{MERAA} Mathematics in Education, Research and Applications
ISSN 2453-6881

Received: 2017-11-10
Accepted: 2017-12-08
Online published: 2017-12-31
DOI: http://dx.doi.org/10.15414/meraa.2017.03.02.66-72

Original Paper

Opportunities of using the forecasting model on an example of time series analysis

Martin Mariš*

Slovak University of Agriculture in Nitra, Faculty of European Studies and Regional Development, Nitra , Slovakia

ABSTRACT

Time series analysis is an integral part of every empirical investigation which aims at describing and modeling the evolution over time of a variable or a set of variables in a statistically coherent way. In the paper we have used Brown triple exponential smoothing model for estimating the trend as well as a forecast of a given time series of the share of renewable energy sources on gross inland energy consumption on a example of the Slovakia and EU average. According to the model, Slovak Republic might reach the share of the renewables on gross inland energy consumption till to 2020 with anticipated share of 16.25% (90%CI: 13.98: 18.93) and in case of the EU-28 with anticipated share of 15.94% (90% CI: 13.08: 18.08) failing short of expected 20% share set as a overall target.

KEYWORDS: Brown model, renewable energy sources, gross inland consumption, energy policy

JEL CLASSIFICATION: C53

INTRODUCTION

One of the biggest challenges of energy sector nowadays is to provide energy supply in a sustainable and eco-friendly way in the long-term perspective. In order to assure sustainability and durability of our energy sources and keeping in mind the environmental impact of energy production, it is necessary to divert our interest from energy sources that will eventually be depleted (such as fossil fuels) and concentrate on renewable energy sources (RES).

The European Union is one of the largest energy consumers, as well as one of the largest greenhouse gas (GHG) emitters in the world, which calls for a common strategy in the energy sector. The Europe 2020 is the key strategy of the EU aiming at enhancing the economic growth of the EU over the years 2010-2020. This strategy involved energy and climate policy including the so called 20/20/20 targets, namely reduction of greenhouse gas emissions (by 20%), the increase of RES share (to 20%) and the increase of energy efficiency, thus, saving up to 20% in the energy consumption [4]. The strategy 2020 was preceded by Communication

* Corresponding author: Martin Mariš, Slovak University of Agriculture, Faculty of European Studies and Regional Development, 949 59 Nitra, Slovakia, e-mail: martin.maris@uniag.sk

"An Energy Policy for Europe", which outlines developments in the energy sector by 2010 as well as the 2020 targets. Subsequently, in April 2009, the European Council adopted the Directive 2009/28/ES , which is an important element of climate change commitments:

- reduce greenhouse gas emissions by 20% by 2020 compared to 1990,
- increasing the share of renewable energy sources to 20% by 2020,
- achieving a share of 10% of renewable energy in transport by 2020,
- achieving 20% energy savings compared to projection by 2020 [2].

The Directive 2009/28/EC set mandatory national RES targets for Member states. Taking into consideration the RES potential of each Member State and respecting its energy mix, it was decided that the goal could vary, apart from the 10% for transport that was set as an equal target for all. According to the Directive, each Member State would have to adopt a national Renewable Energy (RE) Action Plan, including national targets for the share of RES consumed in transport, electricity, heating and cooling until 2020, notifying their national RE Action Plans to the Commission by 30 June 2010 [5]. Most of the Member states are on the track to meeting, their RES criteria set out by their national plans [2], and almost half of the Member States (Austria, Bulgaria, Czech Republic, Denmark, Germany, Greece, Spain, France, Lithuania, Malta, Netherlands, Slovenia and Sweden) even planned to exceed their own targets [4]. The 2020 targets vary from 10% for Malta up to 49% for Sweden [2]. According to Eurostat, the leaders in RES share are Sweden (53,9%), Finland (39,3%) and Latvia (37.6%).

The 2020 Energy Strategy defines the EU's energy priorities between 2010 and 2020. It aims to:

- reduce greenhouse gases by at least 20%,
- increase the share of renewable energy in the EU's energy mix to at least 20% of consumption,
- improve energy efficiency by at least 20%.

EU countries have agreed that the following objectives should be met by 2030:

- a binding EU target of at least a 40% reduction in greenhouse gas emissions by 2030, compared to 1990
- a binding target of at least 27% of renewable energy in the EU
- an energy efficiency increase of at least 27%, to be reviewed by 2020 with the potential to raise the target to 30% by 2030
- the completion of the internal energy market by reaching an electricity interconnection target of 15% between EU countries by 2030, and pushing forward important infrastructure projects [3].

Slovak Republic had joined to common European energy policy. In own program document Slovakia adopted priorities on the field of energy security, efficiency, competitiveness and sustainable development. Regarding the RES, Slovak Republic adopted framework goal to raise the use of RES relatively to gross consumption of energy from 6.7% in 2005 at least on 14% in 2020 [7].

