

FORECASTING THE NUMBER OF PASSENGERS SERVICED AT THE BULGARIAN RAILWAY STATIONS

Sophia Mirchova
SWU"Neofit Rilski", Blagoevgrad, Bulgaria
sophia_mirchova@abv.bg

Preslav Dimitrov
SWU"Neofit Rilski", Blagoevgrad, Bulgaria
preslav.dimitrov@mail.bg

Abstract:

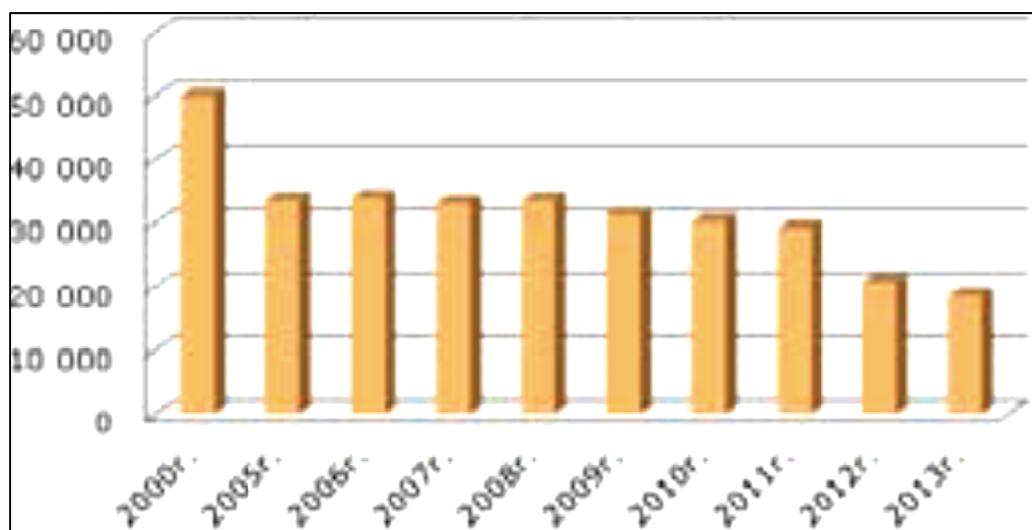
The railway transport in Bulgaria is controlled and coordinated by the Railway Administration Executive Agency. This transport and its infrastructure are put under serious pressure in connection with its membership in the European Union. The problem of forecasting in the new strategic documents is crucial to the formation of proper innovation infrastructure policy for the future development of the tourism in the country. This paper is aimed at presenting the lack of real forecasting in many of the strategic documents adopted for the development of the railway transport in Bulgaria (i.e. the REGULATION No 1335/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2008 amending Regulation No 881/2004 establishing a European Railway Agency (Agency Regulation), COMMISSION IMPLEMENTING REGULATION No 402/2013 of 30 April 2013 on the common safety method for risk evaluation and assessment and repealing Regulation No 352/2009, COMMISSION IMPLEMENTING REGULATION (EU) 2015/10 of 6 January 2015 on criteria for applicants for rail infrastructure capacity and repealing Implementing Regulation (EU) No 870/2014, many directives and decisions concerning the railway transport). There are also many International Bilateral Rail Cross-border Agreements. The paper provides a practical example for the use of the double exponential smoothing in the presence of a linear trend and the lack of cyclicity on the number of tourism arrivals at Bulgarian railway stations.

