Time Series Vector Autoregression Prediction of the Ecological Footprint based on Energy Parameters

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ABSTRACT

Sustainability became the most important component of world development, as countries worldwide fight the battle against the climate change. To understand the effects of climate change, the ecological footprint, along with the biocapacity should be observed. The big part of the ecological footprint, the carbon footprint, is most directly associated with the energy, and specifically fuel sources.

This paper develops a time series vector autoregression prediction model of the ecological footprint based on energy parameters. The objective of the paper is to forecast the EF based solely on energy parameters and determine the relationship between the energy and the EF. The dataset included global yearly observations of the variables for the period 1971-2014. Predictions were generated for every variable that was used in the model for the period 2015-2024.

The results indicate that the ecological footprint of consumption will continue increasing, as well as the primary energy consumption from different sources. However, the energy consumption from coal sources is predicted to have a declining trend.

ACKNOWLEDGMENTS

This research was financially supported by the Mathematical Institute of the Serbian Academy of Sciences and Arts (Project III44006) and through the project of the Ministry of Education, Science and Technological Development of Serbia – TR34023.

INTRODUCTION

There is a clear need to use nature's resources in accordance to their regenerative capacity, and to dispose waste in accordance to the speed of its absorption [1]. In order to do so, the availability of nature's resources and human requirements for natural resources should be estimated, hence the Ecological Footprint (EF) and biocapacity have been introduced. The EF has been developed by Rees and Wackernagel [2,3] and presents "the tool that enables us to estimate the resource consumption and waste assimilation requirements of a defined human population or economy in terms of a corresponding productive land area" [1]. Biocapacity shows the amount of biologically productive land and water area which can be used to provide humanity [4]. Both measures are expressed in global hectares (gha) and are comparable.

The importance of the EF is reflected in the fact that it mainly focuses on the needs of the planet and provides clear approximation of the impact of human demand for natural resources. Natural capital is very much limited and should be carefully and efficiently used, but not abused.

The novelty of this approach is presented in the fact that the forecasting of the EF is based specifically and only on energy parameters. The developed prediction model gives some estimates in terms of future values of observed variables and can help policy makers to create efficient and sustainable decisions.

METHODOLOGY

The dataset used in this research was obtained from several sources [5,6,7] and involves global yearly data for the period 1971-2014. One dependent variable and eight independent variables were analyzed. The dependent variable represents the total EF of consumption, while the independent variables represent the primary energy consumption from different sources, in particular: natural gas, coal, oil, nuclear, hydroelectric, wind, solar photovoltaic (PV), and other renewable sources. The dependent variable, the total EF of consumption, is expressed in gha, while all independent variables are expressed in terawatt-hours. All analyses and modellings were performed using R programming language. In the data preprocessing phase, each variable was separately log transformed. After fitting the model and generating predictions, an inverse log transformation was performed in order to generate real-value predictions. The following step involved creating and fitting the Vector Autoregression model (VAR). The optimal number of lags was estimated based on the Akaike Information Criterion (AIC), and a value of 2 lags was used for creating the model. After fitting the model, predictions were generated for the period 2015-2024.

RESULTS

After fitting the VAR model and generating predictions, the obtained values were inverse log-transformed and the prediction trend for each variable is shown in Fig. 1.

The predictions indicate that the amount of primary energy consumption from gas, hydroelectric, oil, nuclear, and wind sources will have an increasing trend in the upcoming years.

These predictions support previous findings by other authors, such as the use of oil as an energy source which is predicted to increase in the future [8,9,10]. Moreover, from Fig. 1, it is observable that the amount of primary energy consumption from coal sources will decrease in the following years, supporting the findings in [8,9,10]. The use of energy from solar PV sources, and from other renewable sources will increase by the year of 2023, after which it will have a more stable trend. Lastly, considering the total EF of consumption is predicted to increase until 2019, when a slow decrease occurs.

The obtained findings indicate a strong relationship between the energy and the ecological footprint, as with the decrease of fossil fuel consumption, the EF also decreases.

