NEURAL NETWORKS-BASED FORECASTING REGARDING THE CONVERGENCE PROCESS OF CEE COUNTRIES TO THE EUROZONE

Magdalena RĂDULESCU
Logica BANICA

Magdalena RĂDULESCU
Associate Professor, Department of Finance, Faculty of Economics, University of Pitești, Pitești, Romania
Tel.: 0040-740-093.011
E-mail: magdalena.radulescu@upit.ro

Logica BANICA
Associate Professor, Department of Accounting, Faculty of Economics, University of Pitești, Pitești, Romania
Tel.: 0040-745-227.774
E-mail: olga.banica@upit.ro

Abstract

In the crisis frame, many forecasts failed to provide well determined ratios. What we tried to explain in this paper is how some selected Central and Eastern European countries will perform in the near future: Romania, Bulgaria, Hungary, Poland and Czech Republic, using neural networks-based forecasting model which we created for the nominal and real convergence ratios.

As a methodology, we propose the forecasting based on artificial neural network (ANN), using the well-known software tool GMDH Shell. For each output variable, we obtain a forecast model, according to previous values and other input related variables, and we applied the model to all countries.

Our forecasts are much closer to the partial results of 2013 in the analyzed countries than the European Commission's or other international organizations' forecasts. The results of the forecast are important both for governments to design their financial strategies and for the investors in these selected countries. According to our results, the Czech Republic seems to be closer to achieve its nominal convergence in the next two years, but it faces great difficulties in the real convergence area, because it did not overpass the recession.

Keywords: nominal convergence, real convergence, euro-zone, Central and Eastern European Countries, forecasting model, neural networks.

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1. Introduction

Relatively less empirical work has been done on the whole convergence process in the non-member states of the European Monetary Union (EMU). Data limitations pose a significant problem in many Central and Eastern European Countries (CEE) and there were a few yearly observations for these countries after 1990. There were also some problems with the stationary of the time-series in some of the CEE countries. Many time-series display stationary features only after 2000. Most of the empiric studies were conducted for EMU member states.

After the failure of the predictions for the economic crisis of 2008-2009, one of the major goals for scientific researchers became the evaluation of the variables with the highest impact that influence the economic evolution and finding the methods to minimize the risks and reduce the insecurity that rule the business, social and political world in these days.

At macroeconomic level, the forecasting should not remain just an analysis tool, but it is essential to become a strategic tool for the national governments, which would offer them valuable insights in real time, information that could be further used for the correction of certain impact factors.

The construction of solid forecasting models could be achieved after many years of observation, registration and tests on different input variables, and after establishing the importance of each of them in the defined strategy. Then, the resulting prediction set is evaluated in time (at least two semester or year periods) by comparing the results given by the forecasting with the ones from the real economy.

Wieland *et al.* (2012, pp. 523-541) proposed a comparative approach to macroeconomic policy analysis – we have developed a database of macroeconomic modeling. On this subject, the president of the European Central Bank, Jean-Claude Trichet, in 2010, stated straightforwardly and clearly that 'we need macroeconomic and financial models to discipline and structure our judgmental analysis' (Wieland *et al*., 2012, p. 524).

Also, another important idea is the need for various models, grouped in databases, and their validation with the economic reality, not restricted to a single, imposed model:

> 'The key lesson I would draw from our experience is the danger of relying on a single tool, methodology or paradigm. Policymakers need to have input from various theoretical perspectives and from a range of empirical approaches. Open debate and a diversity of views must be cultivated – admittedly not always an easy task in an institution such as a central bank' (Wieland *et al*., 2012, p. 524).

Such a database may include well-known macroeconomic models that could be used to analyze and forecast the evolution of Euro-zone economies, in order to establish the appropriate European country model for its economic strategy.

In this paper we focused on the approach of forecasting the macroeconomic level of five countries from the European Union: Czech Republic, Poland, Hungary, Romania and Bulgaria, paying attention to the importance of prediction in decision making

for current normalization and taking into account the interest of potential investors regarding the economic results of these countries. Also, we have observed the evolution of the main macroeconomic indicators of these countries by comparing them with those for the whole euro-zone.

We consider that such a study could help both the country governments involved and the potential investors. For the governments, it is important to have a scientific vision of the economic future, in order to create the macroeconomic strategies. Regarding the investors, the forecast values of macroeconomic indicators could determine if the strategy to invest in the business market for one specific country is worth the effort or not.

From the point of view of the investors, the priority consists in obtaining reliable information concerning the evolution of the macro-indicators of Czech Republic, Poland, Hungary, Romania and Bulgaria during 2000-2012, in the context of the European Union integration and the future monetary integration and convergence with highly-developed countries.

The analysis of the key macroeconomic indicators and the forecasting of their values for 2013-2014, using GMDH Shell software, offered a consistent overview of their evolution.

What we tried to explain in this paper is how will perform in the near future some selected CEE countries: Romania, Bulgaria, Hungary, Poland and Czech Republic, based on some important progresses both in the nominal and in the real convergence area. They are very different both in the financial performance area and in the real economy area. They also belong to different waves of EU accession. Romania and Bulgaria acceded to EU in 2007 while the last three acceded in 2004. Poland and Romania are the largest countries in the area, but they performed very differently.

The high probability of asymmetric shocks is unlikely to be compensated by labor market flexibility and by the gains from additional trade. This explains the position of the Deutsche Bundesbank which has suggested a later date for accession because of the considerable structural divergence between the present Euro-area and the new member states.

As a result of the Greece's situation, European Monetary Union is reluctant in getting new members. That is why a few countries will be probably selected from now on to become euro member states and only after a close analysis of their nominal and real convergence criteria. The main question posed here is when and how CEE countries will proceed in the final stage of their monetary integration?

Section 2 presents a literature review regarding studies drafted in the nominal and in the real convergence areas and the studies that used neural networks based forecasts; section 3 is discussing the situation of the CEE analyzed countries in the nominal and real convergence area and the prognosis of the European Commission for these countries in the following years; section 4 presents the methodology we used for forecasting; and section 5 presents our estimated results and discussions and section 6 concludes the paper.

