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Forecasting public expenditure by using feed-forward neural networks

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In this paper, we analyse the correlation of the public expenses by functions with real GDP growth, elaborating a model of estimating and forecasting the main public expenses in some selected Central and Eastern European (CEE) countries: Hungary, Poland, the Czech Republic, Bulgaria and Romania. These countries have not adopted the euro yet. This paper presents several forecasting models for the CEE countries public expenditures, during 2015–2016. The models offer a base for the analysis of the potential budgetary implications of the government policies for the target countries. A short- and mid-term forecast for public expenditure is an important part of the modern methods of governmental management for the Central and Eastern European countries. This involves taking into account a wide range of factors, from GDP, inflation, demographic evolution and age share, to public expenditure type correlation. Such a forecast can be obtained with the help of artificial neural networks (ANNs), using the application GMDH Shell, which proved its ability to create complex and accurate forecasts for the economic, social and financial domains.

Keywords: public spending; Central and Eastern European countries; forecasting model; neural networks; budgetary policy; economic growth

JEL classification: C53, C67, H51, H52, H54, H55, H62, H63, H71, H74, I38, O10, O40

1.   Introduction

In the context of the current financial crisis, all the countries had to sustain some specific public spending in order to support future economic growth and poverty reduction. In this paper we analyse the determinants of the functional distribution of the government main expenditure (for social protection, health, education, general public services and economic affairs). First of all, we review the economic literature on the factors affecting each component of the government expenditure and we present how they impact on the economic growth. Then, secondly, we develop an estimating model of the expenditure structure and we used this model to forecast the structure of the government expenditure during 2014–2016 for some selected Central and Eastern European (CEE) countries: Romania, Bulgaria, Hungary, the Czech Republic and Poland. Those countries are in the EU area, but they have not adopted the euro, because they faced difficulties during the crisis in the public deficit area, because of the large public expenditure.

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These analysed countries were supposed to cut their public expenses and public deficits in the last years. After estimating the future developments of these types of public expenditure, we can compare their evolutions with the forecasts of real GDP growth and of public deficits (from the last winter forecast of the European Commission for the selected CEE countries). In this way we can conclude about the future impacts on the economic growth and on the public deficits in these five analysed CEE countries and we can state the features of their future budgetary policy over the next period.

The paper is actually different from other studies that elaborated on this issue and are presented in Section 2, because it relates the forecast of the main government expenditure by function with the GDP and public debt forecast for the CEE selected countries and it emphasises the features of the public spending policy in these analysed countries in the next few years. In this way, we can conclude which countries will focus on social issues in the near future to reduce poverty and inequality and which countries will aim at economic issues and public investment for achieving economic growth. Both issues are important for CEE countries to achieve nominal and real convergence with eurozone members.

Using neural networks to determine and forecast the development of the public spending by function is appropriate when the determination function is not well known and when there are many influencing variables for the public expenditure.

2.   Literature review

The composition of public spending affects the performance of the public sector. First, a high share of non-discretionary expenditures limits the room for governmental manoeuvring. Second, the composition of expenditures reveals the priority setting of an economy on the long-run (education and R&D). The country-specific developments and trends in the composition of public spending can reflect either country-specific objectives or inefficiencies in spending areas (Mandl, Dierx, & Ilzkovitz, 2008, pp. 1–29). The ageing process increases the pressure of the social protection expenses, and so on the public expenses for environment. As a result, other types of expenses could diminish (education public expenses) and that would affect economic growth. Most EU countries increased their public education spending, but there are some countries where it decreased in the last decade, especially after the crisis erupted (Romania, Bulgaria). Poland and Hungary (Afonso, Schuknecht, & Tanzi, 2010, pp. 2147–2164) were efficient regarding the allocation of the public education expenses among the CEE countries.

Public finances aim to contribute to the most effective allocation of public resources with respect to priorities. The main priorities are permanent economic growth, full employment, competitiveness and, in the European context, mainly social cohesion. One possible quantitative definition of a welfare state is the sum of three items: expenditures on social protection, health and education. (Halásková & Halásková, 2013, pp. 255–269).

Public spending is often discussed as though it was a burden on a market economy, which would grow much faster if only public spending were cut back. But the economic history of the last 150 years shows exactly the opposite: that economic growth has gone hand in hand with a rising proportion of public expenditure since the mid-nineteenth century. Public spending has not just risen in line with GDP, it has risen faster than GDP (their proportion of GDP) (Hall, 2014, pp. 1–14).

An analysis of 23 high-income countries from 1970–2006 confirmed 'a positive correlation between public spending and per-capita GDP and a common development

among the 23 countries' (Lamartina & Zaghini, 2008, pp. 1–10). A study of 51 developing economies by staff at the International Monetary Fund found that there was a consistent link across all countries, confirming 'a long-term relationship between government spending and output consistent with Wagner's law' (Akitoby, Clements, Gupta, & Inchauste, 2006, pp. 908–924).

Sava and Zugravu (2010, p. 151) cited the results of Gregoriou and Ghosh (2009, pp. 32–35). They found in 15 industrialised countries that for Brazil and Thailand, public capital expenditure had a significant negative effect, while current expenditure has a significant positive role on economic growth; on the other hand, for countries such as Sudan and Zimbabwe none of the two types of expenditure has a substantial impact on growth.

Afonso, Schuknecht, and Tanzi (2005, pp. 321–347) showed that states with low budgets have the best performance overall, especially in the sectors of administration. States with larger budgets have better performance in reducing income inequality.

The majority of EU member states have a medium-sized public sector. All countries reduced the size of their public sectors. The countries with smaller public sectors recorded the highest growth rates, followed by countries with medium-sized and large public sectors. In Romania, the public spending increased during the crisis, but the growth rates are below the average (Tsouhlou & Mylonakis, 2011).

