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DEVELOPMENT OF TRAM TRANSPORT SYSTEM MODELLING IN THE CITY OF ZAGREB

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Preliminary notes

The work was carried out through the research relationships on passengers transport demand and its size is related to a technical, technological and organizational subsystem in the tram transport system, as well as dominant subsystems within the public urban passenger transportation in Zagreb. After the collection of statistical and mathematical data processing, various studies within the time period since 1995 to 2010, that investigate the relationship do not respect their growth and interconnectivity. The purpose of this project is reflected into the design relevant professional scientific basis for making decisions regarding the management of this transport processes at the strategic level of planning and further development of tram transport system. The aim of the research process modelling given in the stated study within used methods of analysis and synthesis is designed by regression and predictive mathematical models studied size. The study size was established for ten statistically significant trend forecasting mathematical model and the regression model, thereby to distinguish the important size of the negative trends related to the quality of transport services and organizational subsystem while reducing travel demand in a tram transport system.

Keywords: *transport modelling, development, management of tram transport system*

Modeliranje razvitka tramvajskoga prometnog sustava Grada Zagreba

Prethodno priopćenje

Radom je provedeno istraživanje odnosa putničke transportne potražnje i veličina koje se odnose na tehnički, tehnološki i organizacijski podsustav tramvajskoga prometnog sustava, kao dominatnog podsustava u okviru javnoga gradskoga putničkog prijevoza Grada Zagreba. Nakon prikupljanja i matematičko statističke obrade podataka izučavanih veličina unutar vremenskoga razdoblja od 1995. do 2010. istražuje se zakonomjernost glede njihova razvitka i međusobne povezanosti. Svrha rada ogleda se u oblikovanju releventne stručno znanstvene osnove za donošenje odluka vezanih za upravljanje prometnim procesom na strateškoj razini i planiranje daljnjeg razvitka tramvajskoga prometnog sustava. S obzirom na postavljeni cilj istraživanja modeliranja procesa, u radu su korištene metode analize i sinteze, oblikovani su regresijski i matematički prognostički modeli izučavanih veličina. Istraživanjem je za deset veličina ustanovljen statistički značajan matematički prognostički trend model kao i regresijski model, pri tome se izdvajaju negativni trendovi bitnih veličina vezanih za kvalitetu transportne usluge i organizacijski podsustav uz istodobno smanjenje putničke potražnje u tramvajskom prometnom sustavu.

Ključne riječi: *transportno modeliranje, razvitak, upravljanje tramvajskim prometnim sustavom*

1 Introduction

Public urban passenger transport forms an exceptionally significant service enabling normal social functioning and undisturbed economic development. According to Banković [1], the increase in the size of cities results in an increased need to include an increasing number of subsystems of public urban and suburban passenger transport. This means that it is important to achieve full integration and coordination of active subsystems into the system of public urban and suburban passenger transport in order to realise synergic effect of optimal functioning of an integral transport system in meeting the demands for transport services. Public urban passenger transport may be defined as a system of organized line transport of passengers on a territory of a specific urban agglomeration, as well as transport between the narrower city territory and suburban areas on the sections and lines where the majority of passengers are daily migrants. It should be noted that bus subsystem is present in almost every system of urban passenger transport. In the functioning of a system of urban passenger transport particular emphasis is on the technical and technological compatibility of its subsystems, and mutual organisational and tariff harmonisation. It should be noted that there is strong connection of the realised or desired level of quality of the transport service and its price, and that the traffic system affects directly the efficiency and effectiveness of the economic and overall social system [2]. In addition to the offered transportation capacity such as: total number of powered tram cars, total number of passenger places and total number of the offered passenger-kilometres, the researched traffic values also refer to the dynamics of the total covered distance, number and length of lines, average age of the means of transportation. The transport modelling often represents a significant part and basis of the business decision-making process in the optimisation of the transport system [3]. Scientific problem is oriented on analyzing the harmonization of relation between the traffic values from the area of traffic supply and the trends and dynamics of passenger transport demand indicated by the number of transported passengers in the system. Traffic planning is determined by the need for continuous increase in the capacities of the traffic system in order to satisfy the increase in the transport demand [4]. The focus of attention of the transport planners and managers is not just to anticipate and insure the necessary traffic infrastructure and superstructure, but rather also its maximal usage with priority recognition of the transport service users' requirements [5]. Thus, according to Padjen the transport demand has crucial significance for determining and pursuing of the traffic policy, determines the development level of the traffic system as well as the level of its usage, first of all its technical stratum i.e. traffic infrastructure and transport means [6, 7]. The transport modelling plays a significant role in all the more complicated decision-making processes, and especially when referring to the modelling of the traffic development [8, 9]. Regarding the dynamic character of change in the economic and transport system for the traffic analyses more desirable are the analytic methods that detect the changes within shorter periods of time, so that the subject and results of research and modelling are better directed [10]. This being a quantitative research, there is being used dynamic measures of average yearly growth rate and of establishing the value worth trend for the traffic supply and demand in the public urban passenger transport system, correlation and regression analysis. Researched values represent quantitative indicators of transport supply in the system of public city transport, which in the city of Zagreb is run by the public transport operator Zagrebački električni tramvaj (ZET), a branch of Zagrebački holding Ltd.