2. Literature review

Apart from the ambition of meeting the Maastricht criteria in a sustainable way, the aim of the macroeconomic policies in the non-member states is to increase their real convergence towards the more advanced EU economies and to improve their adaptive mechanisms. This is not only in the interest of their smooth accession, but also in the interest of the successful future operation of the Euro-area (Sikulova, 2007, pp. 752-768).

According to Bolle and Jacobsen (2001, pp. 298-305), a revision of the criteria could help minimize risks arising during Euro-area enlargement and would enable the non-member states to cope adequately with special needs of their economies. Kenen and Meade (2003, pp. 1-19) point out that when evaluating convergence progress of the non-member states, equal treatment should not mean identical treatment but equivalent treatment, taking into account the changes brought about by the creation of the monetary union and the situation of the non-member states, which is different from that of the old Member States due to the catching-up process.

Even the European Economic Advisory Group (EEAG, 2007, pp. 73-81) proposed a lower inflation rate criterion to be applied at the EMU accession of the non-member states; and the International Monetary Fund (IMF) argues that meeting the inflation criterion depends much on its interpretation (Schadler *et al*., 2005, pp. 1-22). Some economists even argue for the delay of euro adoption, while a strong trend of real appreciation in the candidate countries remains (Tullio, 1999, pp. 63-104).

Whether monetary policy making will be easier within the enlarged monetary union is still unknown. The divergence of inflation rates will continue to grow and the economic and political weight of the periphery will increase. Low real interest rates at the periphery may increase the risk of overheating and thereby increase the need for fiscal flexibility and structural reforms. These will be new challenges of the enlarged monetary union (De Grauwe and Schnabl, 2005, pp. 537-555). But some studies obtained some results that are suggestive of convergence in inflation but not of interest rates (Siklos, 2010, pp. 507-515). Interest rates in many CEE countries were higher than in the Euro-zone in the entire period after 1990.

Not all the economists considered all Maastricht criteria necessary for accession to the Euro-zone. Buiter (2004a, pp. 146-185) underplays the role of inflation and interest convergence, and of exchange rate management (within the ERM-II in the case of the transition countries aiming to join the euro club): such nominal targets are, according to him, too many and inconsistent; just fiscal sustainability is a decisive requirement.

Buiter and Grafe (2002, pp. 111-142) argue that the exchange rate criterion can be satisfied without the candidate country being an ERM II member. Italy and Finland (and later Greece) joined EMU right from the start, even though they had not spent two years in the ERM when they were admitted. Buiter (2004b, pp. 1-47) warned very recently that the simultaneous pursuit of three nominal targets (nominal exchange rate, inflation target and nominal interest rate target) greatly enhances the likelihood

that a 'major financial accident' will happen. Even talented central banks have their hands full pursuing just one nominal objective (Buiter and Sibert, 2006, pp. 1-12).

Moreover, a higher productivity in the CEE countries will lead to higher inflation rates than in the Euro-zone. So, the author believes that the nominal criteria should be redesigned, because exchange rate stability and prices stability are incompatible. Szapary (2000, pp. 1-10) suggests 'a waiver' or 'derogation' from the inflation criterion for countries with a strong Balassa-Samuelson effect (Poland, Hungary), but these renegotiations or derogations are not allowed by the Maastricht Treaty (the Balassa-Samuelson effect depends on inter-country differences in the relative productivity of the tradable and non-tradable sectors that cause a higher inflation in the countries with a higher productivity).

Some new small EMU member states, such as Slovenia, Malta, Cyprus and Estonia have participated to some narrow ERM II arrangements. Lithuania and Latvia also opted for narrow ERM II. This was supported by strong investments. Nominal appreciation within the large +/-15% ERM2 corridor seems the better choice to reconcile nominal and real convergence (Ireland and Greece cases), but there are countries that have decided to adopt hard pegs to the euro. But some large CEE countries such as Poland, Czech Republic, Hungary and Romania preferred to choose an inflation targeting regime and Bulgaria opted for a Monetary Council. A Monetary Council is perceived as being the best commitment to price stability, exchange rate stability and even fiscal stability. But, a currency board runs the risk of a real misalignment. If a country's inflation remains higher than that of the pegging country, the currency can become overvalued (Pautola and Backé, 1998, pp. 72-113). A real appreciation of the domestic currency could appear in the context of the Balassa-Samuelson effect and the increase of the productivity in these countries and this will affect the competitiveness. But a real appreciation is necessary for some CEE countries prior to their entry into the Euro-zone, because otherwise there will be necessary very tight fiscal constraints. Buiter (2004a, pp. 146-185) considered that a floating exchange rate regime would be more appropriate for the CEE countries in the pre-accession period and he urged for a rapid accession to the Euro-zone, with no ERM II period.

The lagging EU countries, with particular reference to the new EU members, characterized by lower per-capita income levels and consequent strong catching-up processes, will inescapably have – in the transition to EMU and in the first period of euro adoption – higher inflation rates (because of productivity differences between sectors and high inflation in the non-tradable sector, so called Balassa-Samuelson effect) (Marelli and Signorelli, 2010, pp. 140-155). But the Balassa-Samuelson effects are not the same among CEE countries. Égert (2002a, pp. 1-16; 2002b, pp. 273-309) finds little evidence of a higher inflation rate due to the Balassa-Samuelson effect in the Czech Republic, but there are extremely high inflation differentials implied by sector productivity developments and labor shares for Hungary and Poland as reported by Backé *et al.* (2002, pp. 1-61).

According to De Grauwe and Schanbl (2005, pp. 537-555), who emphasize the conflict between nominal and real convergence during the run-up to EMU, the required real appreciation could be achieved by a nominal appreciation of the exchange rate, thus discarding the condition about stability of exchange rates.