The performance is the best in countries where the size of the budget is low. Where the budget is of average size, education records greater efficiency and states with large budgets are more efficient in the field of infrastructure (Afonso et al., 2010, pp. 2147–2164).

A study regarding public sector efficiency in Romania shows a mediocre efficiency in Romanian public administration which is atypical. Infrastructure is still a deficient sector in Romania, but this is specific to a state with a low budget. Efficiency in the health sector, well above average, is due primarily to a relatively low volume of resources employed (Masca, 2014, pp. 326–347). In the Czech Republic or Hungary, public spending on R&D has been growing very fast, indicating increasing efforts to gradually build up their science base. In Poland it has decreased and remains at a rather low level.

An IMF study (International Monetary Fund, 2005) has shown that some studies support the hypothesis that a rise in the share of public spending is associated with a decline in economic growth (Scully, 1989, pp. 49–64); others have found that public spending is associated positively with economic growth (Ram, 1986, pp. 191–203). Public expenditures were observed in one study to have no impact on growth in developed countries, but a positive impact in developing countries (Sattar, 1993, pp. 127–149).

Bose, Haque, and Osborn (2007, pp. 533–556) found that education and public investments projects are the key sectors to which public expenditure should be directed in order to promote a long-lasting economic growth and that a government budget deficit gives rise to adverse growth effects (their analysis covered 30 developing countries). So, it is important how this public expenditure is financed. They suggest that some transfers from the other types of public expenditure are necessary to enhance economic growth, without negatively affecting public deficits.

Generally, economic studies suggest that public sector consumption does not promote economic growth (Barro, 1991, pp. 407–443). Other researches have aimed at identifying a positive effect of household investments in education and health (Otani & Delano, 1990, pp. 76–83). Barro (1991, pp. 407–443) points that some public expendi-

ture has a productive character that stimulates growth while others increase social welfare (productive public expenditure are considered: public expenditure on education, health, economic affairs, environment; the unproductive expenditure are considered: public expenditure on social protection, on general public services, public debt, defence, public order, fuel, energy). Reducing 'non-productive' expenditures and using these funds would certainly apply to the gradual reduction of fuel and food subsidies that distort the incentive structure in the economy (De Wulf, Coutinho, Sassanpour, & Florez, 2010, pp. 43–55).

As factors that determine the public expenditure, the income (determining the level of the public revenues) is important for all the government expenditure functions, having a positive impact. Randolph, Bogetic, and Hefley (1996, pp. 1–82) found that spending on economic services responds primarily and directly to income changes and fiscal policy. Income level determines a wider social security coverage, regarding inequality (Concialdi, 1999, pp. 91–116).

Demographic variables, such as population, play a highly important role in public spending such as economic affairs, as well as health and education and the other economic services, showing negative elasticity (Randolph et al., 1996, pp. 1–82).

Population age structure also proves significant for many functions (spending on health and social security) (Heller & Diamond, 1990, pp. 1–21). In education, Ahlin and Johansson (2001, pp. 331–351) point out that a rise in the proportion of young people will generate pressure for increases in public spending on education. Unemployment surely affects social security, but also education (indirectly) (Painter & Bae, 2001, pp. 370–392). Inequality is a factor to be taken into account in spending on social security. Income and inequality distribution of income are important for social security and health, showing that the most developed countries display a stronger preference for a more equitable distribution. Along with education, these functions are also the least elastic in relation to the relative prices. Both population and age structure have significant effects on many of the functions considered. If the ageing patterns of recent times continue in the developed countries, other expenditure and housing will become of increasing importance in detriment to education and health (Sanz & Velázquez, 2002, pp. 3–20).

3. Developments of the public expenditure by functions during 2000–2013 in the European countries. Special focus on the selected CEE countries

According to Eurostat Statistics (2006), at the beginning of the 2000s, spending by government on social protection, health and education had tended to increase relative to GDP in EU. Overall, the levels of the public expenditure within the Europe-27 for the 2002–2006 time period range between 46.8–47.5% of the GDP. During 2005– 2010, the general government expenditure reached up to 50% of EU-27 GDP. The government spending relative to GDP progressively decreased in the EU-27 between 2003 and 2007, followed by a rise in 2008 and a more emphatic increase in 2009 (Table 4). First in the CEE region comes Hungary, followed by Poland and the Czech Republic. The last ones are Bulgaria and Romania, with low numbers. Their numbers are lower than the EU-27 average; only Hungary displayed higher numbers above the EU-27 average.

Romania started to spend more from the public budget after 2002, and after 2006 its numbers became similar to Bulgaria's. Once the crisis erupted, after 2009, the public spending of CEE countries tended to converge each other's and the EU-27 average. (Figure 1) Regarding the public revenues collected by the public budget, Romania had
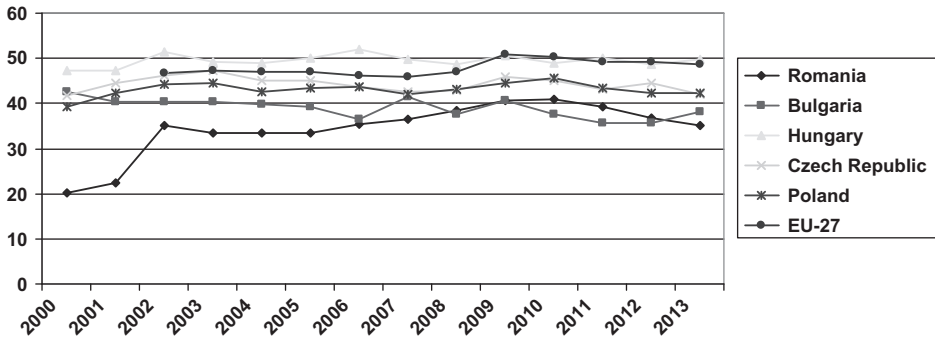
Figure 1.   Public expenditure in GDP in CEE countries (%) Source: EUROSTAT database, 2000–2013.

the lowest financial public resources in the area. The situation changed in 2010, but Bulgaria obtained again larger public revenue in 2013. Hungary ranks the first in the public revenue area too (Table 1).