2 Research results

Values which are within the scope of the research and their time series are shown in Tab. 1, as well as the results of the corresponding statistic descriptive analysis. Correlation analysis by means of applying specific statistical methods and techniques examines the level and direction of relation between two or more researched variables. If there is to be established a specific statistically significant level of connection between two of the variables, by means of regression analysis there is developed an analytic expression or algebraic model which describes the relation between the monitored variables the best it can. Dynamics of single variables over the monitored time period is graphically shown by line graphs. In this paper, dependent variable (Y_i, i = 1,..,12) represents the number of transported passengers during one year. On the other side there are being observed 12 different independent variables (X_i, i = 1,..,12).

Further in the paper graphical presentation is given and statistical analysis of the studied values performed. The data on the passenger transport demand are expressed by the number of carried passengers based on the realised sales of carriers' tickets (internal evidence of ZET about the sold tickets). The prognostic trend model of the development dynamics of individual traffic value (only statistically significant models are presented) has been obtained by means of computer software "Microsoft Excel" and is determined by the equation of linear trend model and determination coefficient (R^2) as a measure of representativeness and the dynamics has also been graphically presented. It should be noted that along with the size of the sample analysed in the paper (N = 16) the following holds: when the value of the determination coefficient R^2 is greater than 0,247 a conclusion follows that the determined mathematical model of prognostic trend of the studied variable is statistically significant with the risk level p < 0,05, i.e. if R^2 is greater than 0,388 with the risk level p < 0,01 [11]. The interconnection as well as the level of correlation between the studied values in the observed period is determined by means of the coefficient correlation matrix (Tab. 2), and thus the statistically significant value of the correlation coefficient (r) is greater than 0,497 with risk level p < 0,05, i.e. greater than 0,623 with risk level p < 0,01 [12].

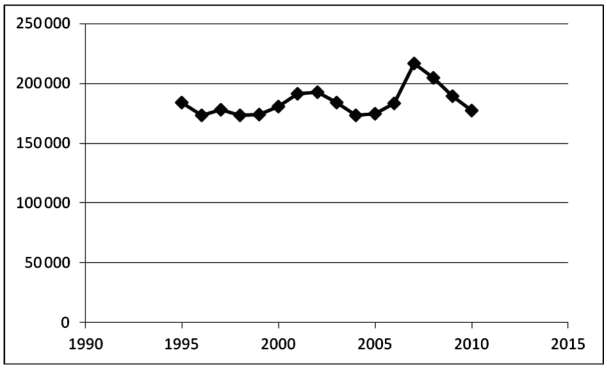

Figure 1 Transported passengers (Y) in the tram transport system of the City of Zagreb in the time period from 1995 to 2010 [13], in 000

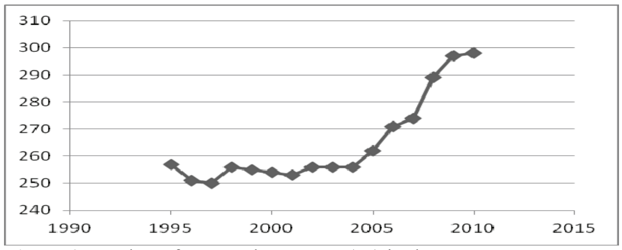

Figure 2 Number of powered tram cars (X_1) in the tram transport system of the City of Zagreb in the time period from 1995 to 2010 [13]

$$Y_1 = 2,89 \cdot X_1 + 243. \quad (1)$$

$$R^2 = 0,71; \ (p < 0,01). \quad (2)$$

Note (valid for all further equations of mathematical prognostic trend models): X_1 = 0 for 1995.