Concerning the New Members, they generally had more difficulties in respecting nominal conditions, but have shown a widespread catching-up – in terms of productivity and per-capita GDP – towards the average EU levels; they are also well integrated, in terms of trade links, with Western Countries (Marelli and Signorelli, 2010, pp. 140-155). Their problems consist in the labor market, especially in some high unemployment rates in some CEE countries (Bulgaria), because of the current recession. The current economic crisis is a challenge for both nominal and real convergence of all European countries (new and old). We could also mention here that after EMU accession, many member states relax their economic conditions and they do not actually fulfill the nominal convergence criteria.

The next issue results from the fact that the non-member states are still experiencing the catching-up process. Countries with a relatively low economic level usually have also low price and wage levels in comparison to the more advanced EU economies. The catching-up process is accompanied by an increase in price levels. High wage, backed by high productivity increases, is also getting in conflict with the inflation criterion (Sikulova, 2007, pp. 752-768). So, optimal timing of entry into the Euro-area based on a complex assessment of a country's readiness is a significant prerequisite for its sound economic development during the membership.

Rossi (2004, pp. 443-469) finds that for present Euro-area countries the process of real convergence has been rather slow both before and after their entry in the monetary union and that this conclusion might apply to acceding countries as well. So, the nominal convergence should imply some real divergence among the non-member states.

Concluding this part, the opinions are very different as far as the nominal and real convergence is concerned. That is why we tried to see how these selected CEE countries will perform in the near future in the nominal and real convergence area. Could those two targets be reached in the same time? What are the costs of obtaining nominal convergence for the real economy? For forecasting the nominal and real convergence ratios in these CEE countries we used a neural networks based model.

According to Khashei and Bijari (2010, pp. 479-485), 'artificial neural networks (ANNs) are one of the most accurate and widely used forecasting models that have enjoyed fruitful applications in forecasting social, economic, engineering, foreign exchange, stock problems'. Neural networks are a branch of Artificial Intelligence (AI) domain, a powerful tool applied for correctly predicting and also, for decision processes in which data connections have to be learned and modeled. Briefly, a neural network is a parameterized non-linear function that can be trained to predict the future values of a variable, by knowing large amounts of historical data, accessing

sources and volumes of collected data, selecting the set of variables that obviously have an influence of the chosen predictive model.

As a consequence, the ANNs were frequently used to forecast the macroeconomic indicators and in literature we find many examples:

- In 2005, Emi Nakamura (2005, pp. 1-10), from Harvard University developed a model of applying neural network for inflation forecasting, using a test set from 1978 until 2002. His study ended with a positive conclusion regarding the short-term inflation forecasting based on ANN.
- Another interesting paper refers to the forecast of Turkey's eight important macroeconomic indicators such as: gross domestic product, inflation (average consumer prices), total investment, unemployment rate (Onder and Bayir, 2013, pp. 73-104).
- A very complex approach comes from Massimliano Marcellino (2002), who starts from the idea of having several competing forecasts for the same variable, which can be combined to obtain a pooled forecast. He compared the relative performance of alternative pooling methods, using very large macroeconomic variables (about 500) for the Euro-area. The author concluded that the ANN model is useful in macroeconomic forecasting, giving the best performance for the macroeconomic variables.
- A study by Samimi and Darabi (2011, pp. 274-278) demonstrates the effects of ANNs models for forecasting government's size in Iran. They used a large set of variables including tax income, population number, government expenditure, GDP and GDP per capita from 1971 until 2007. After testing various architectures, types of functions and learning algorithms they found the appropriate architecture with two hidden layer and twelve neurons in hidden layers.

For any forecasting model, there is a degree of uncertainty due to:

- The estimation of the model parameters;
- The input data, the unexplained variations of the observed variable or measurement errors; and
- The model's uncertainty having multiple causes such as: the model is wrongly specified from the beginning or the assumption that the model parameters are fixed is false (Woschnagg and Cipan, 2004).

Many researchers in this domain state that the true model does not exist (Chatfield, 2001, pp. 80-89) and this affirmation gives us the base for a real vision of forecasting, and not a dream: 'One model, that seems to fit the underlying data best, may be selected as a 'winner' although the other models give a fit very close to the one selected'.

In order to evaluate a forecasting model we defined measures of predictive accuracy, among which the most frequently used are RMSE (Root Mean Squared Error) and MAE (Mean Absolute Error) that will be detailed in the next chapter.

3. Nominal and real convergence ratios in the selected CEE countries. How they performed so far?

For discussing the results of our forecasting model, we will present first the latest developments and prognosis of the European Commission for the nominal and real convergence ratios (Table 1).

Table 1: European Commission's forecasts 2013-2014

Country	Real GDP growth rate (%)	Unemployment rate (%)	Inflation rate (%)	Long-term interest rate (%)	Exchange rate fluctuations (%)	Public deficit (% of GDP)	Public debt (% of GDP
CZECH REPUBLIC 2013	0.0	7.6	2.1	2.2	1.2	-2.8	48.5
CZECH REPUBLIC 2014	1.2	7.7	1.7	2.3	-0.8	-2.9	50.3
POLAND 2013	1.5	10.8	1.6	3.6	1.0	-3.5	55.8
POLAND 2014	2.5	11.0	2.4	3.1	3.5	-3.3	55.7
HUNGARY 2013	0.7	10.7	3.1	6.0	1.5	-2.7	78.1
HUNGARY 2014	1.9	10.5	3.2	5.2	0.0	-2.7	77.2
ROMANIA 2013	1.6	6.9	4.0	4.3	5.0	-2.4	38.6
ROMANIA 2014	2.2	6.8	3.0	3.9	5.0	-2.0	38.5
BULGARIA 2013*	1.0	13.0	1.8	3.9	1.35*	-1.3	17.9
BULGARIA 2014*	1.8	12.8	2.7	4.0	1.35*	-1.3	20.4
EUROZONE 2013	-0.4	12.2	1.5	1.6			
EUROZONE 2014	1.1	12.2	1.6	2.1			

* For Bulgaria real exchange rate (RER) fluctuations

Source: European Commission (2012)

Looking at the evolutions in the nominal convergence field, starting with the forecast regarding the decrease of the inflation rate and the budgetary deficit in the Czech Republic, this country seems to be the only one that will probably fulfill the nominal convergence criteria in 2013. Bulgaria has a high negative net investment position which affects in the future the prices' stability, the inflation's increase being forecasted again for 2014.

