Demand Analysis for Passengers in the Railway Transport Sector Depending to Macro Indicators in Albania

Ersilio Tushaj [1] Shkëlqim Gjevori [2]

[1] *Faculty of Civil Engineering, Polytechnic University of Tirana, Albania*

[2] *Institute of Transport, Ministry of Transport and Infrastructure, Albania*

ABSTRACT

The railway sector in Albania is considered one of the most underdeveloped sectors in the Albanian Transport System. In agreement with annual statistics, in 2014 transport of passengers was ten times lower than in 2001, meanwhile transport of goods were 2.5 times lower. Even though the overall economy during these years has been growing, import/export has been increasing and the number of tourists visiting Albania too. The number of personal vehicles increased three times in the last 14 years. Over 90% of the annual capital investments of the Ministry of Transport has been allocated to road, air and maritime transport, while the funds for the railway sector have been almost non-existent. A series of studies funded by the European Union, have been developed in order to support investments in the existing railway's system. According to statistical data gathered by a variety of fonts, an evolutionary model will be built in order to predict the railway passenger demand in Albania. The aim of this article is to identify the influence of the macroeconomic factors on the railway passenger demand, and to build an evolutionary model based on some relevant variables. This model will be applied in a future scenario in accordance with these variables.

Keywords: railway sector, passengers transport, evolutionary model

INTRODUCTION

The Albanian railway network appears distressed. Even though the main line is 447 km long, only 350 km are functional, type "one-track", un-electrified, designed to reach a speed of 80 km/h, but it actually achieved a speed nearly at 40 km/h. In contrast with other developed countries in the world, which are developing the railway system, building new lines with high speed trains at over 300 km/h; Albania is ranked in the last place in the Region for transport of passengers and goods. After the 1990's in Albania, rail transport was replaced by car usage. State's attention has been generally focused in guaranteeing a satisfactory road infrastructure by neglecting railways. Furthermore, the increase of demand for private road transport has contributed in years to the present situation of the rail transport.

DATA AND METHODOLOGIES.

The data analysed for the purpose of this article has been obtained by the official font of INSTAT – Albania [1], EUROSTAT (General Directorate of the European Commission) [2], by some foreign studies made by Louis Berger company, Transport Infrastructure and Regional

Study (TIRS) [3], REBIS 2005 program [4], IPF 2009 [5] , Albanian Ministry of Transport and Infrastructure and in some recognized methodologies in transport planning. This data ranges from 1991 to 2014. For the years that there is no information, the data has been extrapolated. The information has been analysed using statistical methods, simple linear regression and correlation analysis. The evolutionary model has been built based in the information collected in the last 20 years. A linear system equation in 17 equations and 3 variables has been resolved using numerical analysis approximation methods. The gravitational method has been applied for determining rail passengers flows prediction in the 2025, distributed between the principle economical centres.

SIMPLE REGRESSION ANALYSIS AND CORRELATION.

The data of GDP (Gross Domestic Product), Population, Passengers and Goods, Railway transport flows, Road flows, Air and maritime passengers and goods data transport, budget expenditure of Albanian Ministry of Transport, have been analyzed under the regression analysis and correlation methods (Tab.1). Since it has been elaborated a large set of data, in this article is reported the most important information. The number of rail transport passengers has fallen drastically in the last 20 years as shown in Fig.2.
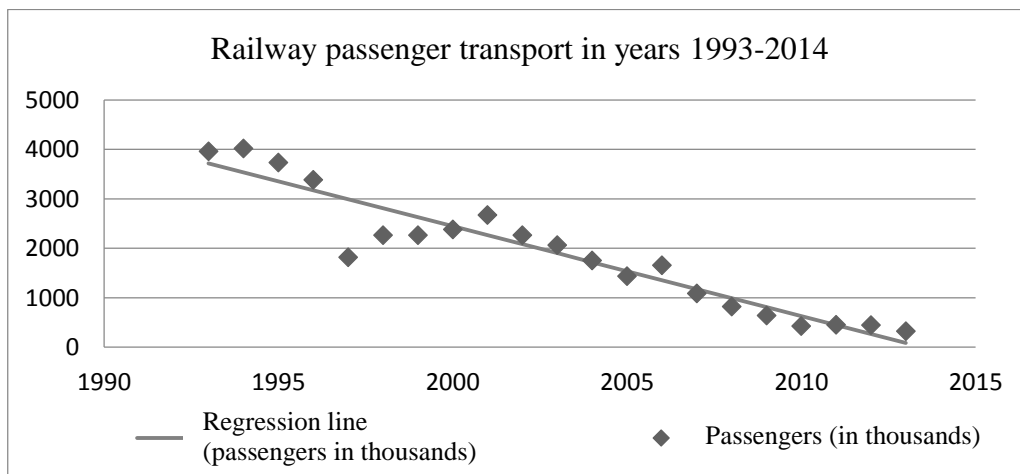

