Scientific Annals of Economics and Business
63 (1), 2016, 47-64
DOI: 10.1515/aicue-2016-0004

THE PROPORTIONS AND RATES OF ECONOMIC ACTIVITIES AS A FACTOR OF GROSS VALUE ADDED MAXIMIZATION IN TRANSITION ECONOMY

Yaroslav I. VYKLYUK*, Valeriy K. YEVDOKYMENKO, Ihor V. YASKAL*****

Abstract

Sustain growth of value added is one of the most important problem in many countries with transition economy. The article provides new evidence about determining the future dynamics of the economic activities with increasing value added. In this paper, we have used Hopfield's neural network to clarify the strategies of social and economic development of country. Three types of strategies have been created with using mathematical models and quantitative assessment of their efficiency has been made. From the simulation results, it is observed that state regulation based on this methodology can build the basis for further improvements in economic policy.

Keywords: gross value added, structure of economic activities, Hopfield's network, strategy

JEL classification: O21, C45, P24

1. INTRODUCTION

Existing social and economic situation in many transition countries requires a rethinking of priorities of their economic development policy. Solving such problems inevitably motivates scientists to refer to the indicator of value added (GVA) created in the production. This need is caused by social importance of compensation of employees; taxes without subsidies on products; gross profit and mixed income, and the importance of adequate assessment of the level of economic development.

Numerous studies point to the emergence of neo-economic model – the symbiosis of technological and non-system factors, as well as ethnic, national, psychological, ethical, cultural factors etc. This symbiosis will be so harmonious how management will be responsible to the new requirements and challenges, including development strategies.

The era of "hard" factors of competitiveness based mainly on natural resources and geopolitical location, is in the past. Today new resources (highly educated and highly skilled

* Bukovinian University, Ukraine; e-mail: *vyklyuk@ukr.net*;
** Bukovinian University, Ukraine; e-mail: *vyklyuk@ukr.net*;
*** Bukovyna State University of Finance and Economics, Ukraine; e-mail: *igoryaskal@gmail.com*;

personnel, creative employees, innovation, knowledge, information) and tools (management, marketing, branding, outsourcing, etc.) play a main role. The latter are generated by global factors in the appropriate environment.

All this encourages further to focus more on value added creation. For example, focus on higher-value added activities is one of points of the new growth model, which was proposed to Central and Eastern Europe countries (Labaye *et al.*, 2013).

Researches concentrated their efforts on sectoral distribution of value added in connection with structural changes (Pavelescu, 2012), regulation of structural changes (Gedz, 2014; Yevdokymenko, 2013) or empirical analysis of the development of the information society, which leads to the formation of a new paradigm of the national economy and structural changes (Pyrog, 2014). Other scholars are paying attention to industry sector and trying to identify the economic activities which have contributed to economic growth and the potential sources of economic recovery in the future (Dachin and Burcea, 2013; Russu, 2015).

However, the structure of the national economy should not develop spontaneously, because it can create a lot of problems. For example, Skribane and Jekabsone analyzing structural changes in Latvia, concluded that "the current structure of the economy has not been deliberate, but spontaneous under the impact of private investment flows that has been determined by the different productivity level and return on investments in product and services sectors. Asymmetric structure of the economy has developed and it cannot ensure stable and sustainable growth, and it is particularly dangerous when capital flows change, as it has been proved by the recent global financial crisis" (Skribane and Jekabsone, 2013). However, further investigations are needed to develop strategies of economic activities reproduction to ensure accelerated growth and interregional equalization in terms of gross value added.

So we propose to consider the value added distribution between economic activities as optimization task. And we propose to use Hopfield neural network for solving this problem. The important property of the Hopfield neural network is the decrease in output by finite amount whenever there is any change in inputs. Thus, the Hopfield neural network can be used for optimization.

Hopfield neural network methodology is widely used in scientific publications, mostly for optimization tasks. For example, this model has been applied for solving the Economic Load Dispatch (ELD), one of the most important optimization problems from the view point of power system to derive optimal economy (Lee *et al.*, 1998; Mishra and Mishra, 2015), the Economic Environmental Dispatch (EED) problem (Garg *et al.*, 2012), for finding approximate Pareto solutions for the multi-objective optimization problem of emission and economic load dispatch (EELD) (Balakrishnan *et al.*, 2003). Wan-Liang *et al.* (2003) proposed method based on Hopfield neural networks for solving job-shop scheduling problems (JSP). In our earlier papers we also applied some of Soft Computing methodology for analysis of regional economic reproduction process in Ukrainian regions Vyklyuk *et al.* (2013), Vyklyuk and Yevdokymenko (2013, 2014). But we do not know scientific works where Hopfield neural network methodology has been applied to find the optimal proportions and rates of economic activities.

In general, the aim of the paper is to use methodology of Hopfield neural network for determining the future structure and dynamic (rates and proportions) of economic activities. Such result provides the necessary scale of reproduction and increasing the creation of value added per capita. Also we are going to prove that differences between predictive values and prediction calculated using the classical trend models may be an important criterion for assessment of effectiveness of existing strategies. In comparison with other papers this one examines the new method (Hopfield's neural network) for analysis and bringing new evidence about the economic strategy development of particular country.

We used data about gross value added for the period 2002-2011 (in case of Ukraine) and for the period 1999-2010 (in case of Romania). Different time periods are not an obstacle for our calculations (and outcomes) because the aim of the article is to propose a new methodology, but not to forecast clear figures of value added. Then we suggest considering three different development strategies and these strategies should be compared in future with real indicators.

The base for our investigation is data about two transition economies: Ukraine and Romania. These countries are promising fields of studying this issue because both have made a transition from state-controlled economies to open, free-market economies since 1990, it is useful to explore influence of transition process on their structure of economies.

2. DATA AND METHODOLOGY

We use data about production (O) and gross value added (GVA) by economic activities (EA). We define production as the value of goods and services resulting from the production activity. First of all we perform ranking of economic activities by two indicators: share of value added in the economic activity's production and share of EA's GVA in total GVA for Ukraine (Table no. 1) and Romania (Table no. 2).

Table no. 1 – Criteria ranking of economic activities (Ukraine, 2010)

The share of value added in the EA's production, %		**The share of EA's GVA in total GVA, %**	
1. Education	66.3	1. Other activities (financial activity; public administration; real estate transaction and other services; culture and sports; household activity; activities of extraterritorial organizations)	26.4
2. Health and social assistance	65.6	2. Trade; repair of motor vehicles, household goods	17.3
3. Other activities (financial activity; public administration; real estate transaction and other services; culture and sports; household activity; activities of extraterritorial organizations)	61.4	3. Manufacturing	16.6
4. Trade; repair of motor vehicles, household goods	56.2	4. Transport and communication	11.6
5. Mining and quarrying	55.6	5. Agriculture, hunting and forestry	8.7
6. Transport and communication	53.0	6. Mining and quarrying	6.9
7. Agriculture, hunting and forestry	42.6	7. Education	5.8
8. Production and distribution of electricity, gas and water	33.9	8. Health and social assistance	4.4
9. Construction	32.9	9. Production and distribution of electricity, gas and water	3.7
10. Manufacturing	19.5	10. Construction	3.4

Source: State Statistics Service of Ukraine.