Poland does not seem to fulfill the criterion of price stability and of the budgetary deficits under 3% in the following years. But it has high values of the public debt, close to 60% and its investment position is weaker than the one of the Czech Republic. The long term interest rate also exceeds the admitted average of the Euro-area, even if its values are lower than Romania's long term interest rate and it is forecasted to decrease under the admitted average of the Euro-area. Romania does not seem to fulfill the inflation criterion either in the next years although the deficit will decrease under the 3% threshold. Also, we fail to fulfill the criterion of the long term interest rate. Hungary fails to fulfill in the future three criteria of nominal convergence, exceeding a lot the

maximum admitted values for them: criterion of prices stability, criterion of public debt and that of long term interest rate.

So, the Czech Republic will be in the next years at the top of the classification with countries willing to adopt the Euro regarding the criterion of nominal convergence, followed by Bulgaria, Poland and Romania, and on the last position there is Hungary.

But no country fulfills the conditions of the central bank's independence, interdiction of monetary financing and judicial integration of Central Bank in the Eurosystem.

From the point of view of GDP per inhabitant, the Czech Republic is at the top in 2012 (79% of the Euro-zone average), followed by Poland and Hungary (66%), Romania (49%) and Bulgaria (47%). Moreover, if we consider the real GDP growth rates in these countries, we see that Poland is the only country which had a positive economic growth in the last two years, being on an ascending trend, followed by Bulgaria, with positive figures and Hungary with negative values. The most powerful decrease of the real GDP was recorded in Romania in 2012, but a high decrease was recorded also in Czech Republic, reaching negative values (see EUROSTAT Statistics Database 2000-2012).

As for the unemployment rate, the highest values are in Bulgaria (over the average of the Euro-area), Hungary and Poland (slightly under the average of Euro-area of 11% in 2012); low values are recorded by Czech Republic and Romania (see EUROSTAT Statistics Database 2000-2012).

As for the labor productivity, all the countries, except Hungary, exceed the average of the Euro-area. The highest level is recorded in Poland, followed by Bulgaria, Romania, Czech Republic and Hungary (see EUROSTAT Statistics Database 2000-2012).

From the point of view of the real convergence, the better situation is recorded in Poland, Romania, Bulgaria and (the two recover as for GDP, because they have a GDP per inhabitant lower than the other three countries of the region), Czech Republic and Hungary. For almost all the analyzed countries, including for Euro-area, the European Commission's forecasts regarding the real increase of GDP were more pessimistic than the partial values effectively recorded in 2013 in these countries and in the Euro-area.

The European Commission forecasts a real GDP in the Euro-area of -0.4% in 2013 (the real value being between +0.1-0.3%) and hardly in 2014 it will reach again positive values predicted to be 1.1%. The unemployment rate in the Euro-area will be also increasing from 11.4% in 2012 to 12.2% as it is predicted to reach in 2013 and 2014. Moreover, although in the Euro-area there were not recorded negative values of the real GDP in 2013, as the European Committee had predicted, but there was a growth of 0.1-0.3% in 2013; however the unemployment rate increased to a level of 12.1-12.2%, as forecasts showed. This together with the strong decrease of inflation under 1% to the end of the year put pressure upon the European Central Bank (ECB) to adopt some measures of strong economic re-launch in order not to fall in the deflationist spiral ac-

cording to the Japanese model. Therefore, ECB is bound to reduce at the end of 2013 the interest rates a lot reported to the forecasts.

4. Methodology

4.1. Using artificial neural networks in forecasting

The architecture of an artificial neural network (ANN) contains a number of neurons, organized on layers, having the capacity to approximate any continuous function, with accuracy. The architecture of the one hidden-layer feed forward network shows that the connection between the input layer (N variables) and the output layer is made by one hidden layer of neurons (M nodes). Generally, the ANNs contain more hidden layers and the model must establish their number, also the number of neurons in each layer, and the connections among the inputs, hidden (s) and output (s) layers.

Each input is connected to all neurons, and the neurons are connected to the output. Each input connection has associated a parameter indicating the strength (a degree of importance), the so-called weight.

The forecasting algorithms based on neural networks are known also as training algorithms, because they iteratively adjust the parameters in order to maximize the accuracy. So, the dataset is divided into two parts: the training and the validation sample.

4.2. Forecasting software neural networks based

The new approach of neural networks forecasting is based on powerful software applications for complex computing and simulations of the target function, with the purpose of minimizing the errors.

Such software has at least three facilities:

1. Data processing that includes the import of data into the application, the split of the dataset into the training and the validation data. Additionally, the software could detect missing values and is capable to replace them with values generated by interpolation, average value or by zero etc.
2. Selecting a forecasting model, by testing several simulation functions and changing the number of hidden layers and the input neurons.
3. Evaluating the accuracy of the model, by providing measures of errors.

The most common measures in assessing the model's performance are RMSE (Root Mean Squared Error) and MAE (Mean Absolute Error).

Mean absolute error is the result of the absolute value of the difference between the estimated forecast and the actual value at the same time. This way of calculating the errors is not impacted by the sign of values, so that the negative values do not cancel the positive values (Saigal and Mehrotra, 2012, pp. 57-66).

$$MAE = \frac{1}{n}\sum_{t=1}^{n}\left|Y_t - F_t\right| \quad (1)$$

The mean squared error (MSE) represents the variability in forecast errors and it is computed as the squared difference between forecast and actual values and then averaged over the sample:

$$MSE = \frac{1}{n}\sum_{t=1}^{n}(Y_t - F_t)^2 \quad (2)$$

The root mean square error (RMSE) measures the average magnitude of the error.

$$RMSE = \sqrt{MSE} \quad (3)$$

4.3. GMDH Shell – Neural network forecasting software

Even if the IT market does offer a large number of forecasting tools, we consider that one of the most significant one is the GMDH Shell environment, professional neural network software, which solves time series forecasting (Geos Research Group, 2013).