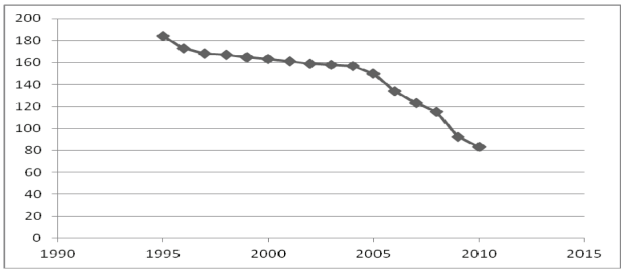

Figure 3 Number of trailer vehicles (X_2) in the tram transport system of the City of Zagreb in the time period from 1995 to 2010 [13]

$$Y_2 = -5,65 \cdot X_2 + 189. \quad (3)$$

$$R^2 = 0,84; \ (p < 0,01). \quad (4)$$

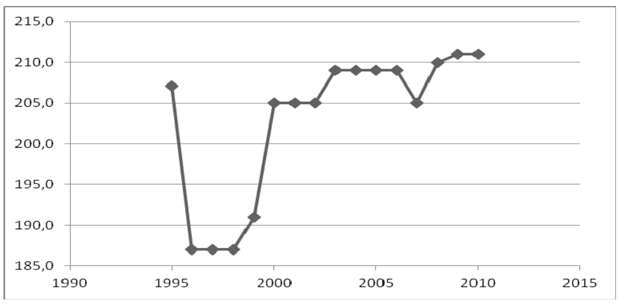

Figure 4 Length of line network (X_3) in the tram transport system of the City of Zagreb in the time period from 1995 to 2010 [13], in km

$$Y_3 = 1,39 \cdot X_3 + 192,4. \quad (5)$$

$$R^2 = 0,52; \ (p < 0,01). \quad (6)$$

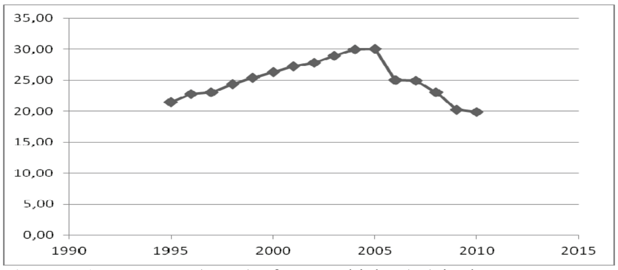

Figure 5 Average age (years) of tram vehicles (X_4) in the tram transport system of the City of Zagreb in the time period from 1995 to 2010 [13]

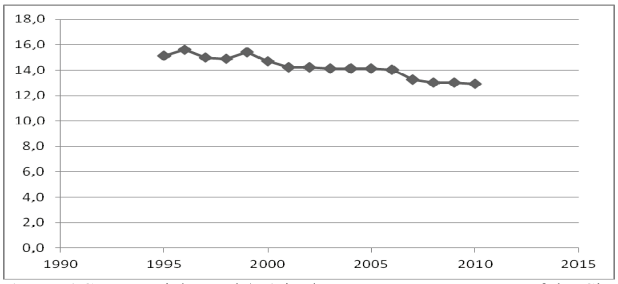

Figure 6 Commercial speed (X_5) in the tram transport system of the City of Zagreb in the period from 1995 to 2010 [13], in km/h

$$Y_5 = -0{,}17 \cdot X_5 + 15{,}5. \tag{7}$$

$$R^2 = 0{,}90;\ (p < 0{,}01). \tag{8}$$

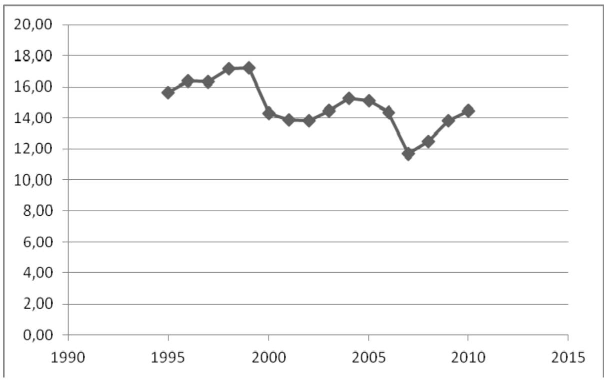

Figure 7 Offered passenger-kilometres per passenger (X_6) in the tram transport system of the City of Zagreb in the time period from 1995 to 2010 [13]