Table no. 2 – Criteria ranking of economic activities (Romania, 2010)

The share of value added in the EA's production, %		**The share of EA's GVA in total GVA, %**	
1. Education	82.8	1. Manufacturing	24.3
2. Public administration and defence, social insurance of public sector	75.8	2. Real estate, renting and business activities	15.2
3. Real estate, renting and business activities	65.9	3. Transport, storage and communications	12.1
4. Financial intermediation and insurance	62.4	4. Construction	10.2
5. Health and social assistance	58.1	5. Agriculture, forestry and fishing	6.4
6. Other activities	55.6	6. Electric and thermal energy, gas and water	5.7
7. Mining and quarrying	48.9	7. Wholesale and retail; repair of motor vehicles and motorcycles, household goods	5.6
8. Transport, storage and communications	46.5	8. Public administration and defence, social insurance of public sector	4.8
9. Agriculture, forestry and fishing	46.4	9. Education	4.0
10. Manufacturing	39.9	10. Health and social assistance	3.4
11. Electric and thermal energy, gas and water	38.7	11. Other activities	2.9
12. Hotels and restaurants	36.5	12. Financial intermediation and insurance	2.5
13. Construction	36.0	13. Mining and quarrying	1.9
14. Wholesale and retail; repair of motor vehicles and motorcycles, household goods	26.5	14. Hotels and restaurants	1.1

Source: Romanian National Institute of Statistics.

From the tables we can make clear idea which rates and proportions economic activities should be developed to maximize the country's GVA and increase GDP per capita. Also we are going to find analytical form of the functional relationship between the total value added and some economic activities' GVA. For this purpose the most important economic activities have been selected.

Based on the ranking there were selected 9 the most significant EAs for Ukraine (x_1...x_9) and 11 EAs for Romania (r_1…r_{11}), as seen in Annex A (A.1 and A.2). The selected quantity depends on the currently available statistical sampling which is the basis for calculating of the functional relationships.

3. RESULTS

The classical approach to the forecasting of economic activity involves the construction and analysis of development trends. Trend model provides calculation of predictive values assuming that the system will be developed by invariable tendencies. In our case, 25 classical trend functions were analysed. The best compatibility with the experimental data for both countries has been demonstrated by linear and polynomial function of the second degree (quadratic function) in the shape of:

$$GVA_{line}^{Ukraine} = -2{,}2 \times 10^{8} + 109983 \times Y, \; R^2 = 0{,}97 \qquad (1)$$

$$GVA_{quad}^{Ukraine} = -1{,}8 \times 10^{10} - 18066991 \times Y + 4529 \times Y^2, \; R^2 = 0{,}98 \qquad (2)$$

$$GVA_{line}^{Romania} = -8{,}4 \times 10^{7} + 42125 \times Y,\ R^{2} = 0{,}98 \qquad (3)$$

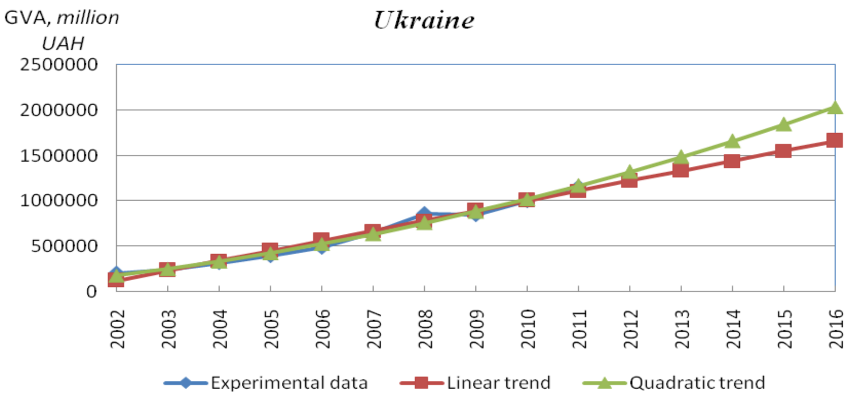
$$GVA_{quad}^{Romania} = -2{,}7 \times 10^{9} - 2767993 \times Y + 700 \times Y^{2},\ R^{2} = 0{,}98 \qquad (4)$$

where Y – year.

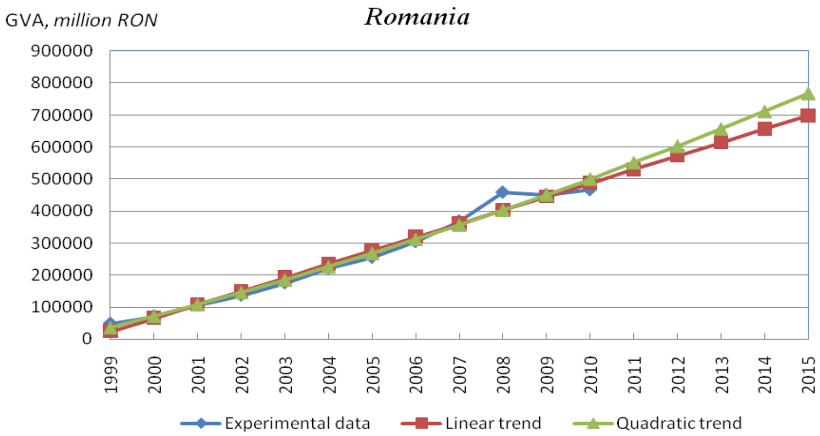
In accordance with calculated trend models after 5 years with invariable tendencies following values of gross value added should be expected:

- 1662892 million UAH (for Ukraine) and 697675 million RON (for Romania) by linear prediction and
- 2034955 million UAH and 766575 million RON by a quadratic prediction.

We consider these values as standards for comparison of strategies (Figure no. 1). "Standard" in our calculations means the changes of economic indicator based on classical econometric approach (construction and analysis of trend models).



a)



b)

Figure no. 1 – Changes in total value added

The problem of analytical form of the functional relationship between gross value added and its components is that no data about factors which affect the components x_i and r_i. The classical approach is as follows:

1. separate trend model is built for each x_i and r_i;
2. multiple regression analysis is carried out according to data from Tables no. 3 and no. 4, as a result linear model is constructed which allows to calculate total GVA based on known values of x_i and r_i;
3. computational results from trend model for each factor are substituted into the resulting linear regression model, which allows determining the predictive value of GVA.

As the calculations have demonstrated very similar results to (1)-(4) were obtained. This concept can be applied in the case of absence of autocorrelation between model's factors. To check this appropriate autocorrelation analysis was made (Tables no. 3 and no. 4).

