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A Neuro-Genetic Model in GDP Forecasting: Case Study Albania

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Abstract. The aim of this paper is to design a neural network model trained with genetic algorithms, called 'neuro-genetic' model, and to use it in Gross Domestic Product (GDP) forecasting. GDP is an economic indicator that represents the value at market prices of all goods and services produced within a country in a given period (usually a year). Its forecasting is of particular importance for the fiscal and monetary policy makers in the preparation of timetables aiming macroeconomic stability and sustainable economic growth. We use ten factors that affect the determination of the GDP for the Albania's GDP forecasting. The genetic algorithm is used to train the weights of different architecture MLPs. We compare the output of these neural networks (NN) and find the best NN architecture which archives the high accuracy for GDP forecasting.

Keywords: artificial neural networks, genetic algorithm, forecasting, GDP

1 Introduction

In aggregate term, the main measuring instrument used to measure a country's economic activity is Gross Domestic Product (GDP) [1]. GDP is an economic indicator that represents the value at market prices of all goods and services produced within a country in a given period (usually a year).
Its forecasting is of particular importance for the fiscal and monetary policy makers in the preparation of timetables aiming at macroeconomic stability and sustainable economic growth.
The quarterly GDP data are important for economic analysis, because it gives insight on the general economic activity, on the fluctuations of business cycle and on the economic turning points. The quarterly GDP is published by the national statistics agencies with different time lags after the reporting quarter. The progress of information systems in terms of quarterly GDP measurement process, aims to narrow them. Notwithstanding the developments in this field, the availability of preliminary estimations of GDP, even in short terms is a necessity for the decision-making process [2]
Several studies use neural network models in forecasting GDP but there is no article that tries to predict Albanian GDP with neural networks. The approach that has been widely used to predict GDP is a regression analysis.
(Çeliku, Kristo and Boka) (2009) in the discussion paper treats several models to forecast quarterly GDP in Albania. They consist on ARIMA models with seasonal components and indicator models, similar to bridge models. This paper presents a first attempt to model the GDP using a multi equations system which accounts for the sectional interactions. This model cannot be used for forecasting purposes because of short time series. [2]
Giovanis (2009) in his paper is using the ARIMA and ANN to predict the rate of economic growth in the USA. This study examines the estimation and forecasting performance of ARIMA models in comparison with some of the most popular and common models of neural networks. The results of this study indicate that neural networks models outperform the ARIMA forecasting.
Tkacz and Hu (1999) studied forecasting GDP of Canada. The result of this study is that the best neural network models outperform the best linear models by between 15 and 19 per cent at this horizon, implying that neural network models can be exploited for noticeable gains in forecast accuracy.

Due to the difficulties encountered in modeling the quarterly GDP and the fact that ANN has proven to be an efficient tool for non-parametric model data in the form of non-linear function; we aim to develop a forecasting model of Albanian Gross Domestic Product with artificial neural network approach.

The advantage of artificial neural network approach is that this model can capture the relationship of nonlinear data, especially if the economy is very volatile, and it is superior when forecasting chaotic data. [1]
In ANN models, one has to make two choices when specifying the model: the number of input and hidden neurons, and the number of hidden layers. The underlying economic theory or statistical features of the data can determine the number of input neurons, and certain formulas or trial and error can specify the number of hidden layer neurons. As for the number of hidden layers, although the complexity of the models can increase by introducing extra layers, in most economic applications only one layer has proven sufficient, reducing the number of choices the modeler should make.
Many economic applications of the ANN models use the feed forward ANN model with back propagation learning algorithm. However, the performance of back propagation ANN can be improved, when a better learning algorithm is applied. In this paper, we forecast the GDP using ANN model equipped with Genetic Algorithm.
Genetic Algorithm is an optimization algorithm adapted for genetic science and can be used for learning algorithm in the ANN model instead of the traditional gradient descent.
The rest of the paper is organized as follows. Section 2 presents a brief description of the ANN and GA. Section 3 explains the details of the model and the data that are used. Section 4 explains the results of the neuro-genetic model and finally, Section 5 presents our conclusions.