MATERIAL AND METHODS

The main objective of the paper is to show on the possibilities of developing a forecasting model based on underlying non-linear trend for a given variable in time series analysis. For this purpose we decided to use *Brown triple exponential smoothing model* in estimating of the point forecast ex ante, determined in time $t = T$ for time $t + h$ for $h = 1,2, \dots, H$. As a underlying variable we choose an evaluation of the development of the use of the RES in Slovakia compared to the EU-28 average and assessment. Thus we would like to consider if national strategic goals regarding the share of the RES on gross inland energy consumption[1] are achievable till 2020.

The research sample consists time series-data about the share of the RES of gross inland energy consumption in percentage for Slovakia in the respective time period 1990 – 2015, thus $N = 26$. The development of the share of the RES gross inland energy consumption, we compare with the EU-28 average. Furthermore, we make a short-term forecast of the RES share till 2020 in the case of the Slovakia and also for the EU-28 average via using statistical extrapolation methods. The time-series data are obtained from Eurostat.

After consideration of various methods of extrapolation [8], [6] we have opted for *Brown triple exponential smoothing model*. For our research we use the *second order polynomial (quadratic trend).* We use adaptive estimation of the three parameters of local quadratic trends in time t, generally defined:

$$y_t = \beta_0 + \beta_1 t + \frac{1}{2}\beta_2 t^2 + \varepsilon_t \quad (1)$$

Furthermore, triple exponential smoothing is derived from the use of three exponential averages

$$S_t^{(1)} = \alpha y_t + (1-\alpha)S_{t-1} \quad (2)$$

$$S_t^{(2)} = \alpha S_t^{(1)} + (1-\alpha)S_{t-1}^{(2)} \quad (3)$$

$$S_t^{(3)} = \alpha S_t^{(1)} + (1-\alpha)S_{t-1}^{(3)} \quad (4)$$

Each parameter we estimate by use the:

$$\hat{\beta}_{0,t} = 3S_t^{(1)} - 3S_t^{(2)} + S_t^{(3)} \quad (5)$$

$$\hat{\beta}_{1,t} = \frac{\alpha}{2(1-\alpha)^2}\left[(6-5\alpha)S_t^{(1)} - (10-8\alpha)S_t^{(2)} + (4-3\alpha)S_t^{(3)}\right] \quad (6)$$

$$\hat{\beta}_{2,t} = \frac{\alpha^2}{(1-\alpha)^2}\left(S_t^{(1)} - 2S_t^{(2)} + S_t^{(3)}\right) \quad (7)$$

Where $\alpha \in \langle 0; 1 \rangle$ is smoothed constant.

Next we make the point estimation of the forecast ex ante for time $t = T$ on time $t = T + h$ for $h = 1,2, \dots, H$:

$$\hat{y}_{T+h} = \hat{\beta}_{0,T} + h\hat{\beta}_{1,T} + \frac{1}{2}h^2\hat{\beta}_{2,T} \quad (8)$$

Next, the crucial issue to determine the smoothing constant of α. According the literature, under the subjective choice we should apply the rule: if slope parameter of the time series is unstable (higher variability), than $\alpha \to 1$, if the time series is stable (lower variability) we should choose „lower" level of α [8].

Further we should determine the confidence interval for y_{T+h} on [8], [1].

$$\hat{y}_{T+h}(T) \pm z_{1-\frac{\alpha}{2}} * d_h * MAE_T \quad (9)$$

[1] Note: **Gross inland energy consumption**, sometimes abbreviated as **gross inland consumption**, is the total energy demand of a country or region. It represents the quantity of energy necessary to satisfy inland consumption of the geographical entity under consideration

Where $\hat{y}_{T+h}(T) = \hat{\beta}_{0,T} + h\hat{\beta}_{1,T} + \frac{1}{2}h^2\hat{\beta}_{2,T}$ is point estimation in the time $t = T$ for time $t = T + h$; $z_{1-\frac{\alpha}{2}}$ is % quantil of the normal distribution $N(0;1)$, d_h we compute following

$$d_h = 1.25 * \sqrt{\frac{1+\frac{1-\alpha}{(1+\alpha)^3}[(1+4\alpha+5\alpha^2)+2(1-\alpha)(1+3\alpha)h+2(1-\alpha)^2h^2]}{1+\frac{1-\alpha}{(1+\alpha)^3}[(1+4\alpha+5\alpha^2)+2(1-\alpha)(1+3\alpha)+2(1-\alpha)^2]}} \quad (10)$$

$$MAE_T = \sum_{t=1}^{T} \frac{|y_t - \hat{y}_{t-1}(1)|}{T} \quad (11)$$

Where α is smoothed constant.
Finaly we verify the practical convenience of the model via using the Theil decomposition of the mean square error (MSE) as following:

$$MSE = \left(\bar{\hat{y}} - \bar{y}\right)^2 + \left(s_{\hat{y}} - rs_y\right)^2 + (1 - r^2)s_{\hat{y}}^2 \quad (12)$$