For the member countries with data available for 2000–2004, most saw an increase in the social protection spending as a percentage of GDP. In 2004, EU spending amounted to 18.9% of GDP, compared with 19.1% for the EU15. The countries with the lowest rates are the countries of Eastern Europe (Estonia, Latvia, Lithuania and Romania) their score being lower than the EU-27 average (Eurostat, 2006). Among the analysed CEE countries, the country with the highest score is Hungary, followed by Poland and Bulgaria. After them we find the Czech Republic and Romania placed the last in this rank. After 2007–2008, the public expenditure on social protection started to increase in Bulgaria and Romania and they closed the gap with the Czech Republic. Only in 2013 did the public spending on social protection decrease in Poland and Hungary, which had high numbers, and that type of public spending converged in all the CEE analysed countries. They always had values lower than the EU average. Only Poland compared with the EU numbers at the beginning of the 2000s (Table 4).

From 2007 to 2009, EU-27 expenditure on social protection increased. This was due both to the evolution of GDP in current prices and social phenomena related to the economic crisis such as increases in unemployment. Until the crisis erupted in the EU, in 2008, the total expenditure on social protection decreased in Poland. In contrast, increases were observed during the same period in Romania and Hungary. From 2009 to 2012, the social protection expenditure as a ratio of GDP increased in all EU countries, except for Hungary. The EU Member States, which joined the EU after 2004 tend to have the lowest shares for social protection (Eurostat, 2013).

Health represents 6.4% of EU GDP in 2004. Data for EU15 and the eurozone for the period 2000–2004 show a steady rise in government spending on health. The Czech Republic is the only CEE selected country that invests more in the health sector than the EU-27 average (Eurostat, 2006). It is followed by Hungary and Poland. Romania and Bulgaria rank the last; Bulgaria having a low score, half of the EU-27 average. Bulgaria invested more public money on health before the crisis, during 2004–2006, but then its spending decreased. Hungary also invested more money on health. Romania decreased its spending during 2010–2011. All the values almost converged in 2013 (Table 4).

Table 1. Public revenues of GDP in selected CEE countries (%).

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Bulgaria	40.9	37.9	38.3	39.8	38.1	36.1	39.4	39.3	36.4	34.1	32.6	34.7	37.1
Czech Republic	37.2	38	42.1	39.4	38.7	38.5	39.3	38.1	38.1	38.6	39.6	39.8	40.7
Hungary	43.3	42.2	42.1	42.5	42	42.5	45.2	45.3	46.2	456.2	44.4	46.4	47.3
Poland	37.4	37.7	37.9	37.4	38.9	39.7	41.2	40.3	40.1	38.9	39.5	40.8	38.2
Romania	32.6	32.9	31.7	32.2	32.3	33.1	35.4	33.4	31.8	33	33.7	33.4	32.8
EU-27	–	–	–	–	–	–	44.4	44.5	44.1	436	44	44.7	45.4

Source: EUROSTAT database 2000–2013.

Also, at EU-27 level, the public expenditure on health significantly increased from 2009 onwards. In most reporting countries, 'health' was the second largest function in public expenditure after the social protection (Eurostat, 2013). The lowest ratios of GDP were found in Romania (Table 4).

Hungary and Poland spent more on education than the EU-27 average most of the time. After the crisis erupted, Hungary invested less on education. Next rank the Czech Republic and Romania. The Czech Republic invested constantly in the education sector, with a short-time period of a small decrease during 2008–2009. After that, it also increased the public money directed to the education sector. Bulgaria has also low numbers, but Romania ranked last almost the entire analysed period (Table 4).

The CEE countries faced the biggest fiscal challenges during the crisis, which was reflected in comparatively large drops in the growth rates of education and health spending during 2009–2011. These countries will also find it hardest to regain pre-crisis spending growth rates. This will affect the accumulation of human capital and the future growth prospects in the region. For example, Romania substantially reduced education personnel in 2009, largely by curtailing supplements to base salaries (Brumby & Verhoeven, 2010, pp. 193–206).

Spending on general public services amounted to 3.7% of GDP in the EU in 2004. Hungary spent on public services more than the EU-27 average for the entire period analysed in this paper. Bulgaria also displayed higher numbers at the beginning of the 2000s and at the beginning of the crisis (Eurostat, 2006). Bulgaria almost doubled its expenses in GDP in 2007 and in 2009 compared with the previous years. Poland and the Czech Republic rank next among the CEE selected countries. Poland invested more public money in this area before the crisis. Romania ranks the last with a score that is half of the EU-27 average. Romania allocated more money in this area during 2000–2001, more than the EU average, but after 2002, it decreased its spending. During 2012–2013, the public expenses for the general public services decreased a lot in Bulgaria and Romania (Table 4).

The government expenditure on economic affairs recorded the highest level in the Czech Republic in 2004 (Eurostat, 2006). All selected CEE countries have higher numbers on that specific issue against the EU-27 average after 2005. Before 2004, Poland had lower number than the EU average. Romania also displayed lower numbers for 2000–2001. Now, Hungary, the Czech Republic and Bulgaria, have a similar score, the highest in the region. Poland and Romania display lower values than the first two countries.

The level of the productive spending is the lowest in Romania and Bulgaria and the highest in the Czech Republic. The countries with a comparatively lower level of economic development tend to exhibit larger levels of public capital investments as they attempt to converge to the level of capital stock of the more advanced economies. The highest gross capital and net capital formation is in Romania and Poland (European Commission, 2012b).