Keywords: railway transport, strategic documents, railway infrastructure policy, double exponential smoothing method forecasting, Holt method; linear trend

1. INTRODUCTION

The railway transport in Bulgaria is controlled and coordinated by the Railway Administration Executive Agency. This transport and its infrastructure are put under serious pressure in connection with its membership in the European Union. The problem of forecasting in the new strategic documents is crucial to the formation of proper innovation infrastructure policy for the future development of the tourism in the country. In many of the strategic documents adopted for the development of the railway transport in Bulgaria (i.e. the REGULATION No 1335/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2008 amending Regulation No 881/2004 establishing a European Railway Agency (Agency Regulation), COMMISSION IMPLEMENTING REGULATION No 402/2013 of 30 April 2013 on the common safety method for risk evaluation and assessment and repealing Regulation No 352/2009, COMMISSION IMPLEMENTING REGULATION (EU) 2015/10 of 6 January 2015 on criteria for applicants for rail infrastructure capacity and repealing Implementing Regulation (EU) No 870/2014, many directives and decisions concerning the railway transport). There are also many International Bilateral Rail Cross-border Agreements. A possible solution can be found in the group of the exponential forecasting methods and in particular in the face of the Halt method of exponential smoothing. This method is explicitly suitable for forecasting and planning of the of the railway transport infrastructure, as it can provide considerably reliable forecast values on the number of passenger arrivals of some of the country's major railway stations, such as the Sofia railway station which is under review in the present article.

Figure 1: Number of passengers arriving at Sofia Central Railway Station



Source: Bulgarian State Railways, Passenger transportation

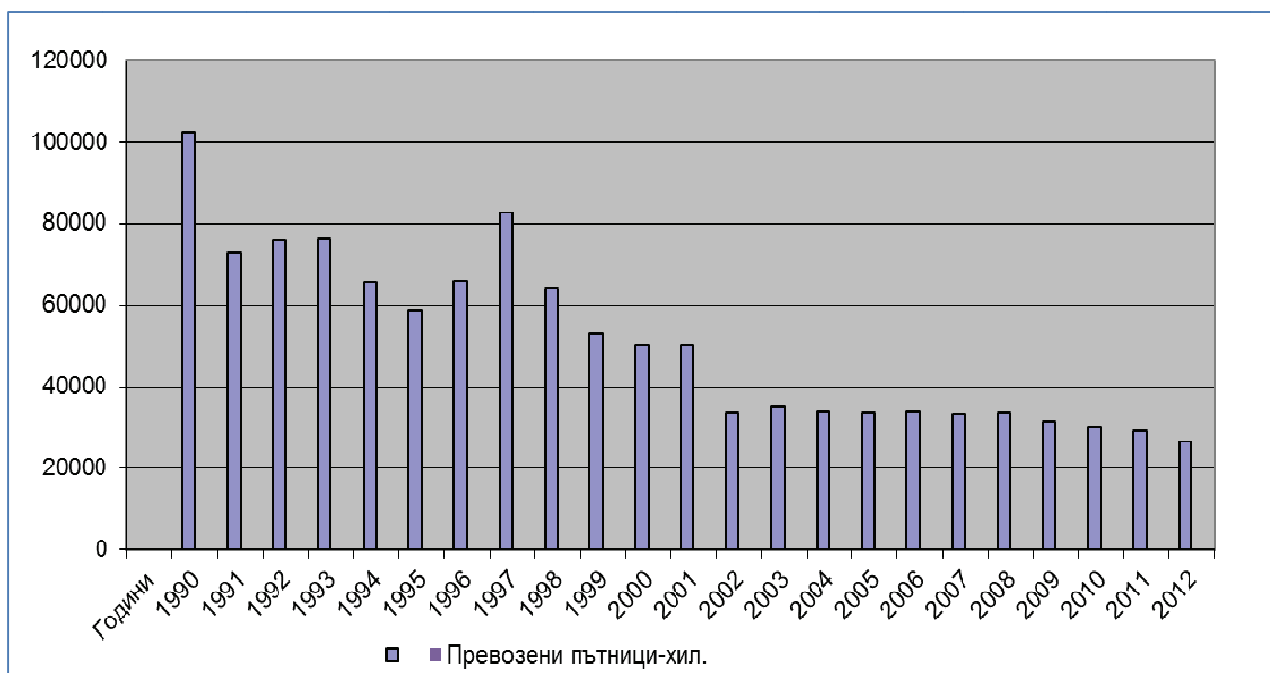
In 2013, four scheduled international trains arrived daily at Sofia's Central Railway Station from Belgrade, Moscow/Kiev, Bucharest and Istanbul. June-September 2013, a seasonal train operated Saratov-Sofia, via Ukraine and Moldova, with carriages to Varna. In 2013, some 1580 international trains from five destinations pulled into Sofia's Central Railway Station. 18,607 passengers arrived via international trains in 2013, which is 10% less than the relevant 2012 figure. The total aggregate figure of passengers arriving to Sofia on international and domestic trains stands at 2,685,000, 1% lower than in 2012. The drop in the number of railway transport passengers has persisted since 2000, in favor of air transport, the reasons obviously being the comfort offered by air travel, the brevity of air travel, and the progress of low-budget airline companies.