For interpretation purpose we divide both sides of the equation of the MSE

$$1 = \frac{\left(\bar{\hat{y}} - \bar{y}\right)^2}{MSE} + \frac{\left(s_{\hat{y}} - rs_y\right)^2}{MSE} + \frac{(1-r^2)s_{\hat{y}}^2}{MSE} = U_m + U_R + U_D \quad (13)$$

where U_m measures the part of the MSE error caused by the distortion of the reality by the model itself. U_R measures part of the MSE error caused by the deviation of population regression function between the values y and $\hat{y}$. U_D is the result of imperfect correlation between the y and $\hat{y}$, thus it is the error with non-systematic nature [8].

For ideal forecasting model it is valid:

$$U_m = 0,\ U_R = 0,\ U_D = 1 \quad (14)$$

RESULTS AND DISCUSSION

For filling the objective of the paper, we opted for Brown triple exponential smoothing model as a main research method. For extrapolation the trend till 2020, we have used second order polynomial.

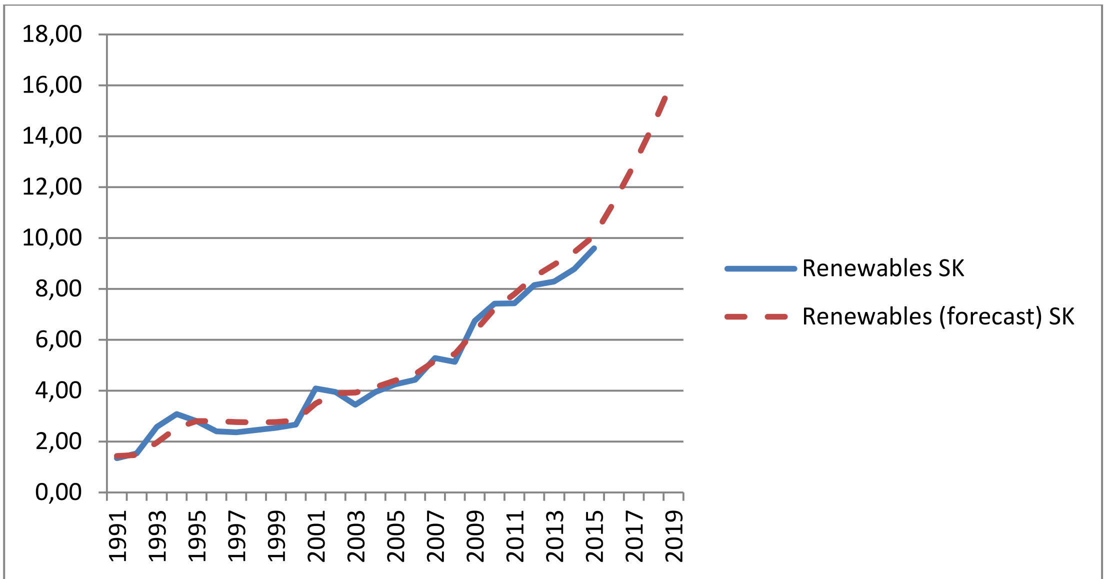

Figure 1 Extrapolation of the trend of the contribution of the RES on gross inland energy consumption in Slovakia in %
Source: Own processing in Excel, based on Eurostat data, 2017

In Figure 1 we can observe the potential development of the RES on gross inland energy consumption till 2020 in Slovakia. We can observe the steady rising trend since 2004 and there are good perspective of achieving national targets. However, the model is able to determine the value of the RES with highest confidence only one period ex ante and we can only try to determine it till 2020 with very low probability.

Table 1 Forecast ex ante for the share of the RES on gross inland energy consumption with 90% confidence interval

Period	Forecast	Lower 90.0% limit	Upper 90.0% Limit
2016	**10.08**	9.36	10.8
2017	**11.41**	10.34	12.47
2018	**12.86**	11.36	14.36
2019	**14.47**	12.49	16.45
2020	**16.25**	13.98	18.53

Source: Author

Table 1 shows forecast ex ante for the contribution of the RES on gross inland energy consumption in % in Slovakia, including 90% confidence interval. According the model the share of the RES should increase and in 2020 might stand around the 16.25% level.

Regarding the Theil decomposition of the mean square error (MSE) we have found out the following results:

$$1 = U_m + U_R + U_D = 0.041 + 0.212 + 0.746$$

Which means that according to the literature source the largest deviation of the model was caused by the non-systematic error, which is positive.The mean absolute percentage error is relatively high, becomes 37%.