4.   Methodology. Characteristics of the neural network forecasting models

Modelling and forecasting the evolution of the economic and social systems is difficult and complex, because it is confronted with uncertainty, non-linearity and a wide range of external elements that influence the process. Artificial Neural Network (ANN) techniques have been found to be useful for this class of complex systems.

According to Khashei and Bijari (Khashei & 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'. Briefly, a neural network is a parametric non-linear function that can be trained to predict the future values of a variable, by analysing large amounts of historical data, and choosing the key influencing factors that define the predictive model in use.

Selecting the right artificial neural network type depends on the application field and data sample. A feed-forward ANN considers that the flow of information is moving from input nodes to output nodes through multiple hidden layers, without loops in the network. The GMDH network architecture contains three types of layers for processing units (also named neurons or nodes) connected by acyclic links:

- Input layer – has the role of transferring the input data (X_1, X_2, ..., X_N) to the hidden layers, as this layer does not have an activation function;
- Hidden layer(s) – designing a multiple-layer configuration – are in fact a number of neurons linked by weighted connections; weights and numbers of layers are typically optimised over an estimation interval (training set) and are then used for prediction on the test data-set and on the selected architecture;
- Output layer(s) – the final layer(s) that collect the features detected and provide the expected answer. The opinion of the researchers is that a neural network with several outputs provides inferior results compared with a network with a single output (Maciel & Ballini, 2008, pp.1–18).

Volterra functional series and the discrete analogue Kolmogorov-Gabor polynomial (1) can perform the approximation of the relationship among the inputs and the outputs of complex systems (Geos Research Group, 2014):

$$Y \; = \; a_0 + \sum_{i=1}^{n} a_i x_i + \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij} x_i x_j + \sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{k=1}^{n} a_{ijk} x_i x_j x_k \tag{1}$$

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

Starting from the Kolmogorov-Gabor polynomial, Geos Research Group developed two types of algorithms: combinatorial and neural networks.

The combinatorial model uses low-order polynomials for every pair of the input variables and it is recommended for non-complex models. For two input variables (x_1, x_2), the output Y is generated by the following sequence:

$$Y = a_0 + a_1 x_1 + a_2 x_2 + a_3 x_1 x_2 + a_4 x_1^2 + a_5 x_2^2 \tag{2}$$

The other class, a GMDH-type neural network, taking into account that usually the input data-set is reduced in size and the weight vector is incomplete, iteratively generates layers of neurons, using neurons taken from previous layers, and a polynomial algorithm for optimisation the neuron connections (Geos Research Group, 2014).

To avoid reaching large-size layers and based on the assumption that a higher level rarely grows in size compared with previous layers, the GMDH-type neural network algorithm divides the additional size of the next layer in two and generates only half of the number of neurons present in the previous layer. More precisely, the number of neurons N at layer k is (Geos Research Group, 2014):

$$N_k = 0.5 * N_{k-1} \tag{3}$$

Subsequent versions permanently improved the GMDH Shell performances, and aimed to increase the accuracy in forecasting problems of artificial intelligence (Ivakhnenko, Ivakhnenko, Savchenko, & Wunsch, 2002, pp. 6–18).

In order to generate the optimal forecasting value, the GMDH process follows four stages:

- In the first stage, an efficient analysis and a careful selection of the input variables and data sample is very important.
- In the second stage the main problem is the selection of the reference function and the way to separate input data into the learning subset. The activation function is necessary for generating the models and for estimating them according to the external criterion. After more simulations, the values that are not efficient enough may be excluded, or the input set may be extended.
- The third step defines a typical problem of taking the optimal decision based on two criteria: the number of variables and the set of observations that must be correlated, for gradually increasing the efficiency threshold.

To obtain good estimation model coefficients it is recommended that the initial data sample should be extended until it contains twice as many terms as in the polynomial model (Ivakhnenko et al., 2002, pp. 6–18). In another frequently occurring case, the data-set to be processed includes too many variables or values per variable, which prolongs the processing time. By setting some threshold value for efficiency, we can exclude inefficient input variables from the sample, thus reducing the calculation time.

- At the fourth stage, we evaluate the model by measuring its accuracy, which must be less than 1%. If the data are imperfect or incomplete, increasing the complexity of the algorithms does not improve the accuracy of the solution.

Concerning the accuracy of the model, GMDH Shell provides two measures in assessing model performance: 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 manner to calculate the errors does not suffer from the sign of values, so that the negative values do not cancel the positive values (Saigal & Mehrotra, 2012, pp. 57–66).

$$\text{MAE} = \frac{1}{n} \sum_{t=1}^{n} |Y_t - F_t| \tag{4}$$

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 (Rădulescu & Banica, 2014, pp. 225–246):

$$\text{MSE} = \frac{1}{n} \sum_{t=1}^{n} (Y_t - F_t)^2 \tag{5}$$

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

$$\text{RMSE} = \sqrt{\text{MSE}} \tag{6}$$

Our experiment is based on neural network - time series model, used for forecasting the future behaviour of output variables, in our case public expenditure indicators for several Central and Eastern European Countries (CEEC). The accuracy of the forecast is strongly related to the size and source of the input data, and to the appropriate definition of variables for the algorithm used. When using GMDH Shell, the wealth of resources available (reporting, plotting, indicators) is invaluable in achieving a high degree of trust for the obtained results.

In this paper, we presented the forecasting for five important public expenditure indicators, based on the variation of the variables presented in Table 4. For each indicator, a model was generated and applied to the European countries involved in this study. Forecasting results are provided in both tabular and graphical forms so that one may assess the accuracy of the models. It is important that the error reference scale for the compared models remains the same. In order to choose the optimal models in our forecasting research study, we used the error measure RMSE.