According to the documentation of the Group Method of Data Handling (GMDH): 'GMDH Shell is an advanced but easy to use tool for predictive analytics and data mining, able to automatically detect usable data inside a file, transform data according to a problem type, drop irrelevant inputs and, finally, construct a set of predictive models at the base of optimal complexity detection and self-organization principals' (Geos Research Group, 2013).

GMDH Shell is recommended in our study due to some important features as follows:

a) the capability to solve different types of forecasting problems, especially time-series forecasting;
b) the migration of input data from XLS and CSV files;
c) the inclusion of specific applications of time-series forecasting: financial management, evaluation of alternative economic strategies, production and capacity planning; and
d) the graphical user interface is very user friendly, and allows to simply select the options and view the results as graphical and tabular presentations of model performance and the importance of each indicator (as input variable), in order to assess the accuracy for the modeled dataset (Khashei and Bijari, 2010, pp. 479-485).

In this paper we propose the macroeconomic forecasting based on the neural network model, using the GMDH Shell software.

For each macroeconomic indicator, a model was generated and we applied it to the European countries involved in this study. The algorithm uses a polynomial function (Geos Research Group, 2013):

$$Y = a_0 + \sum_{i=1}^{n} a_i x_i + \sum_{i=1}^{n}\sum_{j=1}^{n} a_j x_i x_j + \sum_{i=1}^{n}\sum_{j=1}^{n}\sum_{k=1}^{n} a_{ijk} x_i x_j x_k \quad (4)$$

where X ($x_1, x_2, \ldots, x_n$) is the input data vector and A ($a_1, a_2, \ldots, a_n$) is the vector of weights.

So, keeping the same neural type algorithm, but increasing the complexity of the models by using two or three hidden layers, with a number of 6 to 30 neurons, used in order to improve forecast accuracy by less than 0.5.

4.4. The functions used for modeling target variables

For our neural networks based forecasting model we created the functions presented below:

1) **Rate of inflation** = f (GDP, monetary aggregate M3, government deficit/GDP, public debt/GDP)
2) **Rate of inflation** $_{\text{Eurozone}}$ = f (GDP, monetary aggregate M3, final consumption/GDP, government deficit/GDP, net export/GDP)
3) **Interest rate long-term** = f (inflation rate, public debt/GDP, government deficit/GDP, monetary aggregate M3, public expenditure/GDP, GDP)
4) **Interest rate long-term** $_{\text{Eurozone}}$ = f (inflation rate, public debt/GDP, government deficit/GDP, monetary aggregate M3, final consumption/GDP, GDP)
5) **GDP =** f (inflation rate, Gross capital formation/GDP**,** final consumption/GDP, net export/GDP)
6) **GDP** $_{\text{Eurozone}}$ = f (Final consumption/GDP, Gross capital formation/GDP, inflation rate, long-term interest rate)
7) **Unemployment rate** = f (GDP, inflation rate, long-term interest rate)
8) **Unemployment rate** $_{\text{Eurozone}}$ = f (GDP, inflation rate, Gross capital formation/GDP, long-term interest rate)
9) **Exchange rate** = f (inflation rate, monetary aggregate M3, current account/GDP, public debt/GDP, long-term interest rate)
10) **Government deficit/GDP** = f (public expenditure/GDP, public debt/GDP, inflation rate)
11) **Public debt/GDP** = f (inflation rate, exchange rate, long-term interest rate, Government deficit/GDP, public expenditure/GDP, GDP)

For each variable, the functions were built according to the economic theory as far as the influence factors were concerned.

All the used variables are expressed in percentage (%) for similarity reasons regarding their measurement units. Most of these variables are expressed as percentage of GDP and few of them express percentage fluctuations from year to year of the recorded values (such as for M3 monetary aggregate fluctuations from year to year, for real GDP growth rate from year to year or for nominal exchange rate fluctuations from year to year).

The function created for the euro-zone are different from the functions built for selected CEE countries, because the Euro-zone includes both advanced economies and new member states that display some differences against the old member states of the Euro-zone.

5. Results and discussions

Data series that we used in the forecasting model for the analyzed CEE countries and for the Euro-zone were provided by EUROSTAT for 2000-2012 (see EUROSTAT Statistics Database 2000-2012). We forecasted the convergence ratios for 2013-2014 and we compared our results with the European Commission's forecasts for the same period of time and with the partial data published for 2013 for these countries and for the Euro-zone.

In the forecasting model realized in this work, we estimated the indicators of the nominal and real convergence for the CEE analyzed countries and we compared with our forecast for the Euro-area at the inflation rate and at the long term interest rate. We noticed from the data series on 2000-2012 (see EUROSTAT Statistics Database 2000-2012) that the admitted maximum (average of the first three countries +1.5% at inflation and the minimum of Euro-area +2% at the long term interest rate) was around the Euro average both at inflation and long term interest rate. At the other indicators, we compared with -3% at budgetary deficit in GDP and with the maximum of 60% at the public debt in GDP. For the exchange rate, we monitored the forecasted fluctuations for the currencies of the five analyzed countries not to exceed +/-15% as it is provided for the participation in ERMII, before the accession in the Euro-area. However, the analyzed fluctuations were much under the provided limit. In case of Bulgaria, the forecast regards the fluctuations of the real exchange rate because the nominal one has been set since 1997 since the Monetary Council operates in Bulgaria.

Comparing the European Commission forecasts with those resulting from the model designed by us within this work, regarding inflation we may appreciate that in 2013 only Czech Republic and perhaps Bulgaria will fall under the admitted maximum of the Euro-area, the other countries exceeding the admitted maximum (in order: Poland, Romania and Hungary) (Table 2).