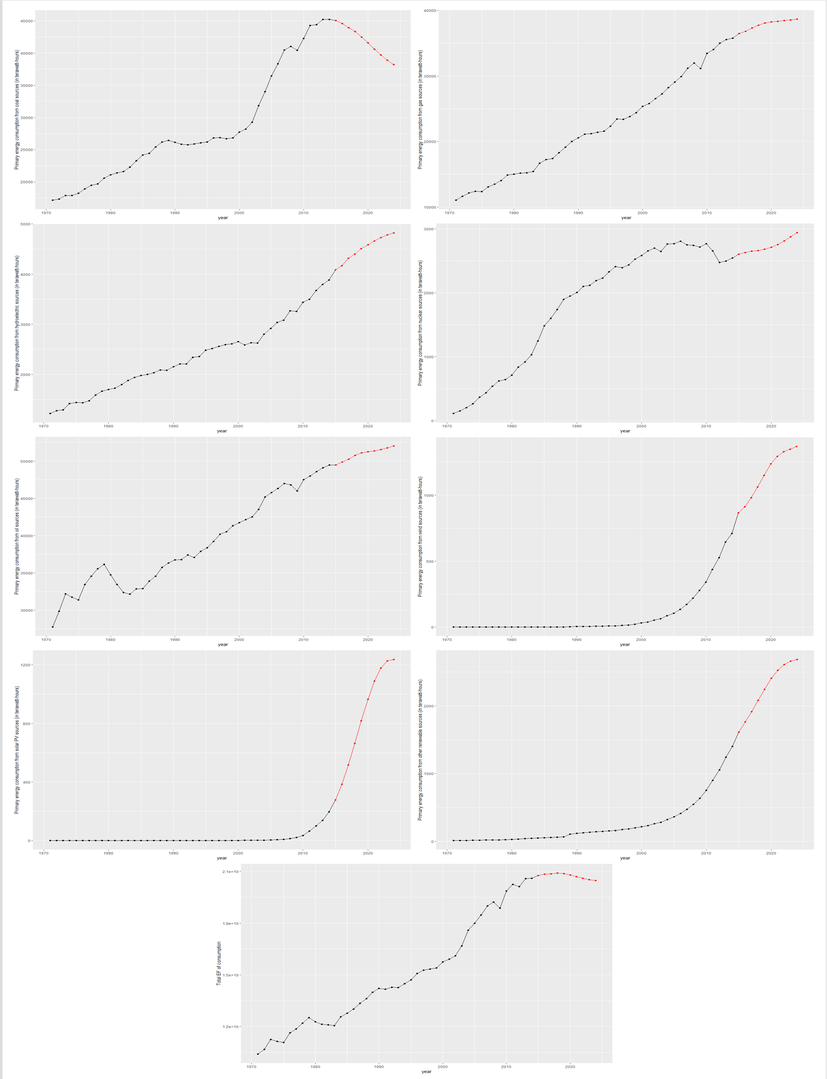

Fig. 1. Predictions by the VAR model.

CONCLUSIONS

This paper analyzed the relationship between the total EF of consumption and the primary energy consumption from coal, hydroelectric, nuclear, oil, natural gas, wind, solar PV, and other renewable sources. The objective of the paper was to create a forecasting model for the EF prediction based only on energy parameters. The prediction model was developed using vector autoregression, where the values of each of the variables were predicted for the period 2015-2024.

The prediction model suggests that the global EF will maintain an increasing trend until 2020, when it slowly starts to decline. Energy sources will maintain a high level of use in the future, with exception of the coal. Based on the predictions, global primary energy consumption from coal sources will decrease until 2024. As coal produces the highest concentrations of carbon dioxide, such predictions are positive.

As more countries set sustainable goals and work towards accomplishing them, further action is still needed. Natural capital should be appropriated on a rational level, considering its boundaries. In terms of energy, the carbon footprint should be of special importance as it considers the effects of each phase of the life cycle of fuel on the environment.

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