5. Discussion of the results

We built a forecast model for the functional structure of the public expenses (the most important public spending: public spending on social protection, health, education, general public services and economic affairs, yearly data). This model could be applied for all five CEE analysed countries so we see the differences in the patterns of those expenses, their influence factors and their impact on the economic growth in the future. We worked with data provided by the Eurostat Database (yearly data) (Table 4) for all the variables we used in the estimating functions. For the public spending on health we found that total population, the unemployment rate, the share of old-age population out of total population, the old-dependency ratio, the inequality and the people at risk from poverty and social exclusion ratio are important. Our findings are in line with the literature presented in Section 2. This type of public spending is also related to the expenditure for social protection and general public services expenditure. GDP, public revenues and public debt generally determine the level of public spending. Education public expenditure depends on the same factors, but also on the share of people under 18 years old that need and benefit from education. Public spending on the general public services depends on the same specific factors and on inflation and public expenses for social protection, health and education. Public expenses for social protection are influenced by the public spending on health and on general public services and the other exogenous factors presented in the other types of public expenses. Public spending on economic affairs is the only type of public expenses influenced by all the other categories of public spending. It is a result of them (Table 4).

In Bulgaria, our model estimates an increase in all types of public expenditure, especially those for social protection and the general public services (non-productive public expenses) (Table 4). So Bulgaria seems to be focused more on economic welfare and development in the short-run, but it also tries to achieve a modest economic growth. Those for economic affairs fluctuate between close values. In the Czech Republic, we estimate the increase in all types of budgetary expenditure analysed, apart from the public expenditure for education, which will decrease, but it should be stated that, in the previous decades, the Czech Republic invested heavily in education and research and therefore it comes from higher education expenditure levels compared with Bulgaria. Although the Czech Republic allocates more for health and general public services compared with Bulgaria, in contrast, the latter will spend more on social protection in the

future. The Czech Republic aims at both economic growth (after a severe recession over the last few years) and economic welfare. Hungary will allocate more to health, general public services and economic affairs. Hungary's expenditure on social protection will decrease, whilst those for education will not change too much in 2014–2016. Whilst the Czech Republic will spend more on health, Hungary will allocate more than the Czech Republic for education, general public services and economic affairs. Unlike Bulgaria, Hungary will allocate more in all areas of public expenditure, except for social protection and general public services. Hungary aims to achieve mainly economic growth in the following years. Poland will allocate more for general public services and social protection (in 2016 they will increase substantially, after a slight decrease in 2014–2015, because the unemployment in Poland is high compared with the other countries under analysis, Poland is surpassed in terms of unemployment by Bulgaria only), whilst the other categories of public expenditure do not record significant changes. (Table 3). Poland aims at economic welfare in the near future, because of its problems on the labour market. It also understood that it should invest more in education to achieve economic growth in the medium and long-run and to cut its large public deficits (by diminishing all types of public spending once the human capital will accumulate and develop). Poland will allocate less for health and more for education, compared with the Czech Republic and Hungary. Poland's health expenditure is the lowest of the countries analysed, similarly for the economic affairs, where the weight is low, but the lowest value is registered by Romania. Hungary, Poland and Romania will register the lowest expenditure for social protection. Romania has the lowest expenditures relative to GDP among the CEE states under analysis. The lowest values are registered in the expenditures on social protection, economic affairs and education. Romania will allocate more for health and education only, the rest of public expenditure being in decline. It aims to maintain its economic growth rates of the last few years. It also cut its public spending in the public administration area during the crisis. In terms of health expenditure, it is followed by Poland only and with regard to the expenditure for the general public services, it is followed by Bulgaria only, which occupies the last position. The high rates of unemployment in Bulgaria and Poland resulted in the increase of the social protection expenditure in these countries, as well as in the Czech Republic (although the unemployment rate fell), but here it is a consequence of the drastic measures during the crisis to maintain the public deficit at low levels. Hungary and Romania will reduce the unemployment rate (Hungary the most); however, here the budgetary deficits recorded higher levels, because the adopted measures were much laxer compared with those in the Czech Republic (Table 4).

Regarding the impact of the public expenditures on GDP in Bulgaria, we underline that the public spending on education and on general public services plays an important role, while the other types of public expenditure are irrelevant to the GDP determination function. In Bulgaria, the expenditure on general public services will record the most significant increase, although Bulgaria is ranked last among the five countries analysed in this chapter. Similarly, the expenditure on education increased, Bulgaria being followed by Romania and the Czech Republic only (however, in the past the Czech Republic had major expenditures in this field). Consequently, the European Commission estimates a growth of approximately 0.8–1% in the coming years, a decline compared with 2013–2014 and the lowest in the region analysed in this work (Table 2). In addition, the public deficits will increase in Bulgaria (Table 2). In the Czech Republic, the expenditure with a significant impact on GDP is represented by the expenditure on general public services. However, in this respect, the Czech Republic lags behind Hungary

Table 2. GDP growth and public deficit/GDP in CEE countries.

