Physica A 465 (2017) 217–220

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

Soft computing prediction of economic growth based in science and technology factors

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HIGHLIGHTS

- The estimation of the gross domestic product (GDP) growth rate.
- Economic growth basis on combination of different factors.
- The accuracy of the extreme learning machine (ELM).

ARTICLE INFO

Article history:
Received 27 July 2016
Received in revised form 9 August 2016
Available online 22 August 2016

Keywords:
Soft computing
GDP
Prediction
Science and technology factor

ABSTRACT

The purpose of this research is to develop and apply the Extreme Learning Machine (ELM) to forecast the gross domestic product (GDP) growth rate. In this study the GDP growth was analyzed based on ten science and technology factors. These factors were: research and development (R&D) expenditure in GDP, scientific and technical journal articles, patent applications for nonresidents, patent applications for residents, trademark applications for nonresidents, trademark applications for residents, total trademark applications, researchers in R&D, technicians in R&D and high-technology exports. The ELM results were compared with genetic programming (GP), artificial neural network (ANN) and fuzzy logic results. Based upon simulation results, it is demonstrated that ELM has better forecasting capability for the GDP growth rate

1. Introduction

Gross Domestic Product (GDP) is the main feature for economic growth. GDP prediction could be challenging task because of uncertain factors. More advances in prediction technique for GDP are needed. In order to reduce wasting many decisions want to know in advance what will be system behavior in economic aspect. In other words investors require to know future technology success. There were several approaches so far for the GDP modeling and forecasting [1]. More complexity has positive impact on economic growth [2]. Article [3] was shown that the artificial neural network (ANN) can produce better results for economic growth forecasting than other methods. There is positive correlation between the forecasters' number and the forecast accuracy [4]. GDP prediction accuracy can improve by expansion in information domain [5,6]. The growth of GDP was considered as a process to describe the logistic-growth equation [7].

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http://dx.doi.org/10.1016/j.physa.2016.08.034
0378-4371/

Table 1
GDP parameters.

Parameter 1	Expenditure in research and development (R&D)
Parameter 2	Articles in scientific and technical journal
Parameter 3	Nonresidents patent applications
Parameter 4	Residents patent applications
Parameter 5	Nonresidents trademark applications
Parameter 6	Residents trademark applications
Parameter 7	Total trademark applications
Parameter 8	Researchers in research and development (R&D)
Parameter 9	Technicians in research and development (R&D)
Parameter 10	Exports in high technology
Output	GDP growth rate

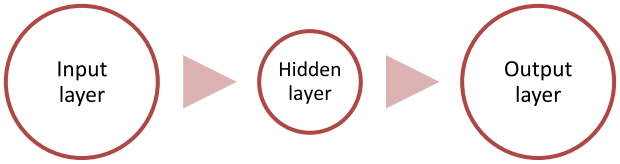

Fig. 1. The main structure of the network for ELM algorithm.

Decisions in any technology investments are influenced by different factors such as human resources, finance investment etc. Prediction of the investment benefits in new technologies is very important in order to reduce resource wasting. The success of the new technologies forecasting is crucial for decision makers. The investors require to know future technology success in order to make investments decision. Patent applications can be used as indicator for prediction of success of technology. Patents and innovations can influence GDP growth rate also.

Even though a number of new mathematical functions have been proposed for modeling of the GDP growth analysis [8–10], in this investigation extreme learning machine (ELM) [11,12] was used for GDP growth rate prediction based on science and technology factors The objective was to analyze the economic growth forecasting based on the research and development (R&D) expenditure in GDP, scientific and technical journal articles, patent applications for nonresidents, patent applications for residents, trademark applications for nonresidents, trademark applications for residents, total trademark applications, researchers in R&D, technicians in R&D and high-technology exports. ELM is capable to solve problems caused by gradient descent based algorithms and to decrease required time for training. ELM has been widely applied for the estimation in many different fields so far [13–16].

2. Methodology

2.1. Database

In this investigation ten science and technology parameters were used as the inputs for the GDP prediction. The data were from 28 countries in the European Union. Table 1 shows all input parameters which were used in this study.

2.2. Extreme learning machine

Extreme Learning Machine (ELM) was developed as a learning algorithm for artificial neural networks (ANN) [13–16]. This approach has advantages as compared with conventional learning algorithms. The main advantage of the ELM methodology is fast training time.

ELM algorithm could be applied only on single hidden layer feed forward networks (SLFNs). This network has three layers as is shown in Fig. 1. There are three layers in the network. Input layer acquires input parameters and sends it to the hidden layer. The hidden layer has hidden nodes and activation function. There are weight vectors between hidden layer and output layer.

Predictive accuracy of the proposed model was assessed using following criteria: the root means square error (RMSE), coefficient of determination (R^2) and Pearson coefficient (r).

3. Results

Fig. 2 shows GDP prediction accuracy results with ELM methodology and also other soft computing methods as comparison. Elm method outperforms ANN [17] and GP [18], fuzzy [19] methods according to the coefficient of determination. In order to demonstrate the merits of the proposed model on a more tangible basis, four models' prediction accuracy was