$$Y_6 = -0{,}23 \cdot X_6 + 16{,}5 \tag{9}$$

$$R^2 = 0{,}48;\ (p < 0{,}05). \tag{10}$$

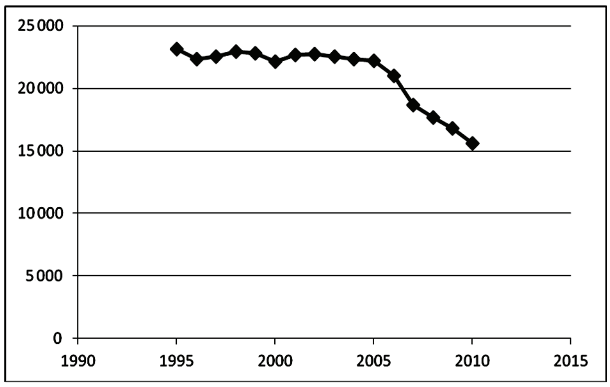

Figure 8 Offered vehicular-kilometres (X_7) in the tram transport system of the City of Zagreb in the time period from 1995 to 2010 [13]

$$Y_7 = -426{,}84 \cdot X_7 + 24{,}334. \tag{11}$$

$$R^2 = 0{,}68;\ (p < 0{,}01). \tag{12}$$

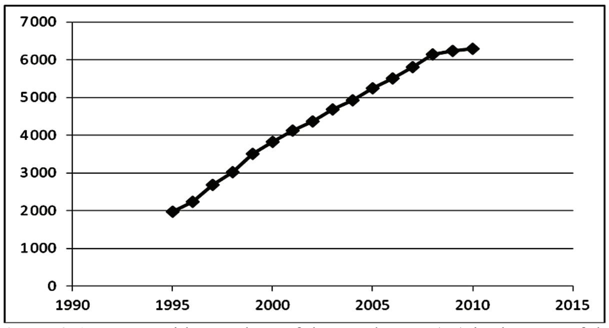

Figure 9 Average paid net salary of the employees (X_8) in the area of the city of Zagreb in the time period from 1995 to 2010 [14], in kn (CRO)

$$Y_8 = 299{,}1 \cdot X_8 + 2169. \tag{13}$$

$$R^2 = 0{,}99;\ (p < 0{,}01). \tag{14}$$

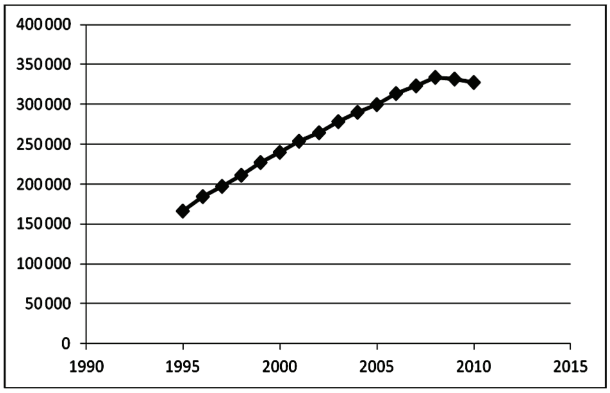

Figure 10 Registered number of personal vehicles (X_9) in the area of the city of Zagreb in the time period from1995 to 2010 [14]

$$Y_9 = 11{,}579 \cdot X_9 + 17{,}847. \tag{15}$$

$$R^2 = 0{,}97;\ (p < 0{,}01). \tag{16}$$

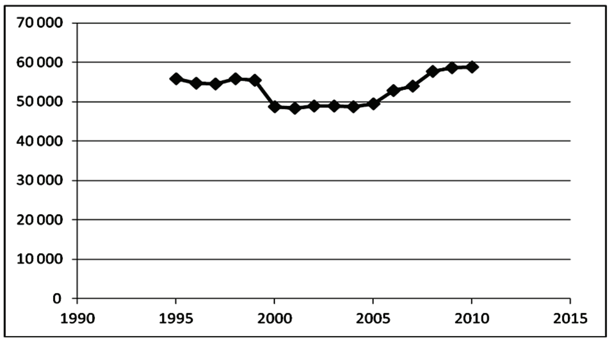

Figure 11 Number of passengers places (X_{10}) in the tram transport system of the City of Zagreb in the time period from 1995 to 2010 [13]