As it is seen from the statistical yearly records of the passengers flows on the Bulgarian railway stations, the number of passengers is slowly but steadily decreasing within the period from 2000 to 2012 (Table 1). This decrease however is accompanied with linear trend with no cyclicity (Figure2). Forecast of the number of passengers served by Bulgarian railway stations by railway transport applying the methods described in this article is presented in figure 2 and table 1.

Table 1: Number of passengers served by Bulgarian railway transport

Years	Total number of passengers served	Inland transport	International transport
1990	102399		
1991	72787		
1992	75909		
1993	76085		
1994	65 730		
1995	58940		
1996	66097		
1997	82656		
1998	64260		
1999	53112		
2000	50028,7	49793,5	235,2
2001	50028,7	41569,5	247,9
2002	33718,5	33441,8	276,7
2003	35205,7	35061,0	144,7
2004	34148,7	34056,1	92,6
2005	33747,6	33571,7	175,9
2006	34112,7	33904,4	208,3
2007	33283,0	32978,1	304,9
2008	33757,8	33301,6	456,2
2009	31360,2	30928,8	431,4
2010	30101,9	29670,9	431,0
2011	29308,2	28920,3	387,9
2012	26523,2	26173,8	349,4

Source: Mirchova, S. (2014) from the NSI (National Statistical Institute)

Figure 2: Number of passengers served including-total number, from inland transport and international transport

Source: Mirchova, S. (2014) from the NSI (National Statistical Institute)

2. OBJECTIVES

As P. Dimitrov (2011, 2012) points out the task of creating an exponential smoothing forecast model for the long-run development of the tourism industry, and in a particular for the Bulgarian railway stations, meets with solving of several major problems:

- (i) Finding of a suitable general indicator, on the basis of which to build the long-run forecasts (the forecast for periods longer than 5 years);
- (ii) Determining the time series pattern, or the so-called “forecast profile” (Gardner, 1987:174-175) (Hyndman, Koehler, Ord and Snyder, 2008:11:23) and the quality of the data in the pattern, on the basis of which to select the suitable forecasting exponential smoothing model.
- (iii) Selecting and using of suitable forecasting techniques;
- (iv) Calculating of long-run forecasts for the value of the above-mentioned general indicator (up to the year 2022).

3. METHODOLOGY AND MAIN RESULTS

With regards to the *first problem*, i.e. the finding of a general suitable indicator, on the basis of which to make the forecast, it can be pointed out that the Bulgarian railway stations have published their yearly statistical records of serviced passengers, already presented in point 2 of the present article.