2 The Neuro-Genetic Theoretical Framework

The ANN models are adaptive nonlinear models based on a natural neuron system. A network of neurons is designed in three layers: input, hidden and output layer with adjustable weights connecting them. The network reads the inputs, and then produces the output through a learning algorithm. The process is repeated and the weights are adjusted until the desired level of accuracy is reached.
The most common structure for neural networks is: three layers with full interconnection as shown in Fig. 1.

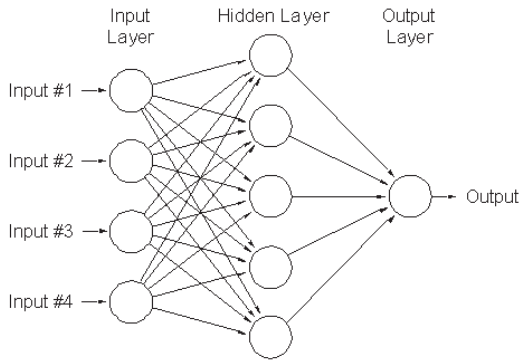

Fig. 2 MLP architecture

There are two kind of learning algorithms: gradient descending method and global search method. While back propagation is classified as gradient descending method, GA is considered as a global search method.
The learning process in an ANN model can take time and may fall in a trap such as local minima, particularly when there are multiple parameters. To avoid such problems, one can use the GA algorithm in the learning process of the ANN instead of the gradient descending method.
A genetic algorithm applies the biological principles of natural evolution in the artificial systems. A genetic algorithm is an iterative procedure that includes a population of individuals, each of them represented by a finite string of symbols, known as genes that encode a possible solution in the space

of a given problem. This space we refer to as the searching space includes all the possible solutions of the respective problem and GA finds the best solution based on the criteria given to the model.
According to Holland (1975) a typical GA uses three genetic operators: crossover, mutation and selection.
In the ANN training, the GA starts with a large population of vectors, called individuals, generated randomly. Each individual of the population represents a possible solution of the problem that is being analyzed. The individuals are selected to create new individuals (offspring) based on some selection criteria such as their fitness – the more adequate (fitting) they are the more the chances they have for reproduction, and through the genetic operators mentioned above it searches for the improved solutions. GA works as shown in the Fig. 2.

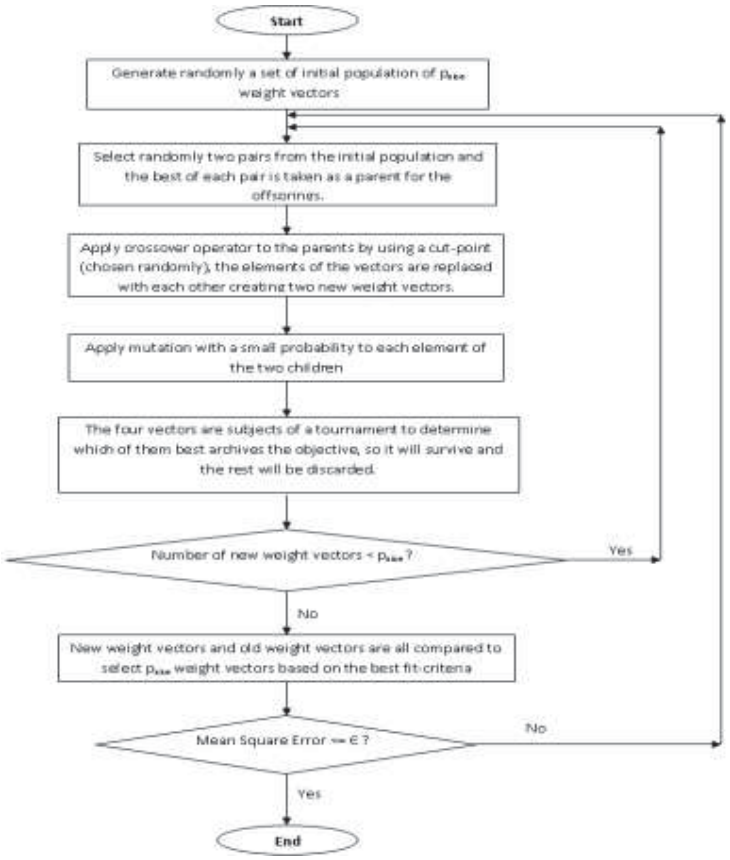

Fig. 3 Training *ANN* with *AG*

3 Model Details

In this section we introduce the model's details, organizing them in three subsections. The first one with respect to the architecture and the activation function; the second with respect to the GA, the parameters and the specifications for the network training and the third and last one with respect to input definition and the data used.