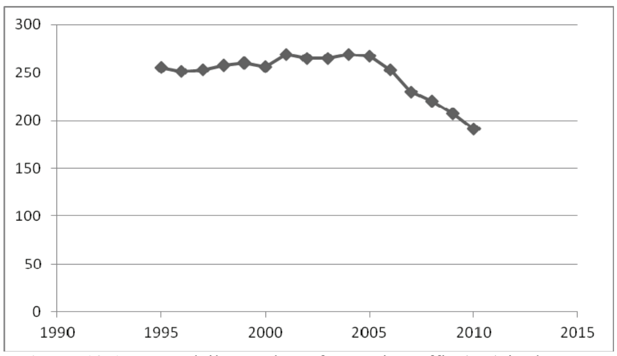

Figure 12 Average daily number of trams in traffic (X_{11}) in the tram transport system of the City of Zagreb in the time period from 1995 to 2010 [13]

$$Y_{11} = -3{,}15 \cdot X_{11} + 271{,}6. \quad (17)$$

$$R^2 = 0{,}41; (p < 0{,}01). \quad (18)$$

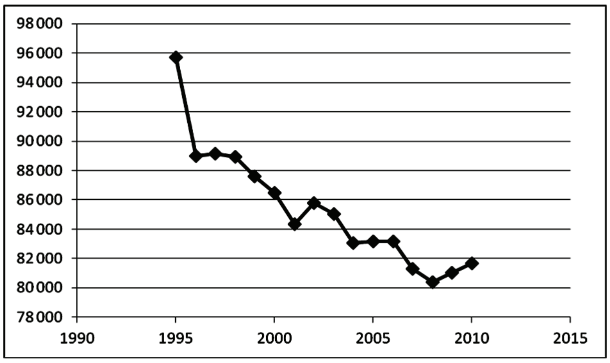

Figure 13 Vehicular-kilometres/average no. of trams (X_{12}) in the tram transport system of the City of Zagreb in the time period from 1995 to 2010 [13]

$$Y_{12} = -781{,}2 \cdot X_{12} + 91{,}215 \quad (19)$$

$$R^2 = 0{,}85; (p < 0{,}01). \quad (20)$$

Below there will be conducted regression analysis of the researched variables. The objective of regression analysis is to express or describe the connection between the observed variables by adequate analytical mathematical expression, i.e. by regression model. The main purpose of that model, apart from explaining the correlations of the observed occurrences, is the possibility of predicting the values of passenger transport demand in the tram transport system of the city of Zagreb for certain values of one or more independent variables.

Regression analysis of the transport demand (Y) and the commercial speed (X_5) to tram traffic are obtained by linear regression model in the form:

$$Y_5 = 303\,809{,}4 - 8387{,}12 \cdot X_5. \quad (21)$$

According to the model (21) and conducted regression analysis it follows that there is a statistically significant relationship (inversely) between the passenger transport demand and achieved commercial speed tram transport system, the value of $r = 0{,}585$ (R^2=0,342) at the level of $p < 0{,}05$.

Regression analysis of the transport demand (Y) and offered seats per passenger-kilometres (X_6) to tram traffic model is obtained by a simple linear regression of the form:

$$Y_6 = 286\,592{,}6 - 6916{,}2 \cdot X_6. \quad (22)$$

According to the model (22) and conducted regression analysis it follows that there is a statistically significant relationship (inversely proportional) between passenger transport demand and offered seats per passenger-kilometres of tram transport system, the value of $r = 0{,}874$ (R^2=0,764) at the level of $p < 0{,}01$.

Regression analysis of transport demand (Y) and average net salary in the City (X_8) is obtained by a simple linear regression model of the form:

$$Y_8 = 166\,944{,}3 + 3{,}97 \cdot X_8. \quad (23)$$

According to the model (23) and conducted regression analysis it follows that there is a marginally statistically significant association (proportional administrative) of average net wages and passenger transport demand in tram transport system, the value of r=0,462 (R^2=0,214) at the level of $p < 0{,}07$.