	2014		2015		2016	
	GDP growth	Public deficit	GDP growth	Public deficit	GDP growth	Public deficit
Romania	3.0	−1.8	2.7	−1.5	2.9	−1.5
Bulgaria	1.4	−3.4	08	−3.0	1.0	−2.9
Czech Republic	2.3	−1.3	2.5	−2.0	2.6	−1.5
Poland	3.3	−3.6	3.2	−2.9	3.4	−2.7
Hungary	3.3	−2.6	2.4	−2.7	1.9	−2.5

Source: European Commission, 2015 Winter Forecast.

and Poland, countries with a similar development level to the Czech Republic and which joined the EU in the first wave, being followed by Romania and Bulgaria only (Table 4). As a result, the Czech Republic comes from negative growth in 2013 and registers values slightly above 2% in 2014–2016 as the European Commission forecasts. Poland will have higher economic growth in the coming period, as well as Hungary until 2015; in 2016, the economic growth of the Czech Republic is expected to be higher than that of Hungary, the latter being on a downward trend since 2014 (Table 2). The Czech Republic also recorded the lowest public deficits in the period after 2007–2008 when the crisis broke out. As for Hungary, the public expenditure with the most significant impact on the evolution of GDP is the expenditure on social protection. As analysed in the forecast above, these are the only expenditures that began to drop sharply in Hungary since 2013, while the other categories of expenditures experienced significant increases (Table 4). Therefore, Hungary will present a downward trend in terms of real GDP, beginning with 2014 (Table 2). For Poland's GDP, the expenditure for economic affairs and education present greater significance (Table 4). We forecast that the expenditures for economic affairs will increase in Poland, but the values are lower than in Hungary, the Czech Republic and even in Bulgaria. The public spending on education will increase slowly, but the numbers are the highest in the region (as during the entire analysed period), and public investments in human capital will support the Polish economy at a constant growth rate of 3.3–3.4% in the following years according to the forecast of the European Commission for the real GDP trend. Moreover, in the case of Poland, the commission forecasts the maintenance of large public deficits, the volume of the public expenditure continuing to be considerable (Table 2). Poland also has a high rate of absorption of the European funds, while the public spending on investments and its efficiency reached average values in the region. That is why Poland displayed a robust and constant economic growth rate. The situation in the other countries in the region is quite different: large public expenses for investments and for economic affairs and a low efficiency of that spending or vice versa. That could explain why the other CEE countries did not reach the Polish performances in the economic growth area. In Romania, the expenditures on social protection and education have the greatest impact on GDP. Social protection expenditures are expected to drop and have the lowest values among the CEE analysed countries (Table 4). Hungary and Romania recorded large expenditures on social protection during the crisis and had higher public deficits. However, Romania and Bulgaria have a higher inequality rate in terms of income distribution (Eurostat Database) and a high risk of poverty and social exclusion, being followed by Hungary.

Table 3.   Unemployment rate.

	2014	2015	2016
Romania	7.0	6.9	6.8
Bulgaria	11.7	10.9	10.4
Czech Republic	6.1	6.0	5.9
Poland	9.1	8.8	8.3
Hungary	7.7	7.4	6.6

Source: European Commission, 2015 Winter Forecast.

In 2013, more than a third of the population was at risk from poverty or social exclusion in several EU Member States: Bulgaria (48.0%), Romania (40.4%) and Hungary (33.5%). In Romania, it decreased compared with 2008, but in Bulgaria and in Hungary it increased. On the contrary, the lowest shares of persons/people being at risk from poverty or social exclusion were recorded in the Czech Republic (14.6%, with a descending trend for this ratio). In Poland, this ratio decreased to 25.8% in 2013 compared with the value reached in 2008.

In addition, in these countries, the share of the retired population of the total population is the highest in this region and because of these considerations, the social protection expenditures are important and have a significant impact on GDP. In Romania, the maintenance of the economic growth at levels close to 3% is due to the increase in expenditure on education, a more significant growth compared with the Hungarian situation and more noticeable in comparison with the decrease of the social protection expenditure.

To conclude, the countries that will allocate more public funds to the education area, namely Romania and Bulgaria, will display a trend for increasing economic growth in the future. Poland and the Czech Republic have already allocated more for education in the future. Poland will sustain its robust path of the economic growth, while the Czech Republic, after the austerity measures and low public deficits during the crisis will begin to rise, from some negative values reached in 2013. Only Hungary will experience economic decline in 2015–2016, as a consequence of the issues related to the field of social protection and the ageing of population and the poverty risk affecting the population in this country, and also as a result of the highly increased expenditure on general public services (unproductive expenditure) and the interest expenditure for the public debt, which is higher in Hungary than in the other countries analysed. In fact, the particularity of Hungary refers to high interest rates paid for its excessive public debt, compared with Bulgaria and Romania, which have reduced public debts. Poland overcame the crisis, spending much from the public budget; therefore, the public deficit was high and remains high, whilst Bulgaria had a high public deficit, but we forecast an increase in all types of public expenditure in 2014–2016, which results in a deficit increase to –3% or even higher negative values, according to the projections made by the European Commission, which confirms the trend we predicted for the functional structure of the public expenditure. The Czech Republic and Romania will continue to register reduced public deficits, whilst Poland will also gradually reduce its public deficit to levels slightly below –3%; however, coming from excessive deficits in 2013–2014. Hungary will remain at levels below –3%, but with values close to the threshold from one year to another because the expenditure on general public services, the public debt interest and expenditure on economic affairs will increase significantly, while the social protection expenditure will decrease. In addition, due to the fact that the unemployment rate

Table 4 Forecast results and functions for the public expenditure by function in the selected CEE countries during 2014-2016