Fig.2 Regression analyses of railway transport passengers in years 1993-2014

Tab.1 Regression analyses data of railway transport passengers in years 1993-2014

	Nr. of passengers (in thousands)
Arithmetic mean	1,902
Minimum in years	329
Maximum in years	4022
Variance	1407042
Standard deviation	1186.2
% Annual incremental	- 11.7 %

The regression function of railway transport passenger flows is presented in Eq. (1), where y represents the rail flows in years and x the year when the function is evaluated.

Eq. (1)
$$y \cong -181.35x + 365142.15 \ (\textbf{\textit{passengers in thousands}}) \tag{1}$$

The observed trend during the last 20 years has been studied in correlation to some macro indicators such as population and GDP. The 1990s have signed a change in the transport uses in Albania with the fall of communism in the country. The correlation study has been extended further to macro data of road, air and maritime data transport.

The capital investments of the Albanian Ministry of Transport, in the different Sectors of Transports have changed during last years. The capital investments on infrastructure have a direct impact to the supply of transport. Changes in the supply for transport can cause a modal split in the demand for transport. Consequently, it has been studied as an important factor the capital investment in the different Sectors of the Albanian Transport System.

The correlation value obtained are resumed in Tab.2

Tab.2 Correlation of Passengers Railway National data to other macro information

Correlation (period 1993-2013)	Data correlation
Railway flows/population	0.95
Railway flows/National GDP	-0.95
Railway flows/Road transport vehicles	-0.90
Railway flows/Maritime transport passengers and goods data	-0.90
Railway flows/Air transport passengers and goods data	-0.87
Railway flows/% Budget Expenditure	+ 0.80

The correlation is strong in all analyzed cases. Depending to population and GDP factor the correlation is negative, while depending to other variables the correlation is positive.

According to the Leontieff Model, the national transport demand depends to macro indicators such as population and GDP. As the above results revealed, there is a strong and negative correlation to the national GDP. For this purpose, we have analyzed some other data in a European context determining the correlation between national railways flow data and GDP evolution, compared in different years. This analysis has been concentrated in 28 European Nations for the last 15 years. The study have revealed a stronger correlation of railway passenger flows to the total GDP of a country instead of population and GDP per capita (Tab.3). [6]

Tab.3 Correlation of Railway passengers flow depending on macro factors

28 EUROPEAN countries analyzed	Correlation for 28 European countries in the last 15 years
Railway passenger flow/Population	$\rho=0.792$
Railway passenger flow/GDP per capita	$\rho=0.160$
Railway passenger flow/Total GDP	$\rho =0.955$

Since a decrease of railway passenger flows that some countries have faced with the growth of the economy, it was examined a further correlation between X and Y, as it is shown in Tab.4. The analysis revealed an interesting result. Railways transport passenger flows in the high developed countries face a strong-positive correlation to their GDP; a neutral correlation in medium developed one; and a strong-negative correlation in the low income countries. The demand splits to other sectors of transport with the increase of the income per capita in the low income countries, as the Albanian context. [6]

Tab.4 Double Correlation of Railway passengers flow depending to GDP.

Double correlation X/Y   Double correlation
X={Correlation: passengers /GDP per capita , **by country** }
Y={average GDP, **by country**} $\rho_{xy}=0.70$