As for the long term interest rate, Czech Republic will have a level under the admitted average of the Euro-area (the average of the Euro-area predicted by us is 3.35% as it was actually obtained in the first ten months of 2013, reported to 1.6% as the European Commission had predicted for the Euro-area in 2013), Bulgaria will have a value close to the maximum admitted average, while Poland, Romania and Hungary, in increasing order of the forecasted values, will record higher values than the admitted maximum (Table 2).

The fluctuations of the exchange rate show the depreciation of all currencies in these countries, the values ranging between 4.2-6.4%, (for Bulgaria it is about the fluctuation of the real exchange rate, the nominal one being fixed), so reduced fluctuations and quite close as value. The highest fluctuations of 5.9%-6.4% will be recorded in 2013 in Hungary and Romania; the lowest fluctuation will be recorded in Czech Republic, 4.2% (Table 2).

As for the budgetary deficit, we forecast its maintenance over 3% only in Poland, in the rest of the countries being under the maximum limit of 3% (Table 2).

Table 2: Forecasts for the nominal and real convergence ratios of the selected CEE countries and Euro-zone

Country	Real GDP growth rate		Unemployment rate		Rate of inflation		Long-term interest rate		Exchange rate fluctuations		Government deficit/GDP		Public debt/GDP	
	value	MAE RMSE	value	MAE RMSE	value	MAE RMSE	value	MAE RMSE	value	MAE RMSE	value	MAE RMSE	value	MAE RMSE
Czech Republic 2013	-1,173	0,0387 0,0567	8,447	0,098 0,197	1,1491	0,4536 0,6786	2,5829	0,2853 0,4939	4,28816	0,000123 0,000175	-2,275	0,0918 0,1486	47,84	0,2681 0,3734
Czech Republic 2014	-1,966	0,1905 0,3145	9,759	0,0924 0,1759	1,2078	0,6358 0,905	2,6954	0,1253 0,1952	4,946	0,920 1,6	-1,789	0,155 0,2164	46,973	0,1175 0,1879
Poland 2013	2,4683	0,1735 0,2776	11,371	0,01655 0,2923	2,1896	0,4466 0,7576	4,9354	0,0243 0,0394	5,0332	0,5621 0,9922	-2,929	0,1743 0,2741	57,8307	0,5046
Poland 2014	2,8558	0,0921 0,1274	10,748	0,1212 0,1737	1,872	0,5996 0,9828	4,208	0,1454 0,2679	3,313	1,4 2,8	-2,507	0,1447 0,2285	56.857	0,4613 0,8591
Hungary 2013	0,5685	0,07298 0,1625	9,985	0,08365 0,1236	2,3406	0,3763 0,6321	6,8624	0,1497 0,2325	5,9989	0,0929 0,1114	-2,580	0,0554 0,0683	76,7616	0,2459 0,4776
Hungary 2014	0,2153	0,1238 0,2006	9,727	0,0541 0,0708	2,403	0,76 1,066	6,9648	0,1918 0,3114	1,5083	0,812 1,915	-2,234	0,623 1,041	74,85	0,853 1,161
Romania 2013	2,4218	0,1054 0,1442	6,401	0,07554 0,133	1,9087	0,1523 0,2683	5,5680	0,4507 0,7645	6,4453	0,6872	-1,419	0,1056 0,146	40,6917	0,3196 0,4707
Romania 2014	2,889	0,1968 0,3167	6,04	0,1088 0,1979	1,290	0,57 0,86	5,059	0,4675 0,7633	1,8926	2,327 4,03	-0,933	0,27 0,4019	38,845	0,466 0,769
Bulgaria 2013 * (RER)	0,8483	0,0918 0,1524	12,45	0,0781 0,1094	1,7915	0,5326 0,8261	3,8676	0,0194 0,0342	5,1035*	0,1716 0,3289	-1,295	0,317 0,4729	19,3117	0,2929 0,5357
Bulgaria 2014 * (RER)	0,930	0,0764 0,1231	12,514	0,2802 0,4152	1,9113	0,6301 0,998	3,0869	0,0764 0,1314	1,171*	0,0100 0,0181	-1,775	0,2232 0,3763	15,6359	0,1904 0,3090
Eurozone 2013	0,4456	0,1654 0,2911	11,316	0,06137 0,1061	1,7426	0,0020 0,0033	3,355	0,1707 0,3202						
Eurozone 2014	2,646	0,1380 0,2297	13,07	0,0396 0,05811	1,7901	0,01248 0,02233	3,3369	0,1968 0,324						

Regarding the public debt, all the countries will encounter in 2013 a growth of the public debt ratio reported to the GDP, but the values will remain under the admitted maximum of 60%. The only exception will be Hungary which will record its decrease to approximately 76.6%, but it still exceeds the admitted maximum (Table 2).

Concluding on the results of our own forecasts, Romania has problems regarding the long term interest rate, having the highest value in the group of analyzed countries, beside Hungary, but it has to continue also the disinflation process. The same recommendations are also for Bulgaria. Czech Republic seems to fulfil the nominal criteria even since 2013. Poland is at the limit of the admitted public deficit and has an increasing public debt, with values which come close to the admitted maximum of 60%. It should provide also the prices stability and the decrease of long term interest. Hungary has the most problems regarding nominal convergence, having the highest predicted inflation of the analyzed countries; the interest rate is also the highest, much higher than the admitted maximum. The public debt is decreasing, but still exceeds greatly the admitted maximum threshold.

Considering the criteria of nominal convergence, according to the European Commission's forecasts, the best position is held by Czech Republic, fulfilling the nominal criteria in 2013, followed by Bulgaria, Poland, and Romania. On the last position is Hungary. Considering the real convergence, the countries closest to meeting the requirements of the Euro-area seem to be Poland, Bulgaria, Romania, Hungary, and Czech Republic.