Table no. 3 – Autocorrelation between components of the gross value added for Ukraine

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
x_1	1.00								
x_2	0.99	1.00							
x_3	0.83	0.87	1.00						
x_4	0.87	0.90	0.95	1.00					
x_5	0.98	0.99	0.92	0.92	1.00				
x_6	0.98	0.97	0.91	0.91	1.00	1.00			
x_7	0.96	0.96	0.93	0.90	0.99	0.99	1.00		
x_8	0.96	0.96	0.91	0.89	0.99	0.99	1.00	1.00	
x_9	0.93	0.95	0.95	0.90	0.98	0.98	0.99	0.98	1.00

Table no. 4 – Autocorrelation between components of the gross value added for Romania

	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}
r_1	1.00										
r_2	0.87	1.00									
r_3	0.81	0.96	1.00								
r_4	0.82	0.87	0.90	1.00							
r_5	0.86	0.99	0.99	0.90	1.00						
r_6	0.88	0.98	0.98	0.86	0.99	1.00					
r_7	0.81	0.99	0.94	0.80	0.97	0.96	1.00				
r_8	0.90	0.98	0.96	0.92	0.98	0.97	0.94	1.00			
r_9	0.88	0.99	0.97	0.87	0.99	0.99	0.97	0.98	1.00		
r_{10}	0.86	0.99	0.97	0.85	0.99	0.99	0.98	0.97	1.00	1.00	
r_{11}	0.76	0.95	0.90	0.69	0.93	0.94	0.98	0.89	0.95	0.96	1.00

As the Tables no. 3 and no. 4 show, there is a close correlation between x_i and r_i. Minimum correlation coefficient is 0.83 for Ukraine and 0.76 for Romania. So, factor analysis should be carried out before using the classical method of forecasting. This preliminary step allows significant reducing the number of model components (Katsikatsou *et al.*, 2012). During this analysis new factors will be received which are linear combination of the initial ones. But semantic meaning of new factors will be lost that makes further analysis and interpretation of the results more complicated. Thus, sensitivity analysis and formation of development strategies become impossible.

Method of development strategy forecasting based on Hopfield's network

To solve the problem of optimizing the country's development strategy taking into account the close relationship between economic activities we propose method which consists of the following steps.

Step 1. Regression models. First of all we make regression analysis, which allows establishing a functional interrelationship between economic activities. Dependences are constructed as follow:

$$x_i = \sum_{j=1}^{9} a_{ij} x_j + b_i \qquad (5)$$

$$r_i = \sum_{j=1}^{11} a'_{ij} r_j + b'_i \qquad (6)$$

In addition $a_{i=j} = a'_{i=j} = 0$. These coefficients can be conveniently presented in the form of square matrices with zero diagonals $A = (a_{ij})_{9\times 9}$, $A' = (a'_{ij})_{11\times 11}$ and vectors $B = (b_j)_9$, $B' = (b'_i)_{11}$. The next results were obtained from the calculations:

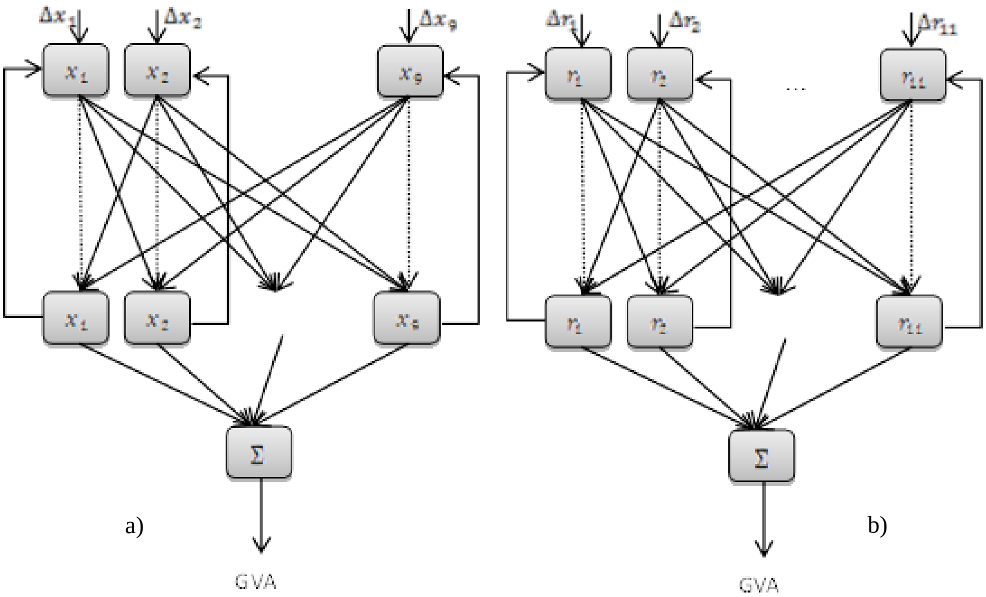
$$A = \begin{vmatrix} & 0.20 & 0.78 & -3.16 & 0.63 & 2.29 & -9.84 & 5.86 & -0.05 \\ 0.48 & & -0.70 & 2.21 & 0.76 & -2.28 & 6.21 & -4.36 & 0.05 \\ 0.87 & -0.33 & & 3.74 & -0.41 & -2.68 & 11.61 & -7.33 & 0.05 \\ -0.25 & 0.07 & 0.26 & & 0.14 & 0.71 & -3.11 & 1.93 & -0.01 \\ 0.66 & 0.33 & -0.39 & 1.89 & & -0.93 & 6.12 & -3.34 & 0.02 \\ 0.34 & -0.14 & -0.35 & 1.33 & -0.13 & & 4.13 & -2.57 & 0.02 \\ -0.08 & 0.02 & 0.08 & -0.32 & 0.05 & 0.22 & & 0.62 & 0.00 \\ 0.12 & -0.04 & -0.13 & 0.50 & -0.06 & -0.35 & 1.58 & & 0.00 \\ -3.98 & 1.74 & 3.34 & -12.77 & 1.72 & 8.93 & -29.79 & 18.30 & \end{vmatrix} \quad B = \begin{vmatrix} 6495 \\ 15337 \\ 490 \\ 492 \\ -14055 \\ 219 \\ 194 \\ -138 \\ 355 \end{vmatrix}$$