3.1 Neural Network

The neural network architecture used in this paper is shown in Figure 3.

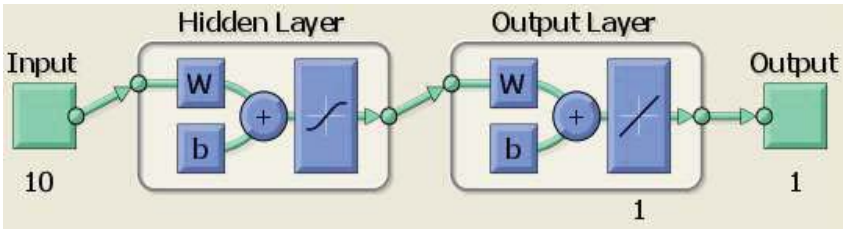

Fig. 4 Neural Network architecture used in this paper

The input layer has 10 neurons as many as the number of variables used to forecast the GDP. These variables will be explained in more details in Section 3.3. As for the hidden layer we tested with different number of neurons. The best architecture, the one that we are presenting in this paper, is designed with 20 neurons in the hidden layer. The output layer has one neuron that corresponds to the GDP growth.
The output of each neuron is a transformation of the input data achieved by an activation function. The neural network node in Aforge.Net framework that we use, offers different activation functions. We use bipolar sigmoid function that has the following form shown in formula (1):

$$f(x) = \frac{2}{1 + \exp(-\alpha * x)} - 1 \qquad (1)$$

We tested the model with different α values, and found that the best value in this case is α=1.

3.2 Genetic Algorithm Parameters and Specifications

The main parameters of the GA were set as:

- Genetic population Size = 100
- Crossover probability in genetic population = 0.7
- Mutation probability in genetic population= 0.3
- Probability to add newly generated chromosome to population = 0.25

3.3 Input definition

The accuracy of GDP forecasting with ANN depends on the selection of the variables to include as input to the network.
In this selection process we were based on the paper of Celiku et al. to use the variables judging their potential economic correlations with the quarterly real growth of GDP.
After different analysis they concluded that the variables that mostly affect the quarterly GDP forecast are divided in these categories:

a. Economic variables
   - Government expenditures, data provided by the Ministry of Finance.
   - Construction permissions for residential and business purposes, in value data provided by INSTAT.
   - Cement consumption, data provided by the INSTAT.
   - Unit value index for total imports, data provided by the INSTAT.

b. Financial variables
   - Interest rate on loans denominated in EURO, data provided by the Bank of Albania;

c. Variables from surveys

Variables from surveys are based on indicators constructed from qualitative surveys developed by the Bank of Albania with businesses and consumers.

- ESI (Alb. TNE), the Economic Sentiment Indicator aggregates in a single indicator the opinions of the main market agents. They are collected from the confidence surveys for the industry, construction and services sector and for the consumers.
- EI (Alb.TE) the survey indicator for the economy
- II (Alb.TI) the survey indicator for industry sector
- CI (Alb.TN) the survey indicator for construction sector
- SI (Alb.TSH) the survey indicator for services sector

In this paper we use all these economic and financial variables combined with surveys' variables. The data used to forecast GDP are quarterly data from January 2005 till June 2013. These data was stored in a .csv file and served as input to the neural network model.

4 Results

The network managed to achieve the expected MSE after 90 thousand epochs. 80% of the data was used to train the neural network, 15% of the data to validate and 5% of the data to test the neural network accuracy. We wanted to compare the results of research with ANN modeling with the prediction made by the government, but couldn't find anything available online.
The data for the real GDP growth and the predicted GDP growth are shown in Table1.