Indicator/Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	RMSE 2015	2016	RMSE 2016
Forecast 2014–2016 Bulgaria																			
Expenditure for social protection	15	13.3	14.4	13.5	11.3	11.1	12.2	13.1	11.2	13.6	14.3	12.9	12.9	14	**15**	**15**	0.01	**14.6**	1.5E-09
Health public expenditure	3.3	2.5	4.5	5.1	6.6	6.7	4.2	3.1	4.5	4.4	4.2	4.6	4.6	4.3	**4.6**	**4.3**	0.01	**4.5**	0.0007
Education public expenditure	4.4	3.8	3.9	4.4	4.2	4.1	3.9	3.9	4.4	4.6	4.1	3.8	3.5	3.7	**3.7**	**3.7**	1.E-04	**4**	1.4E-11
General public services expenditure	9	8.9	7.1	4.3	5.5	6.1	4.7	7.6	5	7.4	3.6	3.8	3.7	2.4	**2.1**	**2.6**	1.E-08	**3**	0.003
Economic affairs public expenditure	3.5	4.2	3.7	5.5	5	4.8	4.6	5	5.7	4	5	4.2	5.2	5.9	**5.1**	**6.2**	8.E-13	**5.8**	2.E-13
Forecast 2014–2016 Czech Republic																			
Expenditure for social protection	13.4	13.3	14.7	14.6	14.1	12.8	12.7	12.9	12.9	14	13.9	13.6	13.8	12.8	**13.4**	**13.7**	1.4E-11	**13.9**	2.3E-11
Health public expenditure	5.7	6	6.2	6.4	7.3	7.2	7.2	7.1	7.2	8	6.4	7.8	7.8	5.9	**4.7**	**6**	0.23	**6**	0.007
Education public expenditure	4.1	4.4	5.2	5.2	4.8	4.8	4.9	4.7	3.9	4.4	4.3	4.5	4.8	3.7	**3.1**	**3.1**	0.0015	**3.1**	3.1E-13
General public services expenditure	3.7	4	4.4	4.9	4.7	5.2	4.3	4.2	4.2	4.8	4.5	4.6	5	4.5	**4.4**	**4.6**	1.E-11	**5**	0.004
Economic affairs public expenditure	7.3	9.4	8.9	8	7.5	6.9	7.1	6.9	7.2	7.6	6.8	6	5.6	6.0	**5.9**	**6.3**	7.E-06	**6.5**	0.0009
Forecast 2014–2016 Hungary																			
Expenditure for social protection	19.3	14.5	15.4	15.9	16	17	17.6	17.3	17.7	18.3	17.2	17.1	17.1	14	**13.5**	**13.1**	0.05	**13.1**	0.004
Health public expenditure	5.9	4.9	5.5	5.7	5.5	5.6	5.6	4.9	4.9	5	5	5.1	5.2	5	**5**	**5.3**	2.5E-08	**5.3**	4.6E-06
Education public expenditure	4.5	5.3	5.8	6.2	5.8	5.9	5.8	5.3	5.1	5.1	4.9	4.7	4.8	4	**4**	**4.1**	1.E-12	**4.1**	3.5E-13
General public services expenditure	9.9	10.6	9.8	9.2	9.8	9.6	9.7	9.6	9.4	10.3	9.2	8.8	9	8.3	**8.5**	**9**	8.E-12	**8.9**	0.007
Economic affairs public expenditure		5.7	7.6	5.9	5.7	5.8	6.4	6.5	5.7	5.5	5.8	7.2	6.2	6.5	**6.5**	**6.8**	0.08	**7.1**	4.7E-05
Forecast 2014–2016 Poland	19.5	20.8	18.3	18.8	17.6	17	16.9	15.7	15.6	16.5	17.1	15.9	16.1	13	**12.7**	**12.8**	0.008	**13.7**	0.0015

(Continued)

Table 4 (Continued).

Indicator/Year Forecast 2014–2016 Bulgaria	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	RMSE 2015	2016	RMSE 2016
Expenditure for social protection																			
Health public expenditure	5.5	5.8	4.4	4.3	4.2	4.4	4.6	4.6	5.1	5.1	5.2	4.7	4.6	4	3.9	4	1.1E-05	4.1	6.5E-06
Education public expenditure	4.9	5.4	6.1	6.1	5.7	6.1	6	5.7	5.1	5.1	5.2	5	5.5	4.8	5	5	3E-11	5.3	1.1E-12
General public services expenditure		6	6	6.3	6.3	6.3	6	5.6	5.4	5.8	5.9	5.8	5.9	5.5	5.7	5.4	1.5E-11	5.3	0.0017
Economic affairs public expenditure		3.4	3.5	3.4	3.4	3.8	4.4	4.5	4.9	5.3	5.7	5.6	4.7	5	4.8	5	1.10E-06	5.1	0.0004
Forecast 2014–2016 Romania																			
Expenditure for social protection	13.2	13.2	10.4	9.3	9.6	9.8	9.7	9.9	11.8	14.2	13.8	14.1	13.6	11.5	11.5	11.1	2E-10	11.1	7.5E-06
Health public expenditure	3.5	3.6	4.9	3.5	3.7	3.7	3.7	4.3	3.8	4.4	5	3.4	3.1	4.4	4.1	4.1	0.22	4.3	0.024
Education public expenditure	2.9	3.3	4	3.5	3.7	3.6	4.1	4.2	4.25	4.3	3.5	3.1	3	3	3.2	3.3	1.8E-05	3.3	1.8E-13
General public services expenditure	7.9	6.5	5.4	4.1	3.9	3.3	3.3	4.3	4.7	4.2	4.4	4.8	4.9	3.4	3	3.2	7.9E-10	3.3	3.3E-07
Economic affairs public expenditure	2.4	2.6	4	5	5.3	5.3	6.9	6.8	6.8	6.8	7	6.6	6.2	4.6	4.5	3.5	8E-10	3.5	0.257

Health public expenditure = f(Total population, Expenditure for social protection, General public services expenditure, Unemployment rate, Share of old-age population of total population, The rate on inflation, Inequality of income distribution, People with risk of poverty of social exclusion, Old-age dependency ratio, Public debt/GDP, GDP, Public revenues of GDP)

Education public expenditure = f(GDP, Unemployment rate, Total population, Rate on inflation, Inequality of income distribution, People with risk of poverty of social exclusion, Expenditure for social protection, General public services expenditure, Public debt/GDP, Public revenues of GDP, Health public expenditure, Share of the population under 18 years old of total population)

General public services expenditure = GDP, Unemployment rate, Share of old-age population of total population, Total population, The rate on inflation, Inequality of income distribution, People with risk of poverty of social exclusion, Old-age dependency ratio, Expenditure for social protection, Public debt/GDP, Public revenues of GDP, Health public expenditure, Education public expenditure)

