehicle are clear this model can be used for other transportation modes.
4-The method of determining fleets life in country and classification of the existing fleet to determine the optimized transportation price.
5-The method of increasing the passenger demand in road transportation and increasing the income aimed for investment, create the occupation and create the journey.
6-The method of increasing the fleet exploitation and optimum use from the existing capacities.
7-The method for creating competition in the system for improving the existing condition by releasing the rate and.
8-The quality of decreasing the effect of environmental elements and non environmental indicators to minimize costs.

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[7] The road construction ministry, the statistics of traffic in the provinces of country, the assistant of keeping and revenue.