Capital investments on railway infrastructure have been dedicated mostly to the Road Sector, as it is shown in Fig.3. The Railway Sector is the only one that has recognized a general fall of investment during last years (Fig.4). Rail transport infrastructure maintenance has suffered due to reduced spending under state budgets, resulting in reduced travel speeds, reliability and punctuality [7]. According to several regional studies, the most important issue that decreases the attractiveness of the Albanian Railway, is the low operational speed, lower than 40km/h. [4] Some models have been developed to verify the demand for passengers and goods and for the evaluation of the necessary total cost for intervention in the rail infrastructure and the safety system. These studies have demonstrated a strong need for capital investment in the Sector, which realization will follow a growth of transport flows for passengers and goods, with a revenue of the investment in about 40 years. [5]
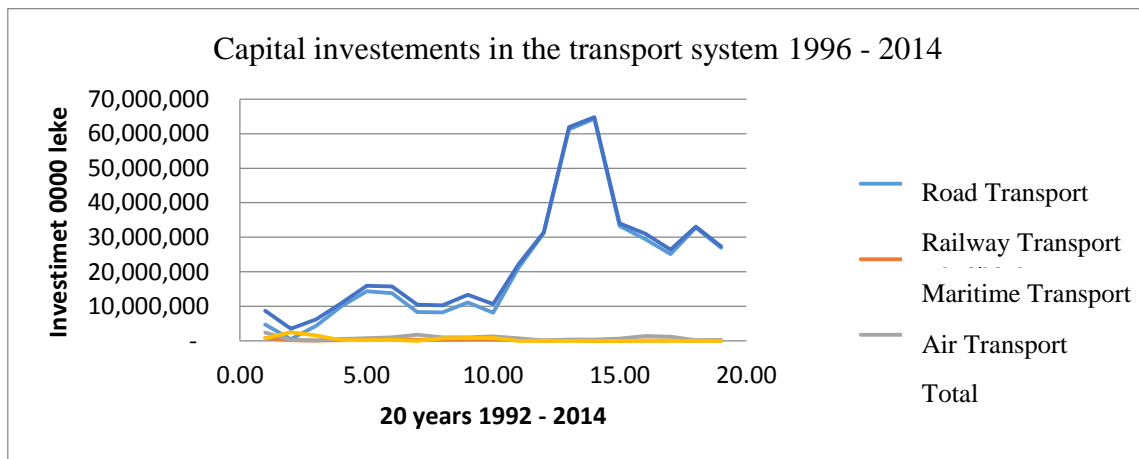

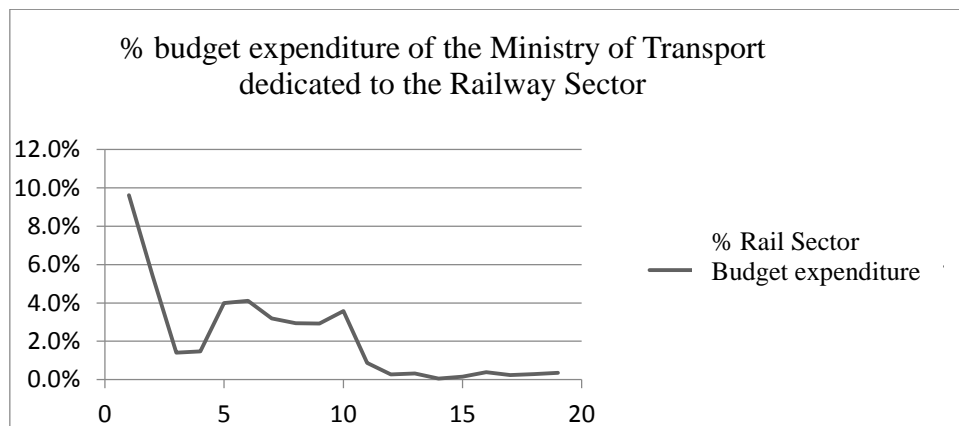Fig.3 Capital investments in the different Sectors of Transports in Albania

Fig.4 % Budget expenditure of capital investment of the Ministry of Transport and Infrastructure dedicated to the Railway Sector.

THE EVOLUTION MODEL OF THE TRANSPORT PASSENGERS DEMAND.

The evolution model is created based on three macro factors that have a strong correlation to the rail passengers flow and are related to it. Since changes in population in Albania during the last 20 years are too low, this factor has not been considered as a variable. The three variables are determined as below:

- **GDP – Gross Domestic Product (in milion lek).** As revealed in this study there is a strong correlation to the Gross Domestic Product in Albania.
- **Registered vehicles (in thousands).** The demand for transport within the country in the early '90s was generally guaranteed by rail. With the increase of investment in the road sector and the reduction of investments and attractiveness of railways, the demand for internal transport within the country, has been supported by the road sector. As follow it has been been taken as a variable the number of registered road vehicles and reported annualy by INSTAT.
- **Index of depreciation/investments.**
  The capital investments in the Sector present an important factor for determining the attractivness and the passenger demand. For this purpose is has been branded a called Index of depreciation/investments, which represents the sum of the parametrized percentage of budget allocated to the Rail transport Sector in the last 5-years, of the year considered.

The evolutionary model has been mathematically determined as a linear function in Eq. (2), depending on the annual data of the three variables (Tab.5). The evaluation of the model consist in determining the three coefficients of the function, a_1, a_2, a_3 ; which best interpret the reality.