Expenditure for social protection = Health public expenditure, General public services expenditure, Total population, Share of old-age population of total population, Old-age dependency ratio, Public revenues of GDP, Unemployment rate, The rate on inflation, Inequality of income distribution, People with risk of poverty of social exclusion, Public debt/GDP, GDP)

Economic affairs public expenditure = GDP, Unemployment rate, Total population, The rate on inflation, Expenditure for social protection, General public services expenditure, Public debt/GDP, Public revenues of GDP, Health public expenditure, Education public expenditure, General public services expenditure)

Source: Eurostat Database 2000–2013 and our own forecast for 2014-2016

fell in all the countries analysed, it was expected one would obtain decreased values for social protection in all these CEE countries (Table 3).

6.   Conclusions

The CEE countries with the larger public expenditure share of GDP have faced a faster impact of this on GDP growth in the short-run (Poland, Hungary and the Czech Republic), due to a large share of productive public expenditure. Bulgaria and Romania have faced this impact only in the long-run, because they focused mainly on the non-productive public expenditure. That explains the gap between these two groups of countries in the economic growth and welfare area. Over the long term, Bulgaria faces significant fiscal pressures from the ageing population, so it is necessary to carry on the reform of the social insurance system. The reform in education that is related to the economic growth is also crucial. Given that, during the crisis, Bulgaria did not borrow much, did not face large public deficits and it displayed the lowest public debt among the analysed CEE countries, it can afford to increase its public spending on the public education and health sectors and even in the social protection area in order to reduce the gap with the other CEE countries regarding the inequality of the income distribution or regarding the poverty risk ratio. So, we forecast an increase in all main public spending in Bulgaria.

Compared with other European countries, the Czech Republic spends a larger proportion of resources on health and economic affairs programmes (mostly expenditures on transport, such as the infrastructure expenditures on roads) and a smaller proportion on education, general public services and social protection programmes. But it spent a lot on education in the past two decades. It considered that a more educated and employed population could also reduce the government obligations for benefits and social assistance. The Czech Republic provides a strong incentive to expand higher education, but its expenses on public education will not be as high as in the past. The Czech Republic will spend more on general public services and on social protection.

Poland's public expenditures and taxes are about as high as in the Czech Republic and higher than in the Baltic States, so it performed well during the crisis and it will continue to perform well. Poland will spend more on health and economic affairs in the near future, but also in the social protection area. Its public spending in the education sector paid off both in economic growth and also in the economic welfare area.

Tax evasion in Hungary is widespread. Relative to the Czech Republic and other CEE countries, Hungarian taxes are very high. Hungary needs a comprehensive structural reform in its public finances that includes far-reaching cuts in spending and tax rates. This is the way to move the potential rate of growth upward and to avoid the risks of a similar crisis in the immediate future. Fiscal adjustment will be achieved in part through reductions in the overall government wage and pension bill.

Romania was supposed to cut its public spending as a result of the agreement with the IMF during the crisis period. Major cuts were for the investment projects co-financed with European funds. After analysing the evolution of the Romanian public expenditures after 2007, we noticed that higher spending was directed to the unproductive areas, while the capital spending declined. It is true that Romania has to struggle with the demographic inheritance and the social effects of the bad reforms implemented in the 1990s. It is also true that the social expenditure, the expenditure for pensions, expenditure dedicated to education or health, is considered 'rigid'. However, without social assistance and especially without pensions, the poverty rate will sharply increase in Romania. Romania has a high dependence of pensioners on the active population,

and this will increase just as in the other CEE countries (European Commission, 2012a). The public–private partnership has to be made and supported based on efficiency criteria in all the areas currently funded largely by the state. It is not only the pension system that affects Romania, but also the quasi-fiscal deficits within the state companies sector, the unsustainable structure of the budgetary expenditure, the very low efficiency of the budgetary expenditure, the lack of prioritisation of investments and the low financial discipline at the level of the local authorities.

In 2014, the wage burden on the public budget maintained a downward trend, reflecting the application of prudent personnel policies for the public sector. In addition, the social assistance expenditure recorded a downward trend. Subsidies were reduced in the period 2013–2014. The reforms in health, energy and transport continued and more public money was allocated in 2013–2014, as well as for environmental protection, whilst for education and research the expenditure remained relatively constant. The weight of public expenditure with investments in GDP was the highest in 2011–2012, comparable to the one in Poland and the Czech Republic, but the efficiency is the lowest in the region (European Commission, 2012a). Romania invests the least in education and the most in social protection and economic affairs (Table 4). Therefore, Romania has to focus on increasing the efficiency of spending the public funds. It has to increase the structural and cohesion funds absorption rate (the lowest in the region) in order to develop economically. The CEE region can benefit from European funds for infrastructure and the digital economy. These two domains are a priority for 2015–2017 according to the European Commission.

These CEE selected countries have to meet both the nominal and real convergence criteria to face the challenges of EMU membership. The social issues are important to reduce the gap with the old EMU member states, and the economic issues are important for achieving economic growth. Romania and Bulgaria should focus on increasing their productive public spending, on promoting the public–private partnership for the non-productive public spending such as social protection and on using the structural and cohesion funds available at the European level. In this way they can improve the efficiency of their public spending. The Czech Republic can afford to spend more on social purposes in the near future, especially due to its public deficit decrease. Poland has high taxes and spends more both in the productive and non-productive public spending area. On the other side, Hungary has to reduce all its public spending for cutting its public deficit and public debt and the highest decrease should be made in the non-productive area, mainly for social purposes. The amount of public investments should increase in Bulgaria. The efficiency of public spending should increase in all these analysed CEE countries.

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