Table 1 Transport demand and elements of transport supply, and the life standard of the users in tram transport system of the City of Zagreb in the time period from 1995 to 2010 – transport company Zagrebački holding d.o.o., Zagreb, Subsidiary Zagrebački električni tramvaj [13, 14]

Year	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
1995	184 189	257	184	207,1	21,50	15,1	15.63	23 132	1983	165 911	55 868	255	95 714
1996	173 234	251	173	187,0	22,80	15,6	16.38	22 330	2239	184 766	54 703	251	88 964
1997	178 079	250	168	187,0	23,10	15,0	16,31	22 551	2688	197 638	54 505	253	89 134
1998	173 172	256	167	187,0	24,40	14,9	17,19	22 941	3017	211 373	55 764	258	88 919
1999	174 223	255	165	191,0	25,40	15,4	17,24	22 776	3510	226 770	55 527	260	87 600
2000	180 946	254	163	205,0	26,30	14,7	14,29	22 137	3832	240 062	48 688	256	86 473
2001	191 065	253	161	205,0	27,30	14,2	13,85	22 691	4131	254 373	48 366	269	84 353
2002	192 579	256	159	205,0	27,80	14,2	13,80	22 734	4374	264 931	48 959	265	85 789
2003	183 784	256	158	209,0	28,90	14,1	14,45	22 532	4680	278 593	48 930	265	85 026
2004	173 298	256	157	209,0	29,95	14,1	15,27	22 342	4929	290 279	48 816	269	83 056
2005	174 878	262	150	209,0	30,02	14,1	15,07	22 200	5239	300 306	49 437	267	83 146
2006	183 428	271	134	209,0	24,99	14,0	14,37	21 010	5516	313 164	52 795	253	83 161
2007	216 894	274	123	205,0	24,91	13,3	11,66	18 699	5806	323 539	53 906	230	81 300
2008	204 547	289	115	210,0	23,06	13,0	12,48	17 683	6145	334 067	57 775	220	80 373
2009	189 529	297	92	211,0	20,26	13,0	13,80	16 776	6229	331 751	58 618	207	81 042
2010	177 609	298	83	211,0	19,91	12,9	14,47	15 597	6291	327 612	58 800	191	81 654
Arithmetic mean	184 466	265	147	203	25	14	15	21 133	4413	265 321	53 216	248	85 357
Standard deviation	12 293	16	29	9	3	1	2	2469	1433	55 873	3818	23	4029
Coefficient of variation	6,7 %	6,2 %	20,0 %	4,5 %	12,8 %	6,0 %	10,5 %	11,7 %	32,5 %	21,1 %	7,2 %	9,5 %	4,7 %
Annual rate of change	–0,24 %	0,99 %	–5,17 %	0,12 %	–0,51 %	–1,04 %	–0,51 %	–2,59 %	8,00 %	4,64 %	0,34 %	–1,91 %	–1,05 %

Note: The tram system number of lines is 19 and was unchanged during the entire period of the project, so due to that reason it is not specifically stated in the table. Number of passengers was recorded through sold tickets.

Table 2 Matrix of correlation coefficient value (r) of the researched values of the tram traffic system of the city of Zagreb in the time period between 1995 and 2010 [13, 14]

Variable	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
Y	1,00												
X_1	0,39	1,00											
X_2	–0,39	–0,96**	1,00										
X_3	0,39	0,55*	–0,55*	1,00									
X_4	–0,11	–0,56*	0,44*	0,13	1,00								
X_5	–0,58*	–0,86**	0,90**	–0,75**	0,16	1,00							
X_6	–0,87**	–0,53*	0,58*	–0,71**	–0,02	0,79**	1,00						
X_7	–0,43	–0,97**	0,97**	–0,47	0,58*	0,85**	0,57*	1,00					
X_8	0,46	0,80**	–0,88**	0,73**	0,02	–0,94**	–0,72**	–0,77**	1,00				
X_9	0,47	0,76**	–0,85**	0,72**	0,07	–0,92**	–0,72**	–0,74**	0,99**	1,00			
X_{10}	0,09	0,64**	–0,50*	–0,16	–0,90**	–0,22	0,09	–0,63**	0,11	0,07	1,00		
X_{11}	–0,33	–0,92**	0,88**	–0,29	0,77**	0,69**	0,40	0,96**	–0,57*	–0,52*	–0,78**	1,00	
X_{12}	–0,43	–0,66**	0,79**	–0,55*	–0,14	0,84**	0,67**	0,68**	–0,94**	–0,95**	0,01	0,46	1,00

Notes to Table 2: Boundary values of determination coefficient R^2 (N=16) and the number of degrees of freedom (df)=14 for value $r > 0{,}497$ with risk level * $p < 0{,}05$; for value $r > 0{,}623$ with risk level ** $p<0{,}01$. The value of correlation coefficient (r) is obtained by an adequate procedure with MS Excel.