Table 3 Comparative data

Time	Real GDP growth (%)	Neuro-Genetic's GDP growth (%)
2005T1	4,347	4,235
2005T2	8,425	8,444
2005T3	6,266	5,958
2005T4	2,863	2,867
2006T1	7,793	7,794
2006T2	1,419	1,426
2006T3	3,765	3,764
2006T4	8,049	8,444
2007T1	5,704	5,694
2007T2	4,497	4,235
2007T3	4,222	4,027
2007T4	6,793	7,133
2008T1	11,371	10,857
2008T2	8,667	8,273
2008T3	8,967	8,444
2008T4	2,256	2,284
2009T1	4,468	4,467
2009T2	7,677	7,133
2009T3	3,473	4,235
2009T4	-1,485	-0,930
2010T1	1,269	1,268

2010T2	1,984	1,976
2010T3	3,148	3,157
2010T4	5,653	5,958
2011T1	5,625	5,636
2011T2	0,891	1,130
2011T3	2,893	3,201
2011T4	2,293	2,284
2012T1	-0,241	0,105
2012T2	2,126	2,126
2012T3	2,696	2,533
2012T4	0,100	0,103
2013T1	0,700	0,740
2013T2	1,1	0,840

We compare the results of neuro-genetic model with the real GDP growth, as shown in Fig. 4.

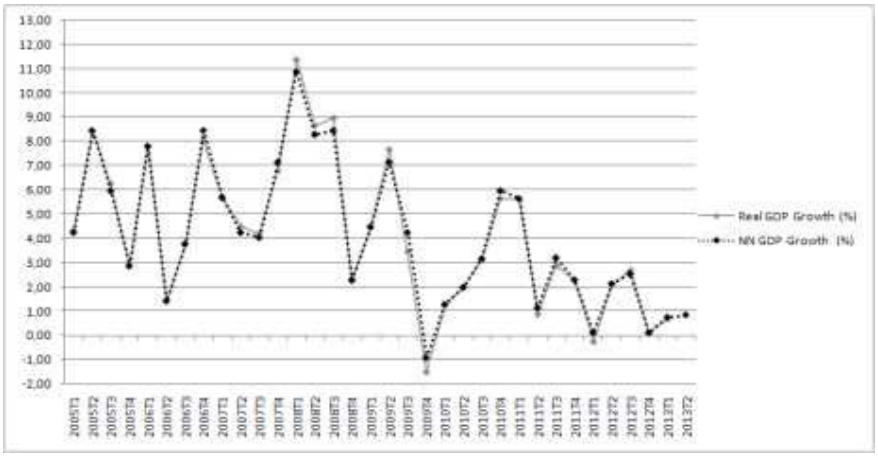

Fig. 5 Comparing *Real GDP* growth with *NN's GDP* growth

This validation process shows the neuro-genetic model is generating value which approximates the value of real GDP growth with measures of forecasting accuracy as shown in Table 2

Table 4 Measures of forecasting accuracy

Measures	Values
MFE (Mean Forecasting Error)	-0,010
MAD (Mean Absolute Error)	0,195
TS (Tracking Signal)	-1,681
MSE (Mean Square Error)	0,084

5 Conclusion

In general, ANN models require large amounts of data. For the case of forecasting GDP growth in Albania, the biggest inhibitor is the lack of sufficient data. This encompasses availability of data, its consistency and the data time span. The neuro-genetic forecasted GDP growth in this study resulted with a MSE equal to 0.084. The model tends to slightly over-forecast, with an average absolute error of

0.195 units. As long as the tracking signal (TS) is between –4 and 4, in our model TS is equal to -1.681, we can say that the model is working correctly.
Our model predicts that the GDP growth for the second quarter of 2013 is 0.84%, but this official GDP growth will be published by INSTAT in October 2013The Lecture Notes in Computer Science volumes are sent to ISI for inclusion in their Science Citation Index Expanded.

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