Eq. (2)
$$Y = F\ (x_1, x_2, x_3) = a_1 x_1 + a_2 x_2 + a_3 x_3 \qquad\qquad (2)$$

where :

$Y - National\ Rail\ transport\ passenger\ demand$
$x_1 - GDP$
$x_2 - Index\ of\ depreciation/investments$
$x_3 - Registered\ vehicles\ (INSTAT)$
$a_1, a_2, a_3 - coefficient$

Tab.5 The data used for evaluating the coefficients of the linear model.

Years	Rail transport passengers flows (in thousands)	GDP (million lek)	Index of depreciation/investment (calculated by summing the last 5 years)	Vehicles registered
	$Y_{annual\ flows}$	x_1	x_2	x_3
1996	3,389	114,540	0.481	346.403
1997	1,820	126,258	0.439	346.198

1998	2,269	145,201	0.357	409.209
1999	2,270	149,148	0.275	471.578
2000	2,381	185,982	0.219	523.043
2001	2,676	216,550	0.164	583.369
2002	2,270	233,954	0.142	622.711
2003	2,070	263,901	0.157	694.097
2004	1,758	274,652	0.172	751.022
2005	1,440	284,655	0.167	814.797
2006	1,659	320,347	0.135	882.209
2007	1,091	349,626	0.106	967.670
2008	822	378,060	0.080	1.080.676
2009	645	397,981	0.051	1.143.936
2010	430	419,893	0.017	1.239.645
2011	453	410,629	0.012	1.300.624
2012	448	394,485	0.012	1.332.811
2013	329	445,952	0.011	1.350.555

The prediction model has been built by resolving a system of 17 linear equations (data of the last 17 years), by numerical analyses approximation. The Index of depreciation/investment gets values from 0.00 to 0.50. A value of 1.00 means that the total budget of one year of the Ministry of Transport and Infrastructure has been allocated totally to the Rail Sector. The model has been finally corrected by decreasing the deviation standard error to 21%. The correction has been evaluated by an arithmetic mean of the data in the range of 5 years, of the year considered (Tab.6). The mathematical expression is given as below in Eq. (3)

Eq. (3)
$$Y = -0.003761238\, x_1 + 6230.718281\, x_2 + 0.012661596\, x_3 \tag{3}$$

Tab.6 Prediction of demand and correction of the model.

Year	Y_{annual} (thousands of passengers)	$Y_{annual\ corrected}$ (thousands of passengers)
2023	6154	6146
2024	6231	6048
2025	5950	**5977**
2026	5837	5828
2027	5714	5705

FUTURE PREDICTION 2025.

The model has been applied to a future prediction in 2025, considering the actual trend of the economy and of the other data in the different Transport Sectors. In the hypothesis of an annual growth of the economy of 4.5%, of the vehicles registered of 3.3%, and Index of depreciation/investment of 1.00; it has been forecasted a total demand for rail transport passengers corrected as in Eq. (4)

Eq. (4)