$$A' = \begin{vmatrix} & -0.32 & 0.05 & 0.45 & -2.82 & 9.64 & -0.02 & 2.93 & 7.18 & -12.46 & 1.84 \\ -0.20 & & 0.04 & 0.40 & -1.13 & 5.18 & 1.09 & 1.39 & 4.16 & -7.08 & 0.69 \\ 0.17 & 0.20 & & -0.39 & 3.43 & -4.73 & 0.14 & -2.20 & -4.92 & 8.09 & -2.01 \\ 0.75 & 1.06 & -0.19 & & 3.69 & -10.90 & -0.36 & -3.03 & -8.13 & 13.58 & -3.03 \\ -0.24 & -0.15 & 0.08 & 0.19 & & 2.81 & 0.01 & 0.87 & 2.17 & -3.67 & 0.70 \\ 0.08 & 0.07 & -0.01 & -0.06 & 0.29 & & -0.05 & -0.29 & -0.74 & 1.30 & -0.19 \\ -0.01 & 0.64 & 0.01 & -0.08 & 0.04 & -1.94 & & -0.47 & -1.77 & 3.07 & 0.31 \\ 0.27 & 0.21 & -0.06 & -0.17 & 0.96 & -3.19 & -0.12 & & -2.43 & 4.26 & -0.62 \\ 0.10 & 0.09 & -0.02 & -0.07 & 0.36 & -1.23 & -0.07 & -0.37 & & 1.69 & -0.23 \\ -0.06 & -0.05 & 0.01 & 0.04 & -0.21 & 0.73 & 0.04 & 0.22 & 0.57 & & 0.13 \\ 0.26 & 0.16 & -0.08 & -0.26 & 1.18 & -3.13 & 0.12 & -0.95 & -2.31 & 3.97 & \end{vmatrix} \quad B' = \begin{vmatrix} -1516 \\ -637 \\ 2635 \\ 4974 \\ -910 \\ 202 \\ -1087 \\ 628 \\ 225 \\ -139 \\ 1669 \end{vmatrix}$$

Step 2. Sensitivity analysis. At this stage, the analysis "what – if" is carrying out. The factor values are fixed based on the performance of last year and the input parameters are changing alternately, say, 10%. Herewith the change of benchmark is studied both in absolute and relative numbers. Such analysis allows building the development tactics for one period of time, in our case – 1 year. Results are represented in Tables no. B.1 and no. B.2.

Sensitivity analysis of regressive models with changing of input parameters by 10% for both countries (Annex B) shows economic inadequacy of indicators. For instance, increasing of GVA in “manufacturing” by 10% ostensibly “provokes” decreasing of GVA in “transport and communication” (x_6) and “health and social assistance” (x_8) etc.

In case of Romania we can see the same situation. So, increasing of GVA in “wholesale and retail; repair of motor vehicles and motorcycles, household goods” by 10% drastically “cuts” GVA in “financial intermediation and insurance” (r_6), “education” (r_9), “public administration and defence, social insurance of public sector” (r_8).



a) Ukraine; b) Romania (Hopfield, 1982)

Figure no. 2 – Neural Hopfield’s network for calculation of GVA

This means the following. Firstly, analysis of each coefficient in tables extremely capacious. Secondly, existing grouping of economic activities prevents a detailed study of the affecting factors. Also a calculation result is contrary to economic logic and makes it impossible to ensure the adequacy of estimated figures and findings. Therefore, to identify interrelationship between economic activities we propose to use Soft Computing methods.

Step 3. Construction of Hopfield’s network. As one can see from Eq. (5) and (6) gross added value of any economic activity can be expressed in term of others. For analysis of those systems it is convenient to use linear neural feedback network – Hopfield’s network (Hopfield, 1982; Atencia *et al.*, 2005). It is presented in Figure no. 2. The solid arrows show impact of some neurons (factors) on the other. Dotted lines indicate the lack of communication between neurons and correspond to the zero coefficients of matrix *A*. Inverse links transmit signals from the second layer of neurons to the first unchanged. Initially, the GVA values for the last year are submitting to the first layer. To calculate values of the second layer, and, respectively, of the first (layer) on the second step of iterations, such equation can be used:

$$X^{it+1} = X^{it} \times W + F \qquad (7)$$

where X^{it} – vector of the first layer for *it* iteration; *W* and *B* – linear regression coefficients, which are linking economic activities. In particular, for Ukraine: $X^1 = (x_i)_9^{2010}, W = A, F = B$ and for Romania: $X^1 = (r_i)_{11}^{2010}, W = A', F = B'$.

As can be seen in both cases, the diagonal elements of the matrix *W* are zero, but the matrix is not symmetric. Dissymmetry of matrix *W* is also reflected on the results of the sensitivity analysis (Annex B). The symmetry of the matrix would mean that there are equal direct and inverse relationships between all economic activities. Now some EAs are characterized by dominant dynamics of development than others. Therefore, as was shown in (Cohen and Grossberg, 1983), this neural network cannot be sustained. To check this fact it is enough to hold a few iterations of Eq. (7) and follow the dynamics of GVA changes, which can be calculated as the sum of the elements of the vector X^{it} (Table no. 5).

Table no. 5 – Changing the GVA values depending on the iteration

Iteration	***1***	***2***	***3***	***4***	***5***	***6***
GVA Ukraine	1167330	1171753	1150180	1264256	658830	1167330
GVA Romania	466191	465771	469341	447138	590492	466191
Iteration	***7***	***8***	***9***	***10***	***11***	***12***
GVA Ukraine	3869744	-13162672	77183723	-402050797	2140003807	3869744
GVA Romania	-329278	5577247	-32347406	211164616	-1352406736	-329278

Source: calculated by authors.

We can see from Table no. 5 that during the first 5 iterations value of GVA varies slightly. These changes are mainly due to errors of rounding calculations. In the case of a stable network such errors do not lead to strong fluctuations in the network. However, since 6 iterations these fluctuations become significant and have disastrous consequences. Consequently, we can claim that self-organization processes do not work in the system of unequal relationships between economic activities. So, absence of state regulation in the system causes irreversible destructive processes.

Step 4. Development of strategy. To avoid such phenomena decision makers have to develop an effective strategy to influence on each factor in model at the beginning of each iteration. We demonstrate it on Figure no. 2. This can be done by putting additional inputs Δx_j into neural network (Figure no. 2). Their semantic meaning is to make external influence on factors x_j from the state or investors. In fact, they reflect an increase of GVA of the *j*-th type of economic activity, which is a result of effective state regulation before iteration. Each iteration is an analogue of the reporting period (1 year). Presented Hopfield network model allows us to investigate several possible strategies for national economy development.

For example, we examine time period of 5 years. The most common are 3 strategies.

Strategy №1. Developing of strategy plan for 5 years with permanent stimulation of all economic activities. One should find those factors of impact $\Delta X = \{\Delta x_j\}_{j=\overline{1,9}}$ that remain unchanged for 5 years. Then the problem is reduced to the following:

$$GVA(2015) = GVA^6 = \sum_{j=1}^{9} [(x]_j)^6 \to \max \qquad (8)$$

under restrictions:

$$X^{it+1} = \left(X^{it} + \Delta X\right) \times W + F,\ i = \overline{1,5}$$
$$0 \le \Delta x_j \le p_j [\bullet (x]_j)^i,\ j = \overline{1,9}$$
$$[(x]_j)^i \ge 0$$

where p_j – the maximum percentage of factor $[(x]_j)^i$ increasing.