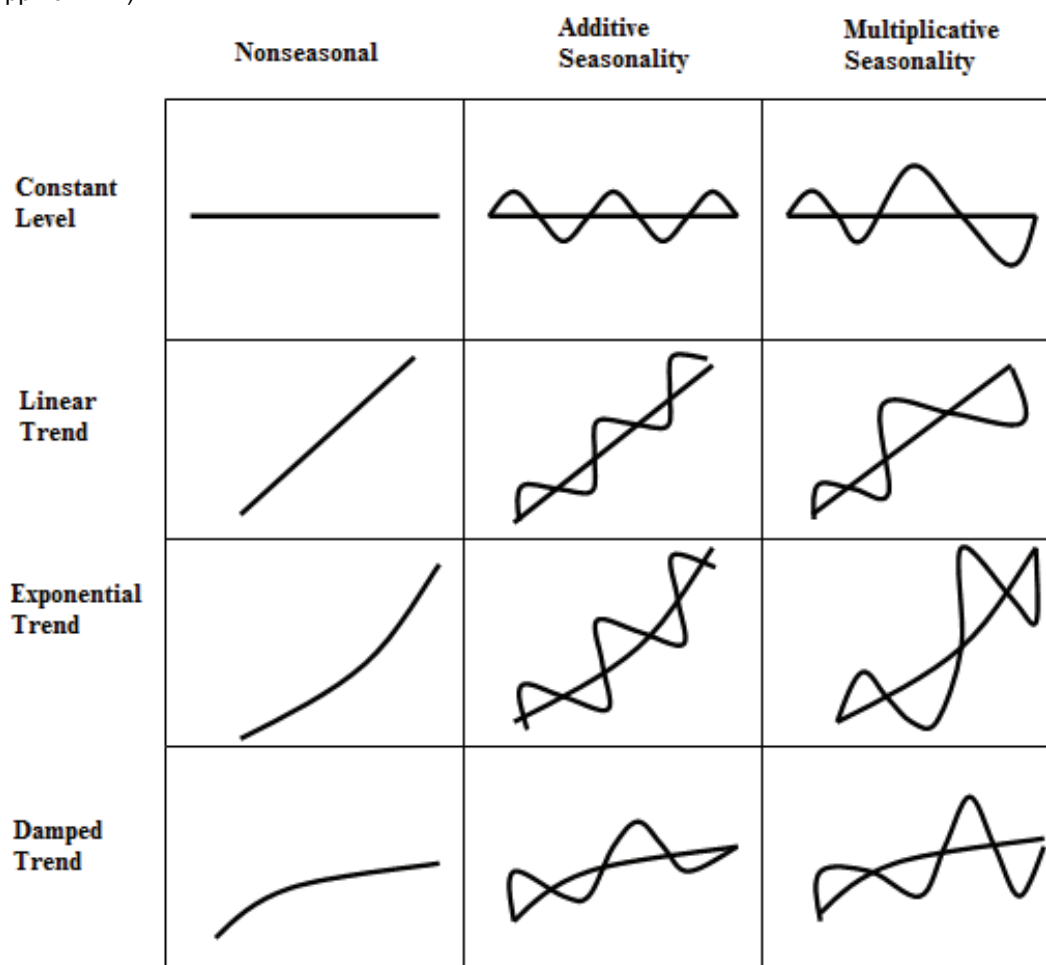
The *second problem* of determining the times series pattern, or the so-called times series’ “forecast profile” is usually solved by comparing the times series in regard with a pre-set classification of exponential smoothing methods or the derived from them forecast profiles in terms of development curves. As Hyndman, Koehler, Ord and Snyder point out (Hyndman et al., 2008:11-12), this classification of smoothing methods originated with Pegles’ taxonomy (Pegles, 1969:311-315). This was later extended by Gardner (Gardner, 1985:1-28) and modified by Hyndman et al. (2002, 2008) and extended by Taylor (Taylor, 2003:715-725) giving a classification set of fifteen models (Table 2). In the regarded time series, as it will become later clear, the Gardner’s much simplified classification can also be successfully used for finding the best fit forecasting method or forecast profile.