Poland wins in terms of economic growth and output, Czech Republic regarding prices stability, budgetary deficit and long term interest rate. For the rest, the countries have similar positions from real and nominal point of view, Bulgaria being before Romania and the most poorly positioned is Hungary whose high public debt is its main problem. According to the forecasts of Hungary National Bank, the public debt will remain for a long time over 60%, even in a time horizon of 14-15 years.

According to our model and the forecasts performed by us, on the first two positions there are Czech Republic (fulfilling the nominal criteria in 2013), Bulgaria (approaching the targets in 2014), Romania, Poland and on the last position, Hungary. The countries hold relatively the same positions as in the classification realized for 2013-2014 according to the European Commission's forecasts, only that Romania obtained better performances than Poland in terms of inflation (much lower than 4% as the European Commission had predicted) and budgetary deficit (much under 3%). But the European Commission shows that Romania will have a higher inflation rate than the one forecasted by us, but the governor of Romanian National Bank announced in November 2013 that we would be under the inflation target of 2.5% in 2013, the 2013 values being of 1.8-2%, this level being under the 4% forecast of the European Commission, while our forecast was of 1.9%, much closer to the partial value effectively recorded in the first ten months in Romania in 2013.

The European Commission forecasts also for Czech Republic inflation around the value of 1.7-2.1%, and the one effectively recorded up to autumn 2013 is around 1%.

But we predicted an inflation rate of 1.1% in Czech Republic, close to the one obtained effectively in 2013. Also, our model predicts a budgetary deficit for Romania of 1.4%, close to the one recorded. In the first 9 months of 2013, the deficit was -1-1.2%, and it seems not to exceed further -1.8%, under the European Commission forecast for Romania in 2013.

Czech National Bank (CNB) interfered with the exchange rate market and devaluated the national currency. The purpose was to stimulate exports as well as to increase inflation which reached a minimum record level. Czech economy started to recover after a recession which affected the country in 2011, but inflation stopped at 1% in the first three terms, much under the target of the National Bank, which was 2%, around the Euro-area average and much under the European Commission forecast of 4% in 2013. Moreover, these measures affect the exchange rate. Thus, the European Commission's forecasts underestimated the effect of the austerity actions adopted in the Czech Republic. This fact is acknowledged also by the IMF officials regarding their forecasts for inflation and economic growth.

However, what happened in Czech Republic proves that the Czech National Bank does not have any longer monetary solutions to relax monetary policies and this interference was a desperate action. Like other European economies, Czechs are afraid that the slight recovery of the economy will be subject to deflation. Practically, Czechs want to enhance inflation by increasing imports prices, but this might decrease the consumption level on short term.

In Central Europe, the rhythm of contracting of the Czech economy is the most rapidly ever recorded and Hungary is heading towards another recession period, while Poland, the greatest economy of the region, is the only one with solid growth in the previous years.

All these countries, dependent on the goods exports to the Euro-area, have encountered the risk of the economic situation deterioration due to weak demand. The increase of governmental expenses for the economy stimulation and establishment of workplaces is therefore entitled.

Due to the reduction of public expenses, only Poland recorded a modest increase in the first part of 2013, but also in the previous years, and the decline of Czech economy got worst. Hungary rejected EU requests for several austerity measures.

EU requests its member states not to record a budgetary deficit over 3% of GDP, a regulation that is quite often breached. 20 out of the 27 EU member states (Austria, Greek, Italy etc.), including the three Central European states (Estonia, Slovakia and Slovenia), have exceeded this limit. However, IMF recommends the Czech Republic to reduce the rhythm of adopting austerity measures for the fulfilment of nominal convergence and to announce supporting measures for the economic growth. In the case of Poland, the Government should avoid the reduction of public investments.

The European Commission as well as our model forecast an increase of public debt in the analyzed countries, except for Hungary, and the reduction of long term interest rate.

In 2010, the Hungarian government suspended the agreement with the International Monetary Fund and adopted a set of measures for fighting against crisis. The measures focused on taxing banks and foreign investors. Even though many austerity measures were needed the government did not take them because of their lack of popularity. So, the Hungary's rating at the international agencies decreased. At the end of 2012, with an increasing and alarming public debt, it announced that the country wants a new agreement with IMF, but the European Commission and IMF requested many changes and austerity measures. Hungary based its economic growth on exports to the EU. Given the situation in the European area, it cannot expect a spectacular economic growth in the near future. The economic growth in Hungary would not exceed 1% in the next years. As a result, the unemployment cannot decrease too much. Its public debt will not also decrease under the maximum of 60%, because its imports cannot decrease too much without affecting the domestic demand and the economic growth. Hungary should follow Romania's example of adopting tight fiscal and monetary measures imposed by the international forums. Romania's ranking is higher than the Hungarian one at the international agencies. In 2013, in Romania a robust economic growth was re-launched. The austerity measures proved their efficiency after a few years.

From the point of view of the real convergence, our model shows a solid economic growth in Poland of 2.4%, this being followed by Romania with a 2.4% increase (compared to 1.6% as the European Commission predicts and the real value which seems to be reached at the end of 2013, this being between 1.8%-2.2%) and by Bulgaria with a lower growth of +0,8%, while the partial values in the first ten months of 2013 show a 0.5-0.6% increase. Forecasted negative values are still recorded by Czech Republic and for Hungary we have obtained +0.5% (the European Commission forecasts showed values of 0.7% in 2013 and the partial data on the first 10 months of 2013 show an increase of 0.5%-0.6%). For the Euro-area, even if the European Commission forecasted a decrease, we obtained a +0.4%, increase close to the partial values recorded in the Euro-area in 2013 (+0.1%-0.3%), this reaching positive values as of the 2nd term. In Romania, the recorded real increase of around 2% exceeds slightly even the modest growth recorded by the Polish market, this being slightly over 1% in the first three terms of 2013 and it seems not to exceed 2% at the end of 2013. Romania has evolved even better than the European Commission forecasts which indicated a 1.6% growth. However, the European Commission forecasts were more pessimistic than the ones obtained through our model for Romania, Poland and Euro area and more pessimistic than the partial results obtained in 2013. Romania is the region leader regarding the economic growth in 2013 (Table 2).