Strategy № 2. A dynamic strategy that involves the formation of a separate optimal strategy for each next year with annual changing of values of impact factors. This increases the total number of variables in solution $\Delta X^i = \{\Delta x_j\}^i_{j=\overline{1,9};\ i=\overline{1,5}}$ that can lead to better results according to the theory of dynamical systems. However, for the strategy creation for 5 years it is necessary to solve specific linear programming problem for each year. Every problem has the number of variables as in the previous case:

$$GVA^{i+1} = \sum_{j=1}^{9} [(x]_j)^{i+1} \to \max,\ i = \overline{1,5} \qquad (9)$$

under restrictions:

$$X^{it+1} = \left(X^{it} + \Delta X^{it}\right) \times W + F,\ i = \overline{1,5}$$
$$0 \le [(x]_j)^i \le [(p]_j)^i [\bullet (x]_j)^i,\ j = \overline{1,9}$$
$$[(x]_j)^i \ge 0$$

where $(p_j)^i$ – the maximum percentage of factor $[(x]_j)^i$ increasing in period *i*.

Strategy № 3. A dynamic strategy of objective function maximizing at the end of 5th year only. The number of variables in this problem is $K = 5 \times 9 = 45$. Restrictions are the same as in the previous case, and objective function has the form (8). In accordance with dynamic system theory such strategy should be the most efficient (Moor and Weatherford, 2004).

Computer simulation

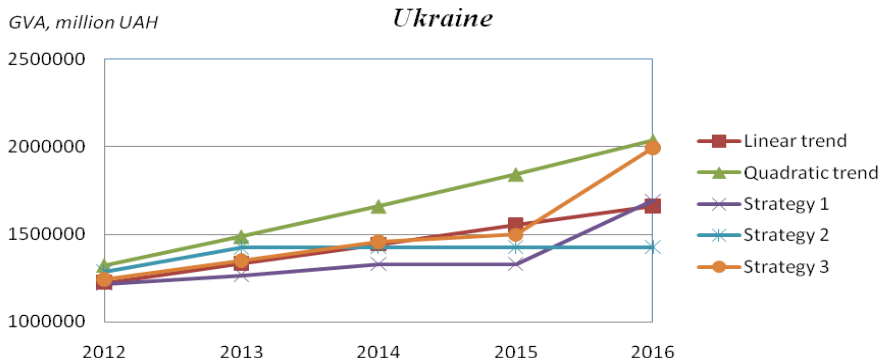
As we can see from Eq. (8)-(9) each iteration step may be presented as a linear programming problem. Therefore, the formation of strategy (type 2) causes no complications and can be made using the simplex method. Optimization problems of the first and third strategies are related to nonlinear programming problems due to iterative calculations of vectors X^{it}. As estimations shown the objective function is nonlinear and contains local extremes, making it impossible to use the method of consolidated gradient (Maksimov and Filipovskaya, 1982) because it's solving depends on the initial variables. In case of the wrong choice, this method searches a local extremum instead of global. Subsequent calculations have confirmed these assumptions.

Genetic algorithm is another progressive method of optimization. In accordance with it values of variables are analogous to genes of living beings. An objective function determines the state of creature which has certain genes. Genetic algorithm randomly generates a population of creatures (the population in estimations was 100 creatures). Then processes of crossing and mutation of these creatures are modelled, according to Darwin's theory (Zhang *et al.*, 2007; Akbari and Ziarati, 2011). The advantage of this method is that the optimization result is independent from the initial values of variables. The obtained value is located in the neighbourhood of the global extremum. The disadvantage is the slow time of calculation (in our case about 30 min. for each optimization). Also found value is not optimal (located near the optimum value). The feature of this method is that it allows slightly violate the restrictions.

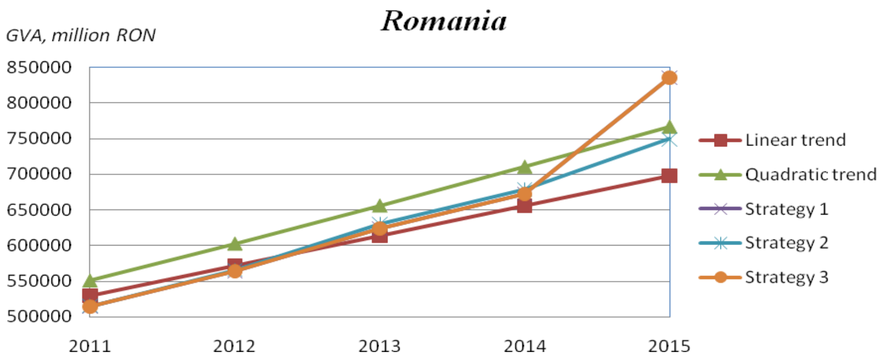
So, genetic algorithm has been used for the initial approximation of optimal solution. Obtained solution has been further specified by classical method of consolidated gradient. Estimations were carrying out with approximation that the maximum percentage of increasing of factors was $(p_j)^i = p_j = 10\%$.

The resulting strategies are presented in Annex C.

Results of GVA dynamic assessment in terms of 3 developed strategies in comparison with 2 trend forecasts are represented on Figure no. 3.



a)



b)

Figure no. 3 – Dynamics of GVA in Ukraine and Romania, depending on development strategies

As one can see from the Figure no. 3a regulation according to the first strategy in Ukraine will allow getting total gross value added at 1,690,995 million UAH in 5 years, which is within the linear trend prediction. Instead, the second strategy management will lead to worse result (1,426,129 million UAH). Noteworthy, that according to this strategy during the first 2 years rapid growth of GVA is observed which surpasses the rates of the first and third strategy. But, after 3-year management by this strategy the economy becomes saturated and value added will not increase for the next 3 years. Such growth will require structural changes in the economy, and new models will be needed to build. But statistics will be not available for these models, so science-based quantitative forecast will not be possible. This means that such regulation in Ukraine is unacceptable. The third strategy has appeared to be most effective. Almost quadratic trend prediction indicator (1,994,313 million UAH) may be reached at the 5th year of forecast.

It is noteworthy that maintaining of linear growth in Ukraine requires more than 10% changes of economic parameters (Table no. 5). That is, following 3rd strategy decision makers can slightly stimulate economic activities (to 10% annually). So, this strategy allows significantly increase economic efficiency in Ukraine without shocks.

Regarding Romania (Figure no. 3b) the 2nd strategy improves the efficiency of the economy. As forecast demonstrates, increasing of GVA is located within linear and quadratic trends. The saturation point (as in case of Ukraine) cannot be observed. Noteworthy, the results of the first and the third strategies almost coincide. Following them the most optimistic quadratic trend may be exceeded on 9%. So, in case of Romania development of strategy is optimal for some years instead annual planning. Similarity of the 1st and 3rd strategy results indicates that Romanian economy is more stable than Ukrainian.

In general, Tables no. C.1 and no. C.2 give us the idea what estimated rates and proportions of economic activities are required to achieve maximum value added in the whole country. We recognize that the scope of any article does not allow demonstrating a detailed analysis of relationships and mutual influence between each factor. This must be done directly by authors of strategies as recipients of the necessary official statistics.

4. CONCLUSIONS

Structure of national economies is not self-organized and there is a need to manage its development efficiently, especially in transition countries. So, we investigate possible ways to optimize the distribution of value added between economic activities.