Table 2: Classification of forecasting methods

Trend component	Seasonal component		
	N (None)	A (Additive)	M (Multiplicative)
N (None)	N,N	N,A	N,M
A (Additive)	A,N	A,A	A,M
A_d (Additive damped)	A_d,N	A_d,A	A_d,M
M (Multiplicative)	M,N	M,A	M,M
M_d (Multiplicative damped)	M_d,N	M_d,A	M_d,M

Source: Hyndman et al. (2008), p.12

Figure 3: Forecast profiles from Exponential Smoothing Models by Gardner (1987), cited by Dimitrov (2012, pp.104-114)



The finding that the time series of the number of the passengers serviced at the Bulgarian railway stations for the time period 2000 – 2012 correspond to the “linear trend, no seasonality” profile and require the “A, N” variation of exponential forecasting methods makes *the third problem, the one of selecting and using of a suitable forecasting exponential smoothing method* much more predetermined and easier to solve. As both Gardner and Hyndman et al. point out this profile corresponds to the method of *double exponential smoothing* in the presence of a linear trend and a lack of cyclicity, known as *the Holt method*. The mathematical notation of this method is as follows:

The mathematical notation of the Holt method is the following:

➤ The smoothing of *the level (the base)* – “L”:

$$(1) \quad L_t = \alpha Y_t + (1 - \alpha)(L_{t-1} + T_{t-1}) \quad 0 \leq \alpha \leq 1$$

➤ The smoothing of *the trend* – “T”:

$$(2) \quad T_t = \beta(L_t - L_{t-1}) + (1 - \beta)T_{t-1} \quad 0 \leq \beta \leq 1$$

➤ The achieving of *the final forecast* “ F_{t+m} ” for “ $t+m$ ” periods ahead in the future:

$$(3) \quad F_{t+m} = L_t + mT_t,$$

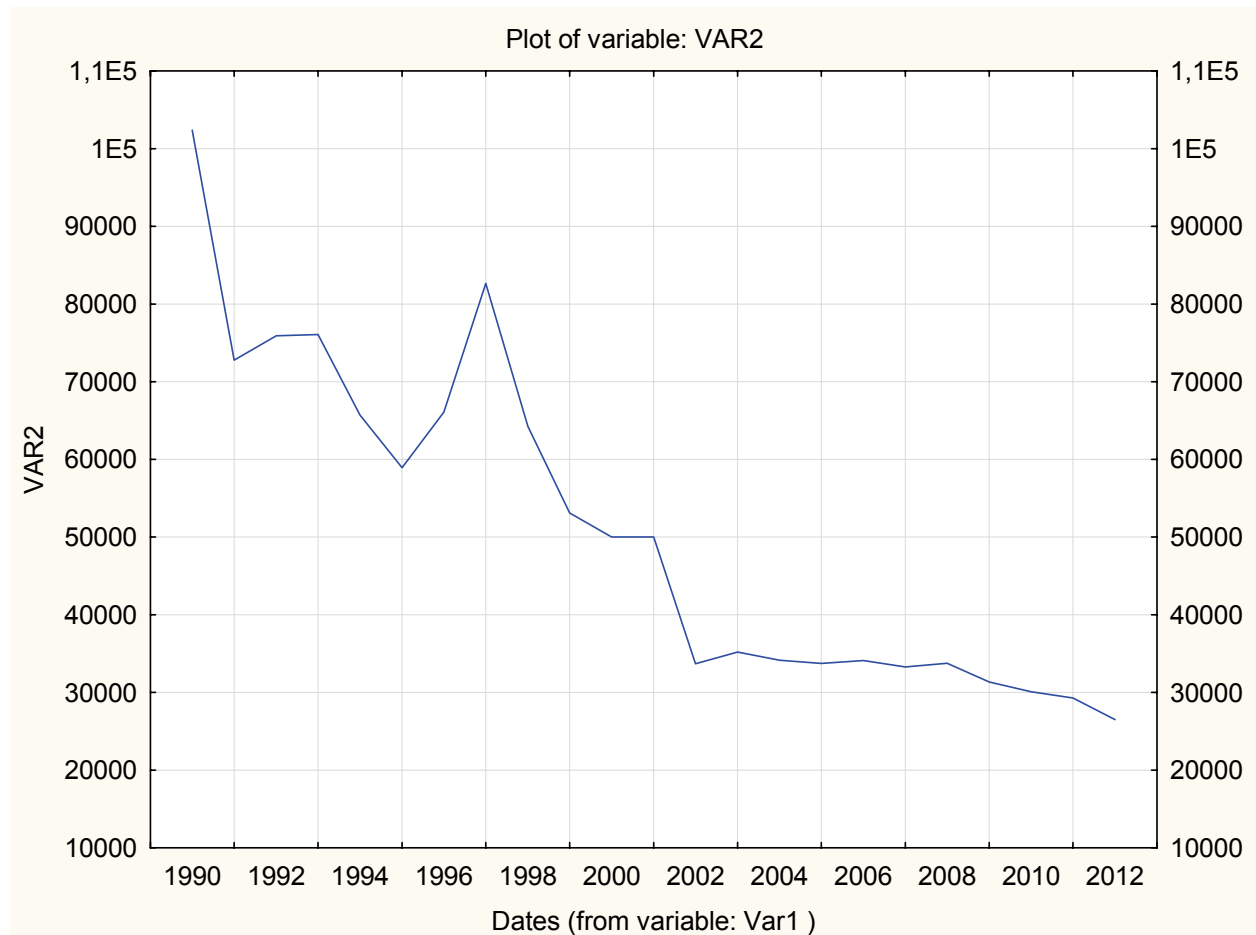
Where:

„ α ” and „ β ” are the smoothing constants for the level and the trend respectfully which could take values between 0 and 1.

After having chosen *the Holt method for linear trend with lack of seasonality* as the proper forecasting technique, calculations of the forecasts up end of 2025 can be achieved, thus solving *the third of the above-set tasks*. Here, two separate STATISTICA software calculation tables can be used in order to demonstrate the technology of applying the above-presented equations, as follows: (i) Table 2 for the Holt Method;

As it is seen from the graphical time series corresponds to the same forecast profile by the presence of a linear trend (reduction) and the absence of cycling that corresponds to the profile of the type (A,N) , which is the Halt method.

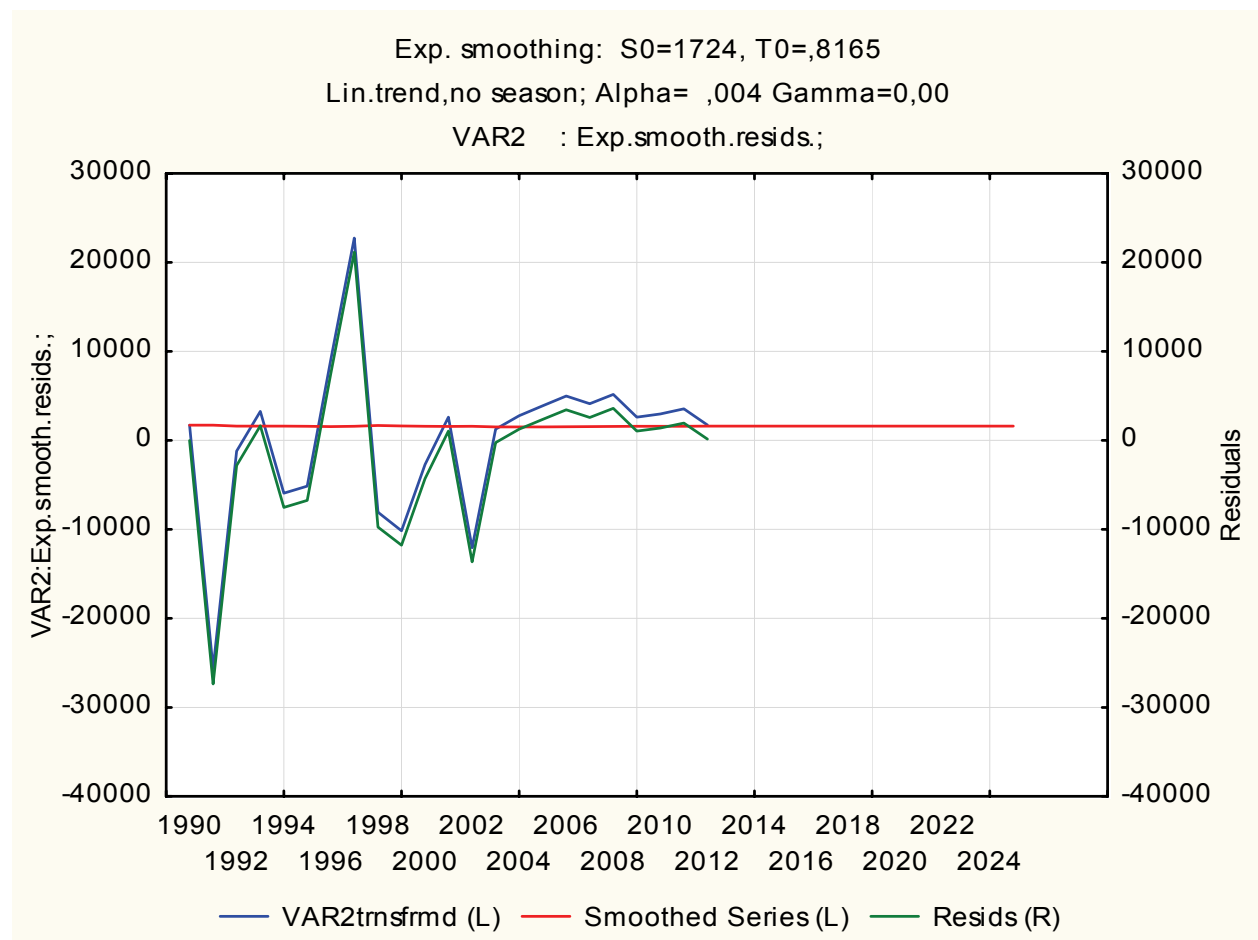
Figure 4: Graphical representations of the time series for the total number of passengers served by railway transport