$$Y_{(2025)} = 5\ 977\ 000 \text{ passengers/year} \tag{4}$$

The total railway passenger demand has been distributed between the principal economical centres of the country, proportionally to their GDP, using the Gravitational method (Tab.7). Further the daily trips distributed between the principal cities have been summed into a Graph, which represents the actual network of the Railway Sector in the country. It has been predicted that between Tirana and Durrës, there can be flows of approximately 10.000 passengers/day in one direction (fig.4).
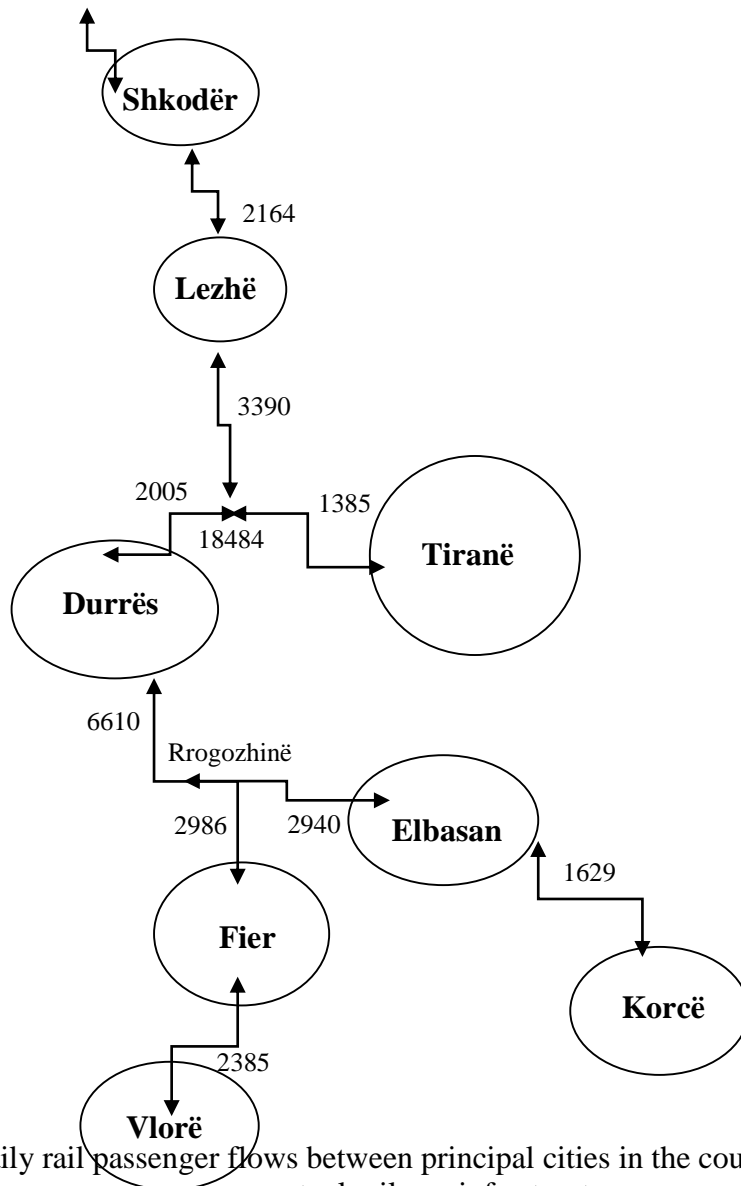

Fig.5 Daily rail passenger flows between principal cities in the country distributed in the actual railway infrastructure.

Tab.7 Daily trips in the O/D matrices.

	Shkodër	Lezhë	Tiranë	Durrës	Fier	Vlorë	Korcë	Elbasan

Shkodër	0							
Lezhë	329	0						
Tiranë	1093	911	0					
Durrës	288	274	4556	0				
Fier	160	128	1519	480	0			
Vlorë	78	61	781	288	822	0		
Korcë	72	58	607	206	92	96	0	
Elbasan	144	123	1367	540	508	259	398	0

CONCLUSIONS

The condition of the railway system infrastructure in Albania is very poor. This situation as the study reveals is a consequence of bad investment politics in the country, in the last 20 years. Most of the transport investments have been allocated to the Road Transport Sector. If the supply of infrastructure is low, even the flows in the sector will be low. The paper brings out an analysis on macro level, according to statistical data related to the Transport System, such as the flow of passengers in the various Transport Sectors, macro indicators such as GDP and population, and some studies that have been done in the last 15 years. Through statistical mathematical method and transport planning, it has been created a simple linear model that best interpret the flows for rail passengers in the country depending on three variables: GDP-Gross Domestic Product by year, vehicles registered by year and a called Index of depreciation/investment. Through this model it has been possible to determine passenger flows in a future scenery in 2025, considering the actual trend of the economy and vehicles registered. The Index of depreciation/investment has been considered with a value of 1.00, as the investments of the annual budget of the Ministry of Transport have been totally allocated to the Rail Sector. This theoretical prediction has generated high flows of passengers in the Sector, with about 10.000 daily trips between Tirana and Durrës. The investments in the Sector are justified by a high demand for passengers transport. Further detailed analyses should be considered in order to study the demand for transport of goods, which may lead to higher revenue for the Sector.

REFERENCES

[1]   "Instituti i Statistikave Shqiptare," March 2016. [Online]. Available: http://www.instat.gov.al. [Accessed March 2016].

[2]   "European General Directorate of Statistics of the European Commission," January 2016. [Online]. Available: http://ec.europa.eu/eurostat. [Accessed January 2016].

[3]   E. I. Bank, "Transport Infrastructure Regional Study (TIRS)," BEI, EU, 2001.

[4]   `E. Commision, "Regional Balkan Infrastructure Study - Trasport, REBIS," REBIS , 2005.

[5]   E. Commission, "Infrastructure Project Facility for Western Balkans," IPF Proposal, 2009.

[6]   E. Tushaj, *Analize e kerkeses per transport pasagjeresh ne Sektorin Hekurdhor Shqiptar,* Tirane: Fakulteti i Inxhinierise se Ndertimit, Universiteti Politeknik i Tiranes, 2016.

[7]   South-East Europe Transport Observatory, "SEETO Comprehensive Network Development Plan 2014," European Union, 2014.