The unemployment rate predicted by us shows its decrease in Romania and Hungary, countries which were however under the Euro-area average and its growth in Poland, but at values of 11.3% under the Euro-area average. Czech Republic will record economic growth and unemployment increase, but starting from low values, slightly over 7%, it will still be under the Euro-area average. Bulgaria will record the

unemployment maintenance even during the economic growth, with values over the Euro-area average (12.2%). Beyond the forecasts of our model, the partial data of 2013 show the strong increase of unemployment in Poland, of 13% over the Euro-area average (Poland economic growth slowed down) and its maintenance within 12-13% in Bulgaria, namely with values close or slightly over the Euro-area average (Table 2).

From the point of view of the real convergence, our model forms a hierarchy of the five analyzed countries in order thus: Poland, Romania, Bulgaria, Czech Republic and Hungary. As for economic growth, Romania reached Poland level even if the European Commission predicted values much lower in Romania, and Romania has also a low unemployment rate compared to that of Poland which is increasing. Czech Republic lost a lot due to recession, which was maintained also by the rough austerity measures adopted by Czech Republic for the fulfilment of the nominal convergence criteria. Moreover, a study carried out by the European Commission (see Eurostat Europe 2020 Indicators) shows that only for the Czech Republic and Poland the unemployment targets may be reached on long term, while in Hungary, Bulgaria and Romania they are not feasible on a time horizon of up to 2020.

However, like the nominal convergence criteria, certain countries of the Euro-area encountered a strong recession (Ireland, Greek and Spain) and a very high unemployment rate compared to the countries applicant to the accession to Euro-area. Moreover, the example of these countries from EMU which do not fulfill any longer the criteria of nominal and real convergence after their accession in the Euro-area, proves the incompatibility of these criteria and their lack of sustainability on the long term.

6. Conclusions

Czech Republic had to reduce its deficit by decreasing public expenses. It also faced an economic decrease. It is worth observing in the future if it will reach again a level of economic growth on the account of net exports (having a deficit of current account lower than the other analyzed countries) and of investments and not on the account of public expenses. Poland has to continue to reduce inflation in order to fulfill the criterion of prices stability in the next 2 years and to reduce its budgetary deficit.

Also, it is appreciated as encouraging the relaxation of the monetary policy in Poland and in the Czech Republic. After two decades of continuous economic growth, Poland is expected to record in 2013 a reduced increase of GDP (the most reduced in the last ten years) due to recession in the Euro-area, which bought 52% of the Polish exports. But Poland is the single country which did not have economic recession. It has the highest degree of European funds' absorption particularly for infrastructure and its sustained growth was due to this during all this period. Poland keeps on relying on the European funds' absorption in order to support the economic growth in the next years.

So, inflation decreased in 2013 in Czech Republic and the measures aimed at increasing taxes and reducing public expenses affected the economic growth and put pressure on the exchange rate and external sector.

Hungary has to reduce its public debt, inflation being however in decrease. It also has to be grounded on investments for economic growth and it should realize an increase of work output. Hungary has to reduce also the deficit of current account in order to reduce the pressures of the external sector. Bulgaria has to reduce unemployment particularly due to the fact that it started the economic growth (even if there are countries that have adopted Euro in the last years with an unemployment much higher than that of the Euro-area and of Bulgaria, this being the case of Slovakia), although the European Commission forecasts show the increase of unemployment in the next years, and it should reduce the high deficit of current account. Romania should focus on the decrease of inflation, long term interest rate and should strive to reach a positive economic growth on the account of investments.

According to the model created by us, but also according to the European Commission's forecasts, Czech Republic will fulfill the nominal convergence criteria in 2013. Bulgaria approaches, with regard to the prices' stability criterion, the maximum average admitted for 2013-2014, but it displays a great gap in the GDP/capita area and its economic growth is quite slow. Bulgarian unemployment is rather high and increasing. Czech Republic has not exited from recession in 2013 due to the drastic austerity measures for the fulfillment of the nominal convergence criteria. In addition, inflation in Czech Republic is slightly increasing and the danger of its non-sustainability appears in the following period of 2013. In Poland, inflation rate will exceed the admitted average in 2014, which is increasing and the long term interest rate is decreasing, but higher than the admitted average of the Euro-area. In Hungary, both the inflation and the interest rate will exceed also in 2014 the admitted average of the Euro-area and the public debt, even if it is decreasing, it still exceeds by a lot the 60% limit. In Romania, the disinflation process will continue and only the long term interest rate will still exceed the admitted average, being further in decrease compared to the one forecasted in 2013. But the forecasts of our model show the continuation of the economic decline in Czech Republic (fact acknowledged by the situation encountered in Czech Republic in 2013, when inflation was extremely reduced, a low budgetary deficit due to the rough austerity measures, which affected greatly the economy). If the European Commission's forecasts of economic growth regarding Czech Republic come true in 2014, inflation will increase greatly compared to 2013. Hungary will decrease slightly while the Euro-area average will be highly increasing. Poland, Romanian and Bulgaria will continue their economic growth. Unemployment shall remain high in 2014 only in Bulgaria, with values close to the Euro-area average, where a slight increase is also recorded.

Romania will perform well with respect to inflation and economic growth, fact which advantages us the most from the analyzed countries in 2013-2014. But the great economic shift concerning GDP per inhabitant in Romania compared to Euro-zone, having half of the Euro-area average, makes its recovery difficult in the next period, particularly on the ground of a reduced inflation.

Our forecasting model is much closer to the partial data and the trends of 2013 in the convergence area against European Commission forecasts for 2013. European Commission's forecasts displayed some large differences for inflation in Czech Republic, Hungary and Romania. There were also large gaps regarding the long-term interest rate area for the Euro-zone and for the rates of economic growth in Romania, Poland and the Euro-zone.

As far as the results for 2014 are concerned, our forecasting is different from the values estimated by the European Commission, but the trend is the same.

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