For this purpose we propose to consider the value added distribution between economic activities as optimization task and to use Hopfield neural network for solving this problem. Such approach allows carrying out quantitative analysis of estimated strategies for countries.

Firstly, we have constructed trend models using linear and polynomial function of the second degree (classical approach). We used results obtained as standard.

Secondly, we have calculated possible indicators using method based on Soft Computing – Hopfield neural network. Proposed procedure consists of several steps: regression analysis, sensitivity analysis, construction of Hopfield network and development of strategies. After that we used genetic algorithm, another progressive method of optimization. As the result, strategies of 3 types have been developed and quantitative assessment of their efficiency has been made. Calculated strategies predict different rates of value added increasing. Dynamic regulation strategy with objective maximization function at the end of the period should be considered as the most effective.

In contrast to current practice (using linear and quadratic models) we have suggested to complement existing approaches used today for the prioritization of socio-economic development. Proposed quantitative method allows determining optimal distribution of gross value added creation between economic activities.

Of course, we are fully aware of some limitations of our findings. For example, we cannot present results in tables or graphs, because we use different quantity of input variable and these variables have different semantic meaning. We can compare only results of optimization (what has been done on Figure no. 3).

Summarizing, we can admit that procedure of Hopfield neural network is applicable and state regulation based on this methodology can build the basis for further improvements in economic policy.

References

Akbari, R., and Ziarati, K., 2011. A multi level evolutionary algorithm for optimizing numerical functions. *International Journal of Industrial Engineering Computations, 2*, 419-430. doi: http://dx.doi.org/10.5267/j.ijiec.2010.03.002

Atencia, M., Joya, G., and Sandoval, F., 2005. Hopfield Neural Networks for Parametric Identification of Dynamical Systems. *Neural Processing Letters, 21*(2), 143-152. doi: http://dx.doi.org/10.1007/s11063-004-3424-3

Balakrishnan, S., Kannan, P. S., Aravindan, C., and Subathra, P., 2003. On-line emission and economic load dispatch using adaptive Hopfield neural network. *Applied Soft Computing, 2*(4), 297-305. doi: http://dx.doi.org/10.1016/S1568-4946(02)00062-5

Cohen, M. A., and Grossberg, S., 1983. Absolute stability of global pattern formation and parallel memory storage by competitive neural networks. *IEEE Transactions on Systems, Man, and Cybernetics, 13*(5), 815-826. doi: http://dx.doi.org/10.1109/TSMC.1983.6313075

Dachin, A., and Burcea, F. C., 2013. Structural changes and productivity in the crisis period in Romania. The industry case. *Theoretical and Applied Economics, XX*(6(583)), 139-148.

Garg, E. M., Singh, E. M., and Girdher, E. V., 2012. Comparative study of economic load dispatch (ELD) using modified Hopfield neural network. *International Journal of Computing & Business Research*. http://www.researchmanuscripts.com/isociety2012/43.pdf

Gedz, M., 2014. Regulation of Structural Changes in the economy of Ukraine. *The Russian Academic Journal, 29*(3), 35-38. doi: http://dx.doi.org/10.15535/279

Hopfield, J. J., 1982. Neural Networks and Physical Systems with Emergent Collective Computational Abilities. *Proceedings of the National Academy of Sciences of the United States of America, 79*(8), 2554-2558. doi: http://dx.doi.org/10.1073/pnas.79.8.2554

Katsikatsou, M., Moustaki, I., Yang-Wallentin, F., and Jöreskog, K. G., 2012. Pairwise likelihood estimation for factor analysis models with ordinal data. *Computational Statistics & Data Analysis, 56*(12), 4243-4258. doi: http://dx.doi.org/10.1016/j.csda.2012.04.010

Labaye, E., Sjåtil, P. E., Bogdan, W., Novak, J., Mischke, J., Fruk, M., and Ionuțiu, O., 2013. *A new dawn: Reigniting growth in Central and Eastern Europe* Retrieved from http://www.mckinsey.com/insights/economic_studies/a_new_dawn_reigniting_growth_in_central_and_eastern_europe

Lee, K. Y., Sode-Yome, A., and Park, J. H., 1998. Adaptive Hopfield neural networks for economic load dispatch. *IEEE Transactions on Power Systems, 13*(2), 519-526. doi: http://dx.doi.org/10.1109/59.667377

Maksimov, Y. A., and Filipovskaya, E. A., 1982. *Algorithms for solving nonlinear programming problems*. Moscow: MIFI.

Mishra, S. K., and Mishra, S. K., 2015. A Comparative Study of Solution of Economic Load Dispatch Problem in Power Systems in the Environmental Perspective. *Procedia Computer Science, 48,* 96-100. doi: http://dx.doi.org/10.1016/j.procs.2015.04.156

Moor, J. H., and Weatherford, L. R., 2004. *Decision modelling with Microsoft Excel* (6 ed.). Moscow: Williams Publishing House.

Pavelescu, F., 2012. Fluctuation of economic activity, sectoral distribution of gross value added and the size of backward multipliers in Romania during the period 1989-2009. *Romanian Journal of Economics, 35*(2(44)), 88-112.

Pyrog, O. V., 2014. Structural changes in the model of national economy of Ukraine under an influence of informatization of society. *Effective Economy,* (7). http://www.economy.nayka.com.ua/?op=1&z=3170

Russu, C., 2015. Structural Changes Produced in the Romanian Manufacturing Industry in the Last Two Decades. *Procedia Economics and Finance, 22,* 323-332. doi: http://dx.doi.org/10.1016/S2212-5671(15)00296-8

Skribane, I., and Jekabsone, S., 2013. Structural changes in the economy of Latvia after it joined the European Union. *Intellectual Economics, 7*(1(15)), 29-41.

Vyklyuk, Y., Rotar, A., and Yevdokymenko, V., 2013. Formation of strategy reproduction patterns of economic activity in the regions based Soft Computing in the context of accelerating the growth of the gross regional product. *Collection Of Scientific Articles, Economic Sciences, 9,* 99-116.

Vyklyuk, Y., and Yevdokymenko, V., 2013. *Development of Soft Computing techniques to optimize the formation of strategy reproduction patterns of economic activity in the regions.* Paper presented at the International Scientific Conference Information technology, economics and law. State and Development Trends, Chernivtsi.

Vyklyuk, Y., and Yevdokymenko, V., 2014. New methods of Soft Computing in regional development strategy formation. *MEST Journal, 2*(2), 274-284. doi: http://dx.doi.org/10.12709/mest.02.02.02.28

Wan-Liang, W., Xin-Li, X., and Qi-Di, W., 2003. *Hopfield neural networks approach for job shop scheduling problems.* Paper presented at the IEEE International Symposium on Intelligent Control, Houston, Texas.

Yevdokymenko, V., 2013. *Features of reproduction governance of social and economic processes of the region in modern conditions*. Chernivtsi: Tekhnodruk.