Values in Table 1 and 2:

Y Transported passengers (in 000)
X_1 Number of powered tram cars
X_2 Number of tram trailers
X_3 Length of line network (km)
X_4 Average age (years)
X_5 Commercial speed (km/hour)
X_6 Offered places-km per passenger
X_7 Offered vehicle kilometres (in 000)
X_8 Average net salary (Croatian kuna)
X_9 Number of personal vehicles
X_{10} Number of passengers places
X_{11} Average daily no. of trams in traffic
X_{12} Vehicle kilometres/average no. of trams in traffic (in 000)

Regression analysis of transport demand (Y) and the number of registered passenger cars (X_9) in the tram traffic is obtained by a simple linear regression model of the form:

$$Y_9 = 156\,776{,}5 + 0{,}104 \cdot X_9. \quad (24)$$

According to the model (24) and the conducted regression analysis it follows that there is a statistically significant correlation between passenger transport demand and the number of registered passenger cars, the value of r =0,474 (R^2=0,225) at the level of $p < 0{,}06$.

Multiple regression analysis of transport demand (Y) with a total length of lines (X_3) and offered seats per passenger-kilometres (X_6) in a tram transport system gets the appropriate model in the form:

$$Y = 449\,875 - 616\,48 \cdot X_3 - 9501{,}22 \cdot X_6. \quad (25)$$

The statistical significance of the model (25) is at the level of $p < 0{,}01$ with a value of $r = 0{,}933$ ($R^2 = 0{,}87$).

The given results of correlation analysis are the following: a) established a reciprocal relationship with the travel demand sizes X_6 ($p < 0{,}05$) and X_7 ($p < 0{,}01$):

b) Travelling speed X_5 is inversely correlated with size X_8 ($p < 0{,}01$) and X_9 ($p < 0{,}01$),
c) Shifted vehicular kilometres X_7 proportionally related to the average daily number of tram traffic ($p < 0{,}01$).

3 Argument

Through the analysis of observed values, shown in Tab. 1, it is possible to conclude the following: a) the size of Y refers to a passenger demand for the stated number of passengers carried, and b) the size of X_1, X_2, X_4, X_{10}, and X_{11} refers to the technical elements of the subsystem tram system, c) X_3 is the length of the network lines in the system, d) the size of X_7 and X_{12} is associated with organizational program system of tram transport system, e) the size of the X_5, and X_6 is associated with the quality of transport services, f) the size of X_8 and X_9 is related to the level of living standards of existing and potential service users of urban public transport tram. The transport demand shown by the number of passengers carried (Y) in the tram traffic system observed in the period is within the limits of a minimum 185 ÷ 217 million passengers annually, with an average value of approximately 185 million. The negative average annual rate of change in the travel demand is –0,24 %, so that within that same period it is decreased by –3,6 %. The number of motor tram cars (X_1) of 15,9 %, with a positive average annual rate of change of 1 % (predictive mathematical model is statistically significant at $p < 0{,}01$), which is consistent with the trend of procurement of modern low-floor trams, in which motor vehicles and trailers-modules form a single composition. In accordance with the trend of abolishing traditional tram composition (in which part of the engine with one or more trailers) the number of connecting tram vehicles (X_2) in the same period is decreased by 54,9 %, with a negative average annual rate of change of –5,2 % (statistically significant trend). The length of the line tram network (X_3) (statistical significance of trend $p < 0{,}01$), increased by 1,9 % with an average annual rate of positive change of 0,12 %. The substantial investment is given in modernizing tansport resources, their average age (X_4) is reduced by 7,4 % and now it is 25 years.

Commercial travel speed (X_5) in a tram transport system was reduced in the explored period by 14,6 %, with a negative annual rate of change of –1,04 % (statistically significant trend $p < 0{,}01$). Regression analysis showed a strong association of commercial speed (X_5) with passenger demand (reciprocal links), and the resulting model established a significance level of $p <$

0,05. The size (X_6) of generated per passenger-kilometers has a steady downward trend at an average annual rate of change of –0,5 %, which is observed in the period fell by 7,4 %. The size (X_6) as an element of transportation offers the regression analysis is firmly associated with the transport demand, which was established by the appropriate regression model (significance level of $p <$ 0,01). Actual vehicular kilometers (X_7) were reduced in this period by 32,6 %, with an average annual negative rate of change of –2,6 % (statistically significant trend). The average net salary (X_8) and the number of registered passenger vehicles (X_9), associated with the level of living standards have shown steady growth, with both trends deriving prognostic model on the level of statistical significance of $p < 0{,}01$.