Source: Mirchova, S. (2014) from the NSI (National Statistical Institute)

In applying the methodology for forecasting by double exponential smoothing in the presence of a linear trend and the lack of cyclicity there is a highly negative trend for reduction of the estimations. After 2015 they became negative. In this case for the indicator number of serviced passengers who cannot take negative values, we can reach the conclusion that if you keep both existing processes and factors affecting the development of time series, it is possible to achieve a drastic reduction in the number of passengers served and factual collapse of this sector in the long run perspective.

Figure 5: Graphical representations of the time series for the total number of passengers served by railway transport, forecasted results and the absolute size of the forecast error



Source: Mirchova, S. (2014) from the NSI (National Statistical Institute)

Table 3: Description of the parameters of the forecasting model used to calculate the estimates for the total number of passengers served by railway transport method Holt calculated with software "STATISTICA" ®

	Exp. smoothing: $S_0=1724$, $T_0=,8165$ (Spreadsheet1ZP) Lin.trend,no season; Alpha= ,004 Gamma=0,00 VAR2 : Exp.smooth.resids.;	
Summary of error	Error	
Mean error	-1,520503E+03	
Mean absolute error	5,794583E+03	
Sums of squares	1,850090E+09	
Mean square	8,043868E+07	
Mean percentage error	7,881569E+01	
Mean abs. perc. error	-1,592030E+01	

Source: Mirchova, S. (2014) from the NSI (National Statistical Institute)

Table 4: Estimated value and errors in estimates of the number of passengers served by railway transport for the period 1990 - 2025 with software "STATISTICA" ®

Var1 (Dates)	Exp. smoothing: S0=1724, T0=,8165 (Spreadsheet1ZP) Lin.trend,no season; Alpha= ,004 Gamma=0,00 VAR2 : Exp.smooth.resids.;		
	VAR2 trnsfrmd	Smoothed Series	Resids
1990	1724,4	1724,858	-0,4
1991	-25640,6	1725,673	-27366,3
1992	-1198,2	1617,025	-2815,2
1993	3261,8	1606,580	1655,3
1994	-5917,8	1614,018	-7531,8
1995	-5134,2	1584,707	-6718,9
1996	9050,2	1558,648	7491,6
1997	22750,1	1589,431	21160,7
1998	-8053,8	1674,890	-9728,7
1999	-10139,4	1636,792	-11776,2
2000	-2706,6	1590,504	-4297,1
2001	2628,8	1574,132	1054,7
2002	-12064,8	1579,167	-13643,9
2003	1280,5	1525,407	-244,9
2004	2779,9	1525,244	1254,6
2005	3890,1	1531,079	2359,0
2006	4992,7	1541,332	3451,3
2007	4132,0	1555,954	2576,1
2008	5175,7	1567,074	3608,6
2009	2619,5	1582,325	1037,2
2010	2984,3	1587,291	1397,0
2011	3559,4	1593,695	1965,8
2012	1742,4	1602,375	140,0
2013		1603,752	
2014		1604,568	
2015		1605,385	
2016		1606,201	
2017		1607,018	
2018		1607,834	
2019		1608,650	
2020		1609,467	
2021		1610,283	
2022		1611,100	
2023		1611,916	
2024		1612,733	
2025		1613,549	

Source: Mirchova, S. (2014) from the NSI (National Statistical Institute)

4. CONCLUSIONS

The forecast results achieved through the Holt method for the annual data of the number of the passengers serviced at the Bulgarian railway stations and the presence of a steady trend of annual decrease show out that there will be a constant decrease of the number of the passengers up to the end of the year 2025. Presented figures and tables also show that the lowest estimation in the forecast model in 2015 was 1,605.385 passengers served. The last realistic value for the previous 2014 is 1604.568. The highest estimation to 2025 is 1613.549 passengers served by Bulgarian railway stations. Based on the achieved forecast values in Table 4 and Figure 5, one can conclude that the variation in the number of the serviced passengers on the Bulgarian railway stations will remain

steadily decreasing. This strongly requires a change in the policy of infrastructure investment of the railway authorities, if they would like to achieve a steadier trend of increase and overcoming this trend they should take really serious actions.

REFERENCE LIST

1. Brown, R. G. (1959). *Statistical Forecasting for Inventory Control*, McGraw-Hill, New York.
2. Brown, R. G. (1963). *Smoothing, Forecasting, and Prediction of Discrete Time Series*, Prentice-Hall, Englewood Cliffs, NJ.
3. Dimitrov, P., (2012). *Long-Run Forecasting Of Ecotourism Receipts For The Needs Of The Bulgarian Municipalities*, Economics & Management Journal, Blagoevgrad, Bulgaria, Year VIII, Issue 1/2012, 104-114.
4. Filipova M., (2010). Peculiarities of Project Planning in Tourism, *Perspectives of Innovations Economics and Business /PIEB, International Cross- Industry Research Journal*, 4(1), 57-59.
5. Gardner, E. S. (JUN.) (1985). Exponential Smoothing: the state of the art, *Journal of Forecasting*, Issue 4, 1-28.
6. Gardner, E. S. (JUN.) (1987). Chapter 11: Smoothing methods for short-term planning and control, *The Handbook of forecasting – A Manager's Guide*, Second Edition, Makridakis, S. and Steven C. Wheelright (Edit.), John Wiley & Sons, USA, 174 -175.
7. Hyndman, R. J. Et Al. (2008). *Forecasting with Exponential Smoothing – The State Space Approach*, Berlin, Germany, 11-23.
8. NIST/SEMATECH e-Handbook of Statistical Methods, April, 2012,
9. <http://www.itl.nist.gov/div898/handbook/>
10. Martin Ivanov, Trials and Conclusions from time series forecasting of the business processes, New Bulgarian University, Sofia, Bulgaria, 2007,
11. http://www.nbu.bg/PUBLIC/IMAGES/File/departments/informatics/lzsledvania/Martin_Ivanov_prolet_2007.pdf
12. Sofia Municipality Tourist Service Municipal Enterprise,(2014) Sofia Tourism in figures, pp. 15