Zhang, J., Chung, H. S. H., and Lo, W. L., 2007. Clustering-Based Adaptive Crossover and Mutation Probabilities for Genetic Algorithms. *IEEE Transactions on Evolutionary Computation, 11*(3), 326-335. doi: http://dx.doi.org/10.1109/TEVC.2006.880727

APPENDIX A

Table no. A.1 – Dynamics of gross value added by economic activities in Ukraine

No.	Economic activities	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
GVA	**Total**	**204342**	**244497**	**318321**	**396003**	**487132**	**656892**	**860714**	**847330**	**999973**	**1165450**
(x_1)	agriculture, hunting and forestry	29418	29059	37258	40542	41006	47417	65148	65758	82641	110564
(x_2)	mining and quarrying	10016	10854	12518	17939	22064	31695	54337	40676	65551	87077
(x_3)	manufacturing	40386	49702	64124	86863	109416	143428	164735	141878	158483	166382
(x_4)	construction	7653	10268	14463	16370	21168	30456	29185	21528	32518	37232
(x_5)	trade; repair of motor vehicles, household goods	24593	31622	41057	56041	68573	95220	131261	129997	164826	203755
(x_6)	transport and communication	27523	35092	42694	47435	56053	70063	87078	97050	111013	133196
(x_7)	education	10819	13781	16252	20882	26243	32905	43520	49239	55678	62099
(x_8)	health and social assistance	7361	9137	10952	13965	17722	22542	29209	34573	42181	45825
(x_9)	other activities	46573	54982	79003	95966	124887	183166	256241	266631	287082	319320

Source: State Statistics Service of Ukraine.

Table no. A.2 – Dynamics of gross value added by economic activities in Romania

No.	Economic activities	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
GVA	**Total**	**48888**	**71991**	**106082**	**136922**	**175641**	**220931**	**255233**	**304270**	**368356**	**458536**	**450979**	**466397**
(r_1)	agriculture, forestry and fishing	7281	8901	15618	17289	22848	31055	24292	26862	23992	34126	32298	29874
(r_2)	manufacturing	10343	17622	26812	33425	40413	52062	61250	72416	86952	100991	99187	113158
(r_3)	construction	2738	3929	6233	8649	11318	14649	18865	25548	37924	56131	52809	47762
(r_4)	wholesale and retail; repair of motor vehicles and motorcycles, household goods	6091	8236	10664	12919	17512	22350	28131	35008	43026	53995	46969	26173
(r_5)	transport, storage and communications	5429	8035	11681	14479	19470	24827	29346	34803	43533	57119	58454	56227
(r_6)	financial intermediation and insurance	950	1236	2301	3857	3686	5593	5826	6182	7923	11407	11250	11681
(r_7)	real estate, renting and business activities	5513	8099	12806	17716	20614	24833	32364	39513	49083	51411	52743	70968
(r_8)	public administration and defence, social insurance of public sector	1828	3460	4249	6060	12329	11605	14613	16016	19567	24344	24566	22343
(r_9)	education	1634	2326	3109	4431	6105	8346	9745	10925	12079	17510	17200	18440
(r_{10})	health and social assistance	1079	1576	1808	3854	4949	6138	7692	8372	10304	13936	13902	15825
(r_{11})	other activities	6003	8569	10801	14243	16398	19475	23109	28626	33974	37566	41601	53946

Source: Romanian National Institute of Statistics.

APPENDIX B

Table no. B.1 – Sensitivity analysis of regression models with changing of input parameters by 10% for Ukraine

Production values		*Input values*								
		x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
x_1	*million UAH*		92891	176404	34410	210975	137034	61203	47197	276628
	increase		6.04 %	5.78 %	-7.36 %	3.60 %	2.79 %	-1.40 %	2.87 %	-13.71 %
x_2	*million UAH*	112061		163925	37771	206534	132093	62250	45561	335743
	increase	1.57 %		-1.70 %	1.69 %	1.42 %	-0.91 %	0.29 %	-0.70 %	4.72 %
x_3	*million UAH*	123254	75977		41491	197179	127457	63443	43677	376121
	increase	11.72 %	-13.27 %		11.70 %	-3.17 %	-4.39 %	2.21 %	-4.80 %	17.32 %
x_4	*million UAH*	98570	95813	180697		210659	138248	60894	47744	273036
	increase	-10.66 %	9.38 %	8.35 %		3.45 %	3.70 %	-1.90 %	4.06 %	-14.84 %
x_5	*million UAH*	123183	103092	158327	40007		130641	63016	44567	355685
	increase	11.65 %	17.69 %	-5.06 %	7.71 %		-2.00 %	1.52 %	-2.86 %	10.94 %
x_6	*million UAH*	140771	57239	131087	46536	191187		65047	41161	439549
	increase	27.60 %	-34.66 %	-21.39 %	25.28 %	-6.11 %		4.80 %	-10.29 %	37.10 %
x_7	*million UAH*	49207	126146	238859	17863	241662	158968		55718	135606
	increase	-55.40 %	44.00 %	43.23 %	-51.91 %	18.67 %	19.25 %		21.44 %	-57.70 %
x_8	*million UAH*	137197	67602	133194	45997	188315	121514	64922		404441
	increase	24.36 %	-22.83 %	-20.13 %	23.83 %	-7.52 %	-8.85 %	4.59 %		26.15 %
x_9	*million UAH*	108751	89255	168247	36748	204354	133831	61976	46029	
	increase	-1.43 %	1.89 %	0.89 %	-1.07 %	0.35 %	0.39 %	-0.15 %	0.32 %	

Source: calculated by authors based on data from State Statistics Service of Ukraine.

Table no. B.2 – Sensitivity analysis of regression models with changing of input parameters by 10% for Romania