Within the regression analysis of correlation of the average net salary (X_8) and the number of registered passenger vehicles (X_9) with the passenger demand (Y) the regression models are obtained by the level of a marginal statistical significance. The total passenger capacity of the tram transport system (X_{10}) was increased in the explored period by 5,2 % (average annual rate of change of +0,34 %). The average number of trams in traffic per day (X_{11}) was reduced by 25,1 % (negative average annual rate of change of –1,9 %), while this trend was statistically significant at $p < 0{,}01$.

The actual vehicular-kilometers (X_{12}) or a traveled distance, and thus the possible accomplished transport work that the average number of trams a day engaged a steady downward trend statistically significant ($p < 0{,}01$), ie the same as observed in the period decreased by 14,7 %, with a negative average annual rate of change of –1,05 %. Multiple regression analysis of the resulting model can be stated: a) the length of the line tram network increased by one mile is expected to reduce travel demand for 616 passengers, that provides the value of a consistent size X_6; b) if the offer is improved by increasing the per unit transport work or actual seats-km per passenger, it is expected to reduce transport demand and number of passengers carried in 9,501, and provided a constant value of the size of X_3. According to the above mentioned, increase in the number of transporting units and capacity may be evaluated as positive, while decrease of travel speed is a negative occurrence, causing reduction of attractiveness to use tram transport system.

4 Conclusion

This study presents a research of dynamics in development of passenger transport demand on one hand, and more variables of transport supply connected to the elements of transport service quality of the tram transport system of the city of Zagreb on the other hand, taking into consideration variables indicating the living standard level of the users of that system services. During the researched period, in the tram transport system of the city of Zagreb the following was found statistically significant: constant increase in the number of powered tram cars together with constant reduction in the number of tram trailers, resulting from the investments of the city of Zagreb into articulated low-floor tram sets.

In accordance with the research results in this period the following can be concluded: a) the size which are related to the technical subsystem with the positive trends in terms of improving their functional level, so the number of tram motor cars (X_1) was increased by 15,9 %, the average age (X_4) was reduced by 7,4 % and at the end of the same period it was 19,9 years (in 2005 it was 30 years), and the total passenger capacity (X_{10}) was increased by 5,2 %; b) associated quality of transport services and technological subsystem are statistically significant in a negative trend, so that the travelling speed (X_5) decreased by 14,6 % with an average value in 2010 of 12,9 km/h, and the size (X_6), which refers to the realized transport operation / per passenger fell by 7,4 %; c) the length of the line of the tram network was increased by 1,9 % (a statistically significant trend of a steady growth); d) the size of which is associated with the organizational and technological subsystem with a constant negative significant trends that have passed the vehicular kilometres (X_7) is decreased by 32,6 % and the average number of trams involved in traffic per day (X_{11}) was reduced by 25,1 %; e), associated with the level of living standards and the related number of passenger cars, it had a statistically significant trend of steady growth; f) passenger transport demand in the system has a decreasing trend, compared with the year 2010 and the year 1995, it was reduced by 3,6 %, which is an extremely unfavourable trend, and it is certainly contrary to the wishes and expectations of shareholders, in this case the owner, the City of Zagreb.

This fact further confirms the fact established by the correlation analysis that follows and which is inversely proportional relationship between the speed of travel and the number of passenger cars in the road network. Meanwhile, within that time period the following important trends should be emphasized: a) constant and intense downward trend in the passenger transport demand shows that the number of passengers carried since 2007 was reduced by 18,1 %; b) a steady increasing trend in total passenger capacity, so since 2004 the total number of passenger seats was increased by 20,4 %.

In accordance with these trends it can be concluded that during the observed period there was no congruence of the development in the passenger capacity of tram transport system as a significant factor of transport supply with the dynamics of the development of passenger transport demand. Disadvantage of the situation is related to a constant decrease of travelling speed in the tram transport system, resulting in combined traffic system of the city of Zagreb within which the public urban transport does not have priority over individual and other traffic systems.

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