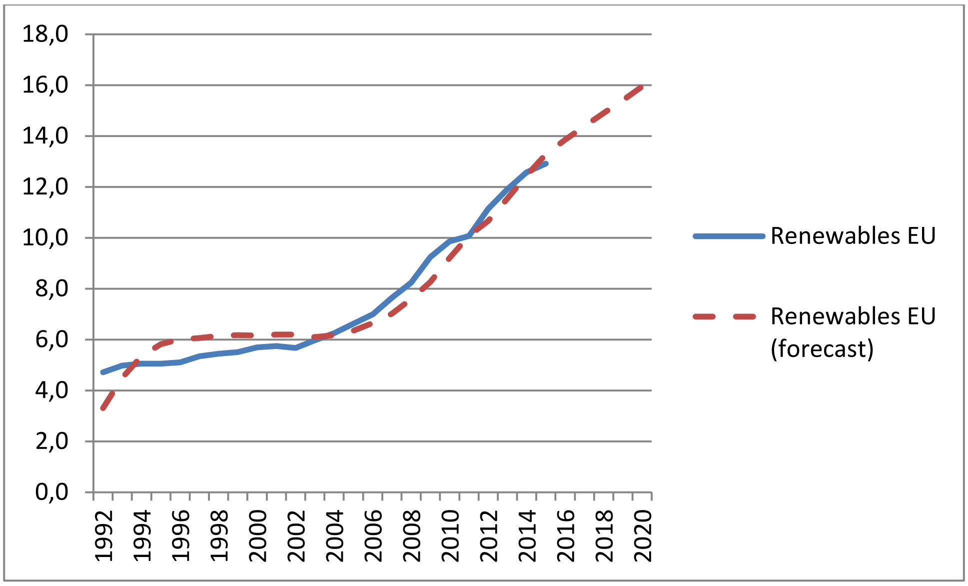

Figure 2 Extrapolation of the trend of the contribution of the RES in gross inland energy consumption in EU-28 in %
Source: Own processing in Excel, based on Eurostat data, 2017

In Figure 2 we can observe the potential development of the RES on gross inland energy consumption till 2020 in EU in average. We can observe the steady rising trend since 2002 and there are good perspective of achieving national targets of the member states, however in EU average it might fail short of expectations according the Strategy 2020. However the same is valid as in previous case, the probability of the "correct" estimation up to 2020 is diminishing.

Regarding the Theil decomposition of the mean square error (MSE) we have found out the following results:

$$1 = U_m + U_R + U_D = 0.006 + 0.016 + 0.977$$

Which means that the deviation of the model was overwhelmingly caused by the non-systematic error. The mean absolute percentage error is relatively low, becomes only 7.2%.

Table 2 Forecast ex ante for the share of the RES on gross inland energy consumption with 90% confidence interval

Period	Forecast	Lower 90.0% limit	Upper 90.0% limit
2016	**13.86**	12.84	14.87
2017	**14.39**	12.96	15.81
2018	**14.90**	13.04	16.76
2019	**15.41**	13.13	17.69
2020	**15.94**	13.08	18.8

Source: Author

Table 2 shows forecast ex ante for the contribution of the RES on gross inland energy consumption in % in EU average, including 90% confidence interval. According the model the share of the RES should increase and in 2020 might stand around the 15.94% level.

CONCLUSIONS

The aim of the paper was to point on use of forecasting model for extrapolating the trend of ex ante based on time series of development of the RES on gross inland energy consumption for the Slovakia and EU. For this purpose we opted to use of Brown triple exponential smoothing model which takes into account seasonal changes as well as trends. For underlying trend we have taken second-order polynomial model. The estimation was based on time series observation between the respective years of 1992 - 2015, with extrapolation of the trend up to 2020.

In despite of limited possibilities of the model to make an accurate prognosis up to 2020 we came to the conclusion, that the Slovakia might fill its national objective to reach 14% share of RES on gross energy consumption till 2020. In case of the EU, according the model in average the EU member states fail short of filling the strategic objective of the EU to reach 20% share of RES on gross energy consumption till 2020.

In the paper we have been dealing only with the prognostic application of the model and thus we have relaxed some assumptions like possible residual autocorrelation, which might be expected. Moreover, the model is capable with some level of the confidence to make prognosis only on such a short time periods ex ante (best $h = 1$). In case of our model for the purpose of making the estimation of the parameters, we have made before the estimation of the observing values $y_{t+n} = 1,2 \dots, n$ based on the average coefficient of the growth of the variable, which might be in real condition unrealistic. However the prognostic applications are always connected with distortion and uncertainty, but have practical value in terms of the planning and adjusting the condition in order to achieve the desired results.

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