Production values		*Input values*										
		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}
r_1	*mil. RON*		112496	47826	28736	55519	11935	70930	23172	18745	15642	54759
	increase		-0.52 %	1.05 %	8.40 %	-1.25 %	2.10 %	-0.02 %	3.61 %	1.64 %	-1.13 %	1.45 %
r_2	*mil. RON*	26203		49593	38490	54511	12491	78154	24690	19509	15204	55750
	increase	-12.07 %		4.78 %	45.19 %	-3.05 %	6.85 %	10.16 %	10.40 %	5.78 %	-3.90 %	3.28 %
r_3	*mil. RON*	30029	113259		25613	56620	11635	71015	22084	18346	15874	53587
	increase	0.77 %	0.15 %		-3.38 %	0.70 %	-0.47 %	0.10 %	-1.25 %	-0.52 %	0.34 %	-0.73 %
r_4	*mil. RON*	30978	114131	46296		56713	11543	70740	21922	18260	15923	53299
	increase	3.96 %	0.92 %	-2.18 %		0.87 %	-1.26 %	-0.29 %	-1.98 %	-0.98 %	0.65 %	-1.26 %
r_5	*mil. RON*	13955	106756	66639	47237		13296	71146	27788	20493	14639	60624
	increase	-53.17 %	-5.60 %	40.80 %	78.19 %		13.74 %	0.28 %	24.25 %	11.12 %	-7.47 %	12.31 %
r_6	*mil. RON*	41062	119138	41798	13780	59509		68680	18643	17010	16675	50319
	increase	37.79 %	5.35 %	-11.68 %	-48.02 %	5.84 %		-3.20 %	-16.64 %	-7.76 %	5.40 %	-6.78 %
r_7	*mil. RON*	29693	120842	48300	23963	56282	11367		21510	17952	16108	54843
	increase	-0.36 %	6.86 %	2.05 %	-9.61 %	0.10 %	-2.76 %		-3.82 %	-2.65 %	1.82 %	1.60 %
r_8	*mil. RON*	36338	116183	42411	19748	58178	11035	69890		17613	16314	51852
	increase	21.94 %	2.74 %	-10.39 %	-25.51 %	3.47 %	-5.61 %	-1.49 %		-4.49 %	3.12 %	-3.94 %
r_9	*mil. RON*	43046	120762	38259	11517	60217	10328	67674	17884		16877	49725
	increase	44.45 %	6.79 %	-19.16 %	-56.55 %	7.10 %	-11.66 %	-4.61 %	-20.03 %		6.68 %	-7.88 %
r_{10}	*mil. RON*	10083	101882	60136	47993	50414	13745	75809	29105	21109		60257
	increase	-66.17 %	-9.91 %	27.06 %	81.04 %	-10.33 %	17.57 %	6.85 %	30.14 %	14.46 %		11.63 %
r_{11}	*mil. RON*	39742	116799	36495	10173	59993	10676	72630	19017	17203	16545	
	increase	33.36 %	3.28 %	-22.89 %	-61.63 %	6.70 %	-8.68 %	2.37 %	-14.97 %	-6.72 %	4.58 %	

Source: calculated by authors based on data from Romanian National Institute of Statistics

APPENDIX C

Table no. C.1 – Results of calculated development strategies for Ukraine

	Agriculture, hunting and forestry	Mining and quarrying	Manufacturing	Construction	Trade; repair of motor vehicles, household goods	Transport and communication	Education	Health and social assistance	Other activities
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
	Reality								
2003	-1 %	8 %	23 %	34 %	29 %	28 %	27 %	24 %	18 %
2004	28 %	15 %	29 %	41 %	30 %	22 %	18 %	20 %	44 %
2005	9 %	43 %	35 %	13 %	36 %	11 %	28 %	28 %	21 %
2006	1 %	23 %	26 %	29 %	22 %	18 %	26 %	27 %	30 %
2007	16 %	44 %	31 %	44 %	39 %	25 %	25 %	27 %	47 %
2008	37 %	71 %	15 %	-4 %	38 %	24 %	32 %	30 %	40 %
2009	1 %	-25 %	-14 %	-26 %	-1 %	11 %	13 %	18 %	4 %
2010	26 %	61 %	12 %	51 %	27 %	14 %	13 %	22 %	8 %
2011	34 %	33 %	5 %	14 %	24 %	20 %	12 %	9 %	11 %
	Strategy 1								
2011-2015	1 %	5 %	7 %	2%	4 %	2 %	3 %	2 %	5 %
	Strategy 2								
2011	10 %	7 %	10 %	0 %	10 %	10 %	10 %	6 %	10 %
2012	9 %	10 %	10 %	0 %	10 %	10 %	10 %	6 %	10 %
2013	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
2014	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
2015	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
	Strategy 3								
2011	6 %	8 %	6 %	6 %	8 %	8 %	8 %	3 %	3 %
2012	3 %	7 %	2 %	7 %	4 %	2 %	9 %	0 %	6 %
2013	1 %	1 %	8 %	5 %	2 %	7 %	9 %	2 %	1 %
2014	5 %	9 %	4 %	8 %	2 %	8 %	9 %	5 %	2 %
2015	10 %	1 %	8 %	6 %	7 %	2 %	0 %	8 %	1 %

Source: calculated by authors based on data from State Statistics Service of Ukraine.

Table no. C.2 – Results of calculated development strategies for Romania

	Agriculture, forestry and fishing	Manufacturing	Construction	Wholesale and retail; repair of motor vehicles and motorcycles, household goods	Transport, storage and communications	Financial intermediation and insurance	Real estate, renting and business activities	Public administration and defence, social insurance of public sector	Education	Health and social assistance	Other activities
	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}
	Reality										
2000	22 %	70 %	44 %	35 %	48 %	30 %	47 %	89 %	42 %	46 %	43 %
2001	75 %	52 %	59 %	29 %	45 %	86 %	58 %	23 %	34 %	15 %	26 %
2002	11 %	25 %	39 %	21 %	24 %	68 %	38 %	43 %	43 %	113 %	32 %
2003	32 %	21 %	31 %	36 %	34 %	-4 %	16 %	103 %	38 %	28 %	15 %
2004	36 %	29 %	29 %	28 %	28 %	52 %	20 %	-6 %	37 %	24 %	19 %
2005	-22 %	18 %	29 %	26 %	18 %	4 %	30 %	26 %	17 %	25 %	19 %
2006	11 %	18 %	35 %	24 %	19 %	6 %	22 %	10 %	12 %	9 %	24 %
2007	-11 %	20 %	48 %	23 %	25 %	28 %	24 %	22 %	11 %	23 %	19 %
2008	42 %	16 %	48 %	25 %	31 %	44 %	5 %	24 %	45 %	35 %	11 %
2009	-5 %	-2 %	-6 %	-13 %	2 %	-1 %	3 %	1 %	-2 %	0 %	11 %
2010	-8 %	14 %	-10 %	-44 %	-4 %	4 %	35 %	-9 %	7 %	14 %	30 %
	Strategy 1										
2010-2014	10 %	10 %	0 %	10 %	10 %	10 %	10 %	10 %	10 %	4 %	0 %
	Strategy 2										
2010	10 %	10 %	10 %	10 %	10 %	10 %	10 %	10 %	10 %	5 %	0 %
2011	10 %	10 %	10 %	10 %	10 %	10 %	10 %	10 %	10 %	5 %	0 %
2012	10 %	10 %	10 %	10 %	10 %	10 %	10 %	10 %	10 %	9 %	0 %
2013	10 %	10 %	0 %	10 %	10 %	0 %	10 %	0 %	0 %	10 %	0 %
2014	10 %	10 %	0 %	10 %	10 %	0 %	10 %	0 %	0 %	10 %	0 %
	Strategy 3										
2010	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
2011	10 %	10 %	0 %	10 %	10 %	10 %	10 %	10 %	10 %	4 %	0 %
2012	10 %	10 %	0 %	10 %	10 %	10 %	10 %	10 %	10 %	0 %	0 %
2013	10 %	10 %	0 %	10 %	10 %	10 %	10 %	10 %	10 %	0 %	1 %
2014	10 %	10 %	0 %	10 %	10 %	10 %	10 %	10 %	10 %	0 %	2 %

Source: calculated by authors based on data from Romanian